IRRIGATION DEPARTMENT
GOVERNMENT OF SINDH

SINDH RESILIENCE PROJECT – SRP
(IRRIGATION COMPONENT)

FEASIBILITY STUDY OF 50 NOS OF SMALL DAMS AND LINING OF 50 NOS PONDS / TARAIES IN SINDH PROVINCE

DROUGHT MANAGEMENT PLAN

DECEMBER 2022

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DROUGHT MANAGEMENT PLAN

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ADB	Asian Development Bank
AJ&K	Azad Jammu and Kashmir
AWS	Automatic weather station
BAP	Biodiversity Action Plan
BUIT	Balochistan University of Information Technology
BUITEMS	Balochistan University of Information Technology, Engineering & Management Sciences
CBD	Convention on Biological Diversity
CCS	Climate Change Scenario
CPA	Cumulative Precipitation Anomaly
COP	Conference of Parties
CSOs	Civil Society Organizations
DDMA	District Disaster Management Authority
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
dS/m	Deci-Siemens per meter
ENSO El	Niño-Southern Oscillation
FAO	Food and Agriculture Organization
ETM	Enhanced Thematic Mapper
FATA	Federally Administered Tribal Areas
GB	Gilgit Baltistan
GCISC	Global Climate Impacts Study Center
GoP	Government of Pakistan
HFA	Hyogo Framework for Action
JAS	June August September
KP	Khyber Pakhtunkhwa
LDN	Land Degradation Neutrality
mmhos/cm	Milli mhos per centimeter
MoCC	Ministry of Climate Change
NARC	National Agricultural Research Center
NDMA	National Disaster Management Authority
NDMC	National Disaster Management Commission
NDRMF	National Disaster Risk Management Fund
NDVI	Normalized Difference Vegetation Index
NGO	Non-governmental organization
NRSP	National Rural Support Program
OND	October November December
PARC	Pakistan Agricultural Research Council
PDMA	Provincial Disaster Management Authority
PDMC	Provincial Disaster Management Commission
PPAF	Pakistan Poverty Alleviation Fund
RAI	Rainfall Anomaly Index
RCP	Representative Concentration Pathway

RSPN	Rural Support Program Network
SDGs	Sustainable Development Goals
SLMP-II	Sustainable Land Management Program
SMA	Soil Moisture Anomaly
SPI	Standardized Precipitation Index
SUPARCO	Space and Upper Atmosphere Research Commission
TBTTP	Ten Billion Tree Tsunami Project
TVCI	Temperature Vegetation Dryness Index
UNCCD	United Nations Convention to Combat Desertification
UNICEF	United Nations Children Fund
UNDP	United Nations Development Program
UNHabitat	United Nations Human Settlement Program
WFP	World Food Program
w.r.t.	With respect to

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Pakistan is experiencing an increase in the frequency and severity of droughts especially the Province of Sindh is facing increase in the frequency and severity of droughts mainly due to rise in temperatures coupled with adverse effects of El Nino and decrease in the amount of rainfall during monsoon seasons. The Ministry of Climate Change, Government of Pakistan has taken initiative and is working on National Drought Management Plan to prepare well in advance to reduce impact of drought on the people and the economy of Pakistan. It will have separate drought plans for each of the province. However, the Government of Sindh, due to facing worst droughts frequently, is pro-actively preparing its own Drought Management Plan including a provincial policy on the Drought Management for Risk Reduction, Awareness and Preparedness to cater for its specific needs and conditions.

Drought mitigation means taking actions before, or at the beginning of, drought to help reduce the impacts (or effects) of drought. Many things to mitigate droughts can be done by people, communities, states, and the nation to reduce drought risk. These include making drought mitigation plans, conserving water, building dams and other structures that help us store water, and learning about drought and environment. A key point of dealing with droughts ad related risks is drought preparedness planning (DPP). The purpose of the drought preparedness planning is to derive a drought management plan (DMP) that is dynamic, reflecting the changing government policies, technologies, and natural resource management practices.

Reviewing the world experience, the following steps seem relevant to Sindh province for its DPP:

i. Appointment of a drought task force with representatives of key stakeholders
ii. Define the purpose and objectives of the preparedness plan
iii. Ensure stakeholders' participation and commitment
iv. Inventory resources and identify groups at risk
v. Develop organizational structure and drought management plan
vi. Identify research needs and fill institutional gaps
vii. Integrate science, technology and policy
viii. Build public awareness on the drought management plan
ix. Educate people on drought and its mitigation
x. Evaluate and revise drought preparedness plan incorporating the lessons learnt

Generally, trends and findings derived from historical climatic data for corresponding predictive analyses are used to determine the climate change impacts and forecast occurrence frequency of hydro-meteorological disasters like droughts and severe water shortages etc. This is undertaken using the state-of-the-art scientific and technologically advanced tools. These help in planning and implementing appropriate mitigation strategies to cope timely and efficiently with droughts and their consequences.

Keeping above in view, analysis of hydrological cycle of Sindh Province is undertaken using scientific and technological approach for effective climate change forecasting especially droughts and preparing a management plan accordingly for its mitigation. In this regards, NASA's GLDAS global datasets of hydroclimatic forcing and hydrological fluxes and states were selected and used in this evaluation. These datasets have been extensively used in the hydroclimatic studies all over the world. GLDAS precipitation data has shown to capture spatial variations and time series anomalies.

GLDAS surface temperature has been found to have high accuracy when compared with 13,511 weather stations across the globe, except for the mountainous regions. Number of studies which assessed the accuracy of GLDAS simulated soil moisture in different parts of the world, concluded that GLDAS simulated soil moisture showed high correlations with in-situ remotely sensed products. GLDAS datasets have also been used in drought monitoring and propagation applications. In conjunction with GRACE TWSA, GLDAS simulated soil moisture datasets have been extensively used to estimate regional groundwater depletion in arid to semi-arid regions including Central Valley in California and Indus Basin Aquifer.

The data analysis revealed that rainfall has a slightly increasing trend during these years. It may be result of exceptional rainfall events in the recent years but it will be further verified during the coming years. It may be noted that even the highest average annual rainfall of 258 mm in Tharparkar District is largely inadequate for any meaningful and secure rainfed agricultural production in non-canal commanded areas / non-irrigated areas of Sindh Province. Probabilistic forecast of relatively wet and dry years was carried out for each district using probability distribution of their annual precipitation amounts for 74 years. There is a strong probability of getting at least one year with severe drought and one relatively wet year in every 5 years.

The mean annual temperatures for 24 Districts of Sindh for 74 years (1948-2021) showed rising trend. This coupled with the scarce and unreliable rainfall is a clear evidence that agriculture production in the arid areas depends heavily on the provision of supplementary irrigation facilities through developing surface and ground water resources wherever appropriate and feasible.

Considering the above constraints, small dams and reservoirs, ponds and depressions, whenever and wherever feasible, to store whatever water is available from rainfall and runoff coupled with the use of latest state-of-the-art smart agricultural practices and technologies will contribute significantly in developing and promoting meaningful agricultural production in arid areas of Sindh Province.

There are a number of public and private sector agencies and organizations dealing with drought individually in isolation in Sindh Province. However, there is a strong need to establish a formal institutional mechanism to coordinate the efforts of all those concerned with drought in the province. This will facilitate integration and utilization of their available human and material resources most efficiently and productively to implement the DMP in Sindh Province.

Taking into consideration global experience in this regard, following institutional mechanism through appointing a Provincial Task Force is proposed for Sindh Province. To assist the provincial DTF / DC in technical matters, several specialist sub-committees led by appropriate qualified and competent convenors and comprising of relevant stakeholders shall be established.

For an efficient and effective implementation of DMP, several important operational measures are required. These may include:

- An Early Warning System and Drought Monitor
- Drought Information and Education Center
- District Drought Management Plans
- Provincial Drought Management Fund

Most appropriate and desirable technical drought mitigation measure suitable for arid areas of Sindh Province is water resources management especially through water harvesting and conservation both at field (in-situ) and farm level (individual action), and catchment / watershed / sub-basin / basin level (collective action) to increase water supplies as much as possible. Therefore, rainwater harvesting, conservation and storage at catchment / watershed level / sub-basin / basin level (collective action) to increase availability of beneficial water supplies as much as possible is the need of the hour.

Water harvesting and conservation is being practiced to some extent in Sindh province. However, it needs to be promoted to be undertaken systematically and adapted both intensively and extensively employing state-of-the art materials and methods using latest techniques and technologies.

Water harvesting captures rainfall and /or runoff and utilizes it for drinking or farming either directly or by storing it in surface and subsurface reservoirs. The stored water can be used for supplemental irrigation and other consumptive uses. Water Conservation emphasize most efficient and productive use of available water. A number of technical measures are proposed to be promoted as appropriate under DMP.

The Small Dams Project was launched by the Government of Sindh in 2007 through establishing Small Dams Organization Sindh (SDOS) at Hyderabad for constructing Small Dams, Delay Action Dams, Weirs and I.S.S.O barriers, across the river passages to store surface water and recharge sub surface water to meet the need of irrigation and potable water of the rural population of neglected suburban and remote areas of Sindh.

The SDOS has been instrumental in undertaking feasibility studies and constructing a range of different projects to use the small amount of average rainfall and the run-off generated with it.

A number of feasibility studies were completed in the past; however, a significant progress has recently been made in construction in construction of small dams. This needs to be continued and strengthened further as part of DMP of Sindh Province.

CHAPTER - 1

INTRODUCTION

CHAPTER-1
INTRODUCTION

1.1. Context

The Sindh Province of Pakistan represents about 18% of the country's area and home of about 25% of the country's population. It is situated in a subtropical region i.e. hot in the summer and cold in winter. Temperatures frequently rise above 46 °C (115 °F) between May and August, and the minimum average temperature of 2 °C (36 °F) occurs during December and January. The annual rainfall averages about nearly 230 mm (9 inches), falling mainly during June to September. The southwesterly monsoon wind begins to blow in mid-February and continues until the end of September, whereas the cool northerly wind blows during the winter months from October to January. The Sindh Province lies between the two monsoons - the southwest monsoon from the Indian Ocean and the northeast or retreating monsoon, deflected towards it by the Himalayan mountains - and escapes the influence of both.

The Sindh Province has three climatic regions:

i. Siro (the upper region, centered on Jacobabad);
ii. Wicholo (the middle region, centered on Hyderabad); and
iii. Lar (the lower region, centered on Karachi).

Central Sindh's temperatures are generally lower than those of upper Sindh but higher than those of lower Sindh. Dry hot days and cool nights are typical during the summer. Lower Sindh has a damper and humid maritime climate affected by the southwestern winds in summer and northeastern winds in winter, with lower rainfall than Central Sindh.

About 65% of area of Sindh Province has arid climate. The main arid zones comprise of Thar, Nara and Kohistan, covering 48% of the total area and has 1% of the water resources of the province. Thar zone comprises of District Tharparkar, and a part of Mirpurkhas and Umerkot districts covering about 23,000 km^2. Nara zone consists of desert parts of Sanghar, Khairpur and Sukkur districts covering 22,000 km^2. Kohistan region covers about 23,000 km^2 in the west of Sindh province. It covers flat lands or Kachho from South Manchar lake to north, Kubo Saeed Khan areas as well as western hilly tract. It is a barren hilly tract consisting of outlying spurs of the Kirthar Range. Cultivation is undertaken only along the numerous hill streams (nalas) that carry water during the rains. Cattle grazing is the principal occupation.

Livestock and subsistence agriculture are major sources of income. If timely and sufficient rains are not received during monsoon, drought like conditions prevail causing shortage of water, food, feed and fodder for livestock. Water table depth for portable water is approximately 350-400 feet on the average, that further decreases during droughts. The wells are mostly about one kilometer far from the houses and women have to take several trips to meet household needs of water. About 60% of groundwater is brackish.

The Province of Sindh is experiencing an increase in the frequency and severity of droughts due to rise in temperatures coupled with adverse effects of El Nino and decrease in the amount of rainfall during monsoon seasons. For example, during the monsoon season of 2018, the rainfall received in Sindh Province was 69.5 percent below its average rainfall[1] The province faces moderate to severe drought conditions in 8 districts. Despite government relief operations, a significant number of drought-affected communities remained unattended and are resorting to coping approaches that have severely compromised the wellbeing of children and women. Therefore, preparation of a Drought Mitigation Plan for Sindh Province has become essential.

1.2. Preparation of National & Provincial Drought Management Plans

Realizing the fact that Pakistan is experiencing an increase in the frequency and severity of droughts, the Ministry of Climate Change, Government of Pakistan has taken initiative and is working on National Drought Management Plan. The goal of the Drought Management Plan is to prepare well in advance to reduce impact of drought on the people and the economy of Pakistan. Although the National Drought Management Plan intends to include separate drought plans for each of the province, the Government of Sindh, due to facing worst droughts frequently, is pro-actively preparing its own Drought Management Plan including a provincial policy on the Drought Management for Risk Reduction, Awareness and Preparedness to cater for its specific needs and conditions.

1.2.1. National Drought Management Plan (Annex V)

The Sindh Drought Management Plan, prepared as part of National Drought Plan, is very informative plan giving the latest status report highlighting the important issues faced by Sindh Province due to drought. It has also brought out the on-going efforts for coping with it supported with facts and figures. Also, has made recommendation.

The plan has presented as given below:

- Context
- Areas affected by drought and Aridity including losses and damages from drought
- Main causes of Drought in Sindh
- Drought years and Drought Impacts
- Legal & Policy Framework
- Institutional Framework
- Drought mitigation and preparedness in Sindh
- Recommendations and implementation actions

However, there is a strong need to build further as rightly suggested in the recommendations that additional research coupled with analysis and planning is essential to elaborate further

[1] UN Office for the Coordination of Human Affairs (OCHA) 2019. Pakistan: Drought Fact Sheet: Balochistan & Sindh

details and tailor an action plan appropriate and suitable for Sindh Province at District and grass root / community level.

1.2.2. Sindh Drought Needs Assessment Report (2019)

Sindh Drought Needs Assessment Report (2019) was prepared by the Natural Disasters Consortium (NDC) comprised of IoM, FAO, UNICEF, ACTED and HANDS. In addition, the World Food Programme (WFP) and World Health Organization (WHO) also provided technical support for the assessment. They conducted a comprehensive Sindh Drought Needs Assessment (SDNA) in eight districts of Sindh, namely, Tharparkar, Umerkot, Sanghar, Thatta, Badin, Jamshoro, Dadu and Kambar Shahdadkot.

The assessment was undertaken to:

- evaluate the impact of the drought on agriculture (crop cultivation, production, water availability and livestock), livelihoods and food security, access to water and sanitation and hygiene practices of the households and communities; and
- provide recommendations to the Government of Sindh, NDC partners, and other decision/policy makers to prioritize actions (short, medium and long term) in relevant sectors and geographic areas to address immediate needs, build back better and increase future resilience to drought.

The comprehensive assessment used both quantitative and qualitative data for evaluation of drought impact and needs assessment. The data was collected from 1,229 households located in 69 sampled drought notified revenue villages (Dehs) of the eight districts.

The key findings of this drought assessment report showed that food insecurity is a major challenge in drought affected districts of Sindh. The food adequacy/sufficiency of own produced cereals from previous seasons was only sufficient for 2.8 months. The own produced pulses production was only sufficient for household consumption for 1.6 months. The analysis confirmed that overall, 71% of the surveyed households are moderately or severely food insecure, whereas 32% are severely food insecure. This is measured using the Food Insecurity Experience Scale (FIES) developed by FAO, which is used to compute Sustainable Development Goal (SDG) indicator 2.1.2: the prevalence of moderate or severe food insecurity in the population. Also, it was found that 47 percent of the surveyed households adopted “high” level food-based coping strategies and 25 percent households adopted “medium” level coping strategies, while 28 percent adopted “No/low” level coping strategies.

The higher-level coping strategy index indicates a more serious food security situation. It suggests that a food gap exists in the area and vulnerable households are adopting short-term coping strategies. Overall, 83% of the surveyed households were using at least one livelihood-based coping strategy to meet their food needs. Mainly, 17% of the households were adopting ‘stress strategies’ 18% were adopting ‘crisis strategies’ and another 50%

adopted ‘emergency’ irreversible strategies. These irreversible coping strategies negatively impact food security and livelihood in the future. In terms of health indicators, on average household members travel around 20 kilometers to the health facility they use the most. Overall, 11% of the households have an adult household member (above 18 years age) who is disabled and 4% have a child (below 18 years age) who is disabled. The rate of morbidity among PLW and under 5 children is very high in the surveyed households.

1.2.3. Hyogo Framework for Action

The Hyogo Framework for Action (HFA) was adopted in 2005 at the World Conference on Disaster Reduction, held in Kobe, Hyogo, Japan to reduce disaster losses significantly by 2015 - in lives, and in the social, economic, and environmental assets of communities and countries. This was a global blueprint for disaster risk reduction efforts undertaken between 2005 and 2015. It has five priorities for action:

- Ensure that disaster risk reduction (DRR) is a national and a local priority with a strong institutional basis for implementation
- Identify, assess and monitor disaster risks and enhance early warning
- Use knowledge, innovation and education to build a culture of safety and resilience at all levels
- Reduce the underlying risk factors
- Strengthen disaster preparedness for effective response at all levels

The adoption and implementation of HFA marked a milestone in catalyzing national and local DRR efforts and in strengthening international cooperation through the development of regional strategies, plans and policies.

The HFA drove significant progress in developing institutions, policies, and legislation for disaster risk reduction. Stakeholders at all levels, strengthened their capacities for risk assessment and identification, disaster preparedness, response and early warning.

However, progress towards managing underlying disaster risk drivers remained limited in most countries.

In general, institutional, legislative and policy frameworks did not sufficiently facilitate the integration of disaster risk considerations into development decisions. Consequently, hazard exposure in both higher and lower income countries increased faster than vulnerability decreased, new risks were being generated faster than existing risks were being reduced.

At the end of the HFA implementation, Member States recognized that efforts had not led to reduced physical losses and economic impacts.

They concluded that the focus of national and international attention must shift from protecting social and economic development against external shocks, to transforming growth and development to manage risks, in a holistic manner. Read more in the Synthesis report on consultations on the post-2015 framework on disaster risk reduction (HFA2).

This conclusion formed the basis for the development of the Sendai Framework, the successor instrument to the HFA, which was adopted in 2015.

1.2.4. Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework)

The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) is the successor instrument to the Hyogo Framework for Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters. It is the outcome of stakeholder consultations initiated in March 2012 and inter-governmental negotiations held from July 2014 to March 2015, which were supported by the UNDRR upon the request of the UN General Assembly.

The Sendai Framework was the first major agreement of the post-2015 development agenda and provides Member States with concrete actions to protect development gains from the risk of disaster.

The Sendai Framework works hand in hand with the other 2030 Agenda agreements, including The Paris Agreement on Climate Change, The Addis Ababa Action Agenda on Financing for Development, the New Urban Agenda, and ultimately the Sustainable Development Goals.

It was endorsed by the UN General Assembly following the 2015 Third UN World Conference on Disaster Risk Reduction (WCDRR), and advocates for:

The 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.

It recognizes that the State has the primary role to reduce disaster risk but that responsibility should be shared with other stakeholders including local government, the private sector and other stakeholders.

The Sendai Framework is the successor instrument to the Hyogo Framework for Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters. It is the outcome of stakeholder consultations initiated in March 2012 and inter-governmental negotiations held from July 2014 to March 2015, which were supported by the UNDRR upon the request of the UN General Assembly.

UNDRR is tasked to support the implementation, follow-up and review of the Sendai Framework that has following key priorities.

Priority 1. Understanding Disaster Risk

Disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Such knowledge can be used for risk assessment, prevention, mitigation, preparedness and response.

Priority 2. Strengthening Disaster risk Governance to Manage Disaster Risk

Disaster risk governance at the national, regional and global levels is very important for prevention, mitigation, preparedness, response, recovery, and rehabilitation. It fosters collaboration and partnership.

Priority 3. Investing in Disaster Risk Reduction for Resilience

Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment.

Priority 4. Enhancing Disaster Preparedness for Effective Response and to "Build Back Better" in Recovery, Rehabilitation and Reconstruction

The growth of disaster risk means there is a need to strengthen disaster preparedness for response, take action in anticipation of events, and ensure capacities are in place for effective response and recovery at all levels. The recovery, rehabilitation and reconstruction phase is a critical opportunity to build back better, including through integrating disaster risk reduction into development measures

1.3. Droughts in Sindh Province and their Impact

The Province of Sindh is experiencing an increase in the frequency and severity of droughts due to rise in temperatures coupled with adverse effects of El Nino and decrease in the amount of rainfall during monsoon seasons. For example, during the monsoon season of 2018, the rainfall received in Sindh Province was 69.5 percent below its average rainfall[2].

Sindh province covers about 18% of the country's total geographic area and has about 25% of the country's total population. About 60% of its area is with 66% of its groundwater resources are brackish. District Tharparkar has extremely high vulnerability index for drought followed by Umerkot, Mirpurkhas, Badin, Thatta, Tando Muhammad Khan, Tando Allah Yar, Sanghar, Shaheed Benazirabad, Dadu, Kambar Shahdadkot, and Jamshoro.

The province faces moderate to severe drought conditions in 8 districts. Despite government relief operations, a significant number of drought-affected communities remained unattended

[2] UN Office for the Coordination of Human Affairs (OCHA) 2019. Pakistan: Drought Fact Sheet: Balochistan & Sindh

and are resorting to coping approaches that have severely compromised the wellbeing of children and women.

Livestock and subsistence agriculture are major sources of income. If timely and sufficient rains are not received during monsoon, drought like conditions prevail causing shortage of water, food, feed and fodder for livestock. Water table depth for portable water is approximately 350-400 feet on the average, that further decreases during droughts. The wells are mostly about one kilometer far from the houses and women have to take several trips to meet household needs of water. About 60% of groundwater is brackish.

Therefore, preparation of a Drought Mitigation Plan for Sindh Province has become essential.

1.4. Potential Impacts of Climate Change on Sindh Province

The Climate Change (CC) will have and is currently having a disastrous effect on the province of Sindh and the people.

The communities that live near coasts in Sindh province are at risks of climate change. It can increase the floods, sea level rise, severe storms, coastal erosion as well as droughts and extreme weather events like coastal storms, hurricanes and tornadoes.

Such disasters result in decrease of land and source of revenue while such people are forced to migrate or worse lose their livelihoods and lives.

Some potential common impacts of Climate Change on the Sindh province are:

- Floods
- Cloud outbursts
- Drought
- Desertification
- Less crop yields
- Species extinction
- Extreme weather events
- Heatwaves
- Sea water rise
- Salt-water intrusion

1.5. Preparation of Drought Management Plan of Sindh (DMPS)

1.5.1. Objectives

In line with the National Drought Management Plan, the key objectives of the Drought Management Plan of Sindh (DMPS) are to assist the Provincial Government and relevant stakeholders to provide a mechanism for drought mitigation and resilience through concrete actions, including, assessing drought situation in the province, undertaking drought preparedness and preventive actions to assist communities and their ecosystem in increasing the resilience for drought and taking short, medium and long-term drought mitigation initiatives to minimize human sufferings, economic losses, social hardships and environmental degradation.

1.5.2. TORs of Drought Management Plan of Sindh

The ToRs of Long-term Risk Based Drought Management Plan for Province of Sindh for Risk Reduction, Awareness and Preparedness shall include but not limited to, the following:

i. Evaluate Hydrological Cycle, describing drought and wet years.
ii. Estimate average annual rainfall and runoff in the Province
iii. Evaluate probabilities of occurrence of drought
iv. Assessment of Long-Term impacts of droughts on ecosystem
v. Formulate Awareness and Education Plans.
vi. Propose Drought Mitigation Measures. The mitigation measures may include the following:

a) Construction of small recharge/small dams. In this context compile following data

- Total No of dams already constructed in the province
- Total No of dams under construction in the province
- Total No of dams to be constructed in future under various on-going studies in the province
- Estimate potential of construction of additional dams in the province.

b) This shall include the availably of runoff to be stored in the reservoirs of these dams and availability of potential dam sites for construction of additional dams;
c) Mitigation through plantation in the watershed
d) Mitigation through employing various rainwater harvesting techniques
e) Mitigation through runoff collection using surface and underground structures
f) Mitigation through crop management

It is anticipated that once approved, the DMP will be implemented by the Provincial Drought Task Force jointly with Irrigation Department.

CHAPTER - 2

DROUGHT CHARACTERISTICS

CHAPTER-2
DROUGHT CHARACTERISTICS

2.1. What is Drought?

2.1.1. Definition of Drought

There are many different definitions of drought. However, for this plan, a drought may be defined as a prolonged period of abnormally-low rainfall, leading to lower than expected surface and groundwater reservoir levels. It is a temporary aberration, unlike aridity, which is a permanent feature of climate of an area. It is in contrast is a recurrent, yet sporadic feature of climate, known to occur under all climatic regimes and is usually characterized by variability in terms of its spatial expanse, intensity and duration.

Generally, it is difficult to provide a precise and universally accepted definition of drought due to its complex nature and varying characteristics that manifest across different agro-climatic zones of the world in so many different ways. However, a universally accepted norm is that drought stems from a deficiency or erratic distribution in the rainfall. However, its spread and intensity of the calamity is contingent on several factors, including the status of surface and ground water resources, agroclimatic features, cropping choices and patterns, socio-economic vulnerabilities of the local population etc.

The drought differs from other natural hazards such as cyclones, floods, earthquakes, volcanic eruptions and tsunamis. Its occurrence is contingent upon a number of factors such as cropping choices and agronomic practices, soil types, drainage and ground water profiles, to name a few. However, rainfall deficiency and spatial and temporal distribution, duration and dry spells are acknowledged as the most important triggers for drought. When drought occurs, it becomes essential to manage the available water resources to meet the demand for multiple uses of water.

Unlike aridity, which refers to a permanent climatic condition with very low annual or seasonal rainfall, drought refers to a casual (random) condition of "severe reduction" of water availability compared to the normal values extending along a "significant period" of time over a "large region". Of-course the criteria to define "severe reduction", "significant period" and "large region" are affected by subjectivity, as they derive from the perception of negative impacts of the water deficit as well as from the demand level.

Drought is a complex hydrometeorological phenomenon, caused by meteorological anomalies reducing precipitation, but also affected by the state of the various components of the hydrologic cycle. The term desertification is used to indicate a long-term and somehow irreversible process of decrease or destruction of biological soil potential fostered by several factors (climate, soil properties, and human activities) where drought might accelerate the process.

2.1.2. Categories of Droughts

Generally, droughts are categorized as short, medium or long-term duration, as these descriptions help to identify the triggers and what measures would need to have in place.

2.1.2.1. Short Duration

A short duration or single season drought generally lasts six to nine months and tends to include a hot dry summer with less than 70% of the average rainfall. This means that our surface water sources are drawn down significantly before the start of the winter period.

2.1.2.2. Medium Duration

A medium duration drought comprises two successive dry winters, with an intervening dry summer.

2.1.2.3. Long-term Duration

A long-term duration drought would be signified by two consecutive dry winters and two intervening dry summers. This would be a critical drought scenario.

2.1.3. Types of Droughts

Generally, there are four types of drought events as given below. However, Sindh Province suffers all the four types to different extents in its arid areas.

i. Meteorological Drought is based on the degree of dryness or rainfall deficit and the length of the dry period.
ii. Hydrological Drought is based on the impact of rainfall deficits on the water supply such as stream flow, reservoir and lake levels, and ground water table decline.
iii. Agricultural Drought refers to the impacts on agriculture by factors such as rainfall deficits, soil water deficits, reduced ground water, or reservoir levels needed for irrigation.
iv. Socioeconomic Drought considers the impact of drought conditions (meteorological, agricultural, or hydrological drought) on supply and demand of some economic goods such as fruits, vegetables, grains and meat. Socioeconomic drought occurs when the demand for an economic good exceeds supply as a result of a weather-related deficit in water supply.

2.2. Causes of Drought in Sindh Province

Main causes of drought are as follows[3]:

[3] National Drought Management Plan 2021. GoP

- Increase in population resulting in increased consumption of household firewood and water.
- Land degradation and deforestation of land for non-forestry purposes that causes increase in soil erosion and land degradation weakening the resilience of ecosystem and livelihood of the population.
- Overgrazing: About six million heads of livestock are reared in arid zone of Sindh Province being major livelihood source of the people against the carrying capacity of 2-3 million heads only. Pasture/ rangeland productivity and services and functions of ecosystem is reduced causing soil compaction, wind and water erosion and natural resilience to climate variability as a result of overgrazing. In degraded rangelands, in addition to decreased feed and fodder availability for the livestock, water penetration into the soil to support groundwater recharge is reduced causing drought like situations.
- Climate change Due to climate change impacts, frequency and severity of floods and drought, especially hydrological drought is expected to be enhanced due to precipitation regime's high variability. Extreme events are expected to be increased due to changes in thermal regime and precipitation patterns causing increased glacier melting and later on reduced river flows and intensification in scarcity of water.
- Increased anthropogenic activities Anthropogenic activities like removal of natural vegetation cover, excessive cultivation of marginal lands, excessive pumping and inappropriate use of groundwater increase the use of water in access to renewable water supply and emission of greenhouse gases that lead to more erratic rains and increased temperature supporting drought phenomenon. Excessive pumping of groundwater also results in depletion of groundwater resources.
- Inappropriate use of land without considering land capability classification The Land Capability Classification describe soil productivity and capabilities for planning either grasslands, forest or croplands on an area. The land use is not as per land capability classification.
- Soil Problems, mostly causing increased vulnerability to drought
- Wind erosion.
- The systematic deforestation in Sindh Province over the last 30 years has deprived the province of her massive forest cover, bringing it down to less than 2%. Whereas, according to the UN and WHO standards, a country should have at least a 25% forest cover for a better environment and sustainable livelihood.
- The existing forests in Sindh Province are classified as riverine, irrigated plantations and mangrove forests.
- According to statistics released in October 2017, Sindh's riverine forests had declined to 0.05 million hectares (0.35%), irrigated forests to 0.082 million hectares (0.14%), and mangrove forests to 0.2 million hectares (1.41%).
- El-Nino & La Nina Phenomena
- Increase of atmospheric CO_2 & other greenhouse gases etc.

2.3. Drought Mitigation

Drought mitigation means taking actions before, or at the beginning of, drought to help reduce the impacts (or effects) of drought. Many things to mitigate droughts can be done by people, communities, states, and the nation to reduce drought risk. These include making drought mitigation plans, conserving water, building dams and other structures that help us store water, and learning about drought and environment.

The severe drought events that have occurred globally during the past decades have increased awareness and understanding regarding the negative and adverse impacts of this hydrometeorological hazard on human and ecosystems. This has also led to develop a range of drought mitigation measures. The necessity of an urgent response to drought event is strongly recognized in arid and semiarid regions, where the risk of severe water shortages is growing, due to the pressure of increasing demands on scarce water resources presenting a high natural variability.

The perception of the priority actions necessary to cope effectively with drought can be very different, according to the mandate and jurisdiction of the organization preparing or dealing with mitigation of adverse impacts of drought. However, a large consensus exists on the necessity of a comprehensive approach including:

- A better knowledge of the drought phenomenon through understanding its general meteorological causes as well as of undertaking continuous monitoring of drought conditions;
- An accurate assessment of drought impacts on human, eco-system, economic and social systems; and
- The definition and identification of a set of preparatory actions aimed to mitigate drought impacts and to reduce the vulnerability of water systems to droughts.

The drought mitigation in Sindh Province has mostly been as ‘Reactive’ comprising emergency relief measures whereas it needs to be ‘Pro-active’ which requires preparations in well advance using all the knowledge, skills and resources both human and financial.

The drought mitigation actions and measures may include a large number of preparatory activities that can be grouped into three main categories:

- Water resources management to increase water supplies;
- Water demand management to reduce water needs & requirements; and
- Minimization of negative and adverse impacts of drought.

Each of the above category will contribute to mitigate the negative and adverse physical, economic and social impacts of drought in different ways. Multi-criteria decision-making may be employed to compare different drought mitigation measures to choose the appropriate combination of actions for implementation. The multi-criteria decision-making (Figure 2.1) follows six steps that includes[4], i) problem formulation, ii) identify the requirements, iii) set goals, iv) identify various alternatives, v) develop criteria, and vi) identify and apply decision-making technique.

2.4. Drought Mitigation Approaches

There are two key approaches towards drought mitigation. These are:

- Reactive Approach
- Proactive Approach

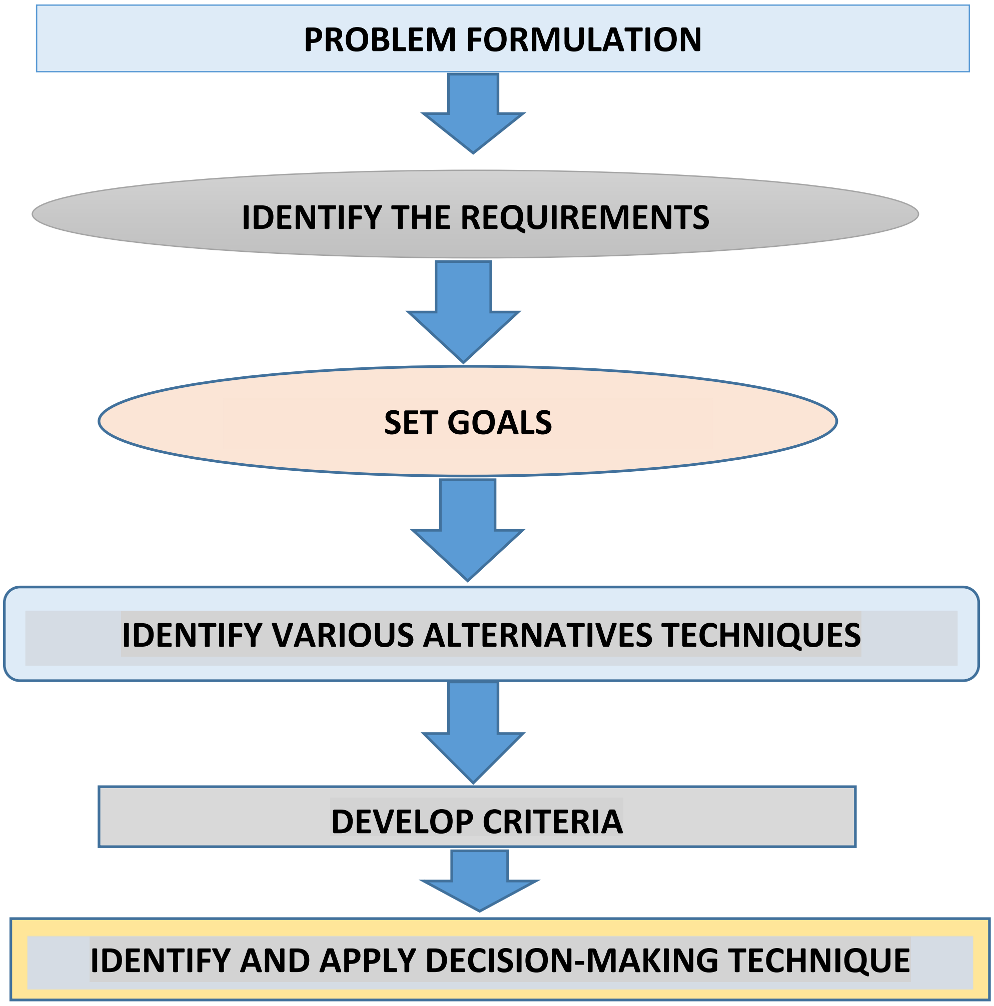
It is important to understand the difference between the two approaches i.e. behaviors and ways of thinking.

2.4.1. Reactive Approach

The Reactive Approach towards drought mitigation is managing the drought once it emerges or being encountered, without appropriate arrangements made in advance on how to cope with drought, what to do for its mitigation, when to do, and whom to involve in dealing with it. A Reactive Approach towards drought mitigation does not have an adequate plan, preferably not a strategy.

[4] Davood Sabaei, John Erkoyuncu and Rajkumar Roy 2015, A review of multi-criteria decision-making methods for enhanced maintenance delivery. ScienceDirect. Procedia CIRP 37 (2015) 30 – 35

Figure 2.1: Multi-Criteria Decision-Making (Six Steps)



2.4.2. Proactive Approach

The Proactive Approach towards drought mitigation requires advance preparation of both long-term actions oriented to reduce vulnerability of water supply systems, and short -term actions to be taken during the drought period. The role of a drought monitoring system and an appropriate institutional framework for effective drought management is also highlighted.

2.5. Risk Management Versus Crisis Management Approach

The traditional approach taken for drought management has been reactive, relying largely on crisis management. This approach has been ineffective because response is generally untimely, poorly coordinated, and poorly targeted to drought-stricken areas. In addition, drought response is post-impact and relief tends to reinforce existing resource management methods. It is precisely these existing resource management practices that have often increased societal vulnerability to drought. The provision of drought relief only serves to reinforce the status quo in terms of resource management.

Many governments and other organizations now understand the weaknesses of crisis management and are striving to learn how to employ proper risk management techniques to reduce societal vulnerability to drought and, therefore, lessen the impacts associated with future drought events. As vulnerability to drought has increased globally, greater attention has been directed to reducing risks associated with its occurrence through the introduction of planning to improve operational capabilities (i.e., climate and water supply monitoring, building institutional capacity) and mitigation measures that are aimed at reducing drought impacts.

In the past, when a natural hazard event and resultant disaster has occurred, governments have followed with rescue, relief, impact assessment, response, recovery, and reconstruction activities to return the region or locality to a pre-disaster state. However, little attention is paid to preparedness, mitigation, and prediction/early warning actions (i.e., risk management) that could reduce future impacts and lessen the need for government intervention in the future.

2.6. Concept of Drought Risk Management

The concept of drought risk management is based on that:

- The drought will re-occur;
- The severity of a particular drought event cannot be fully predicted in advance;
- Planning and preparation in advance is essential to mitigate drought impacts;
- Drought mitigation is an ongoing process involving structural and non-structural measures; and
- That all water users have a responsibility to conserve water through using as efficiently as possible.

Risk can be defined in different ways hence the risk management is also open to several different interpretations. When combined with the emotional context of drought induced suffering of individuals, communities, animals and the environment, the risk is magnified and distorted. Drought risk in a wider context can be described as the area's exposure to the natural hazard and society's vulnerability to it[5]. The common description in relation to drought risk is:

Risk = Hazard x Exposure x Vulnerability

Where:

- Risk exists where people, property, production and means of production can be affected by drought;
- Hazard is present where drought is likely and people and resources can be affected;

[5] D. Wilhite, M. Sviboda and M. J. Hayes 2006. Understanding the Complex Impacts of Drought: A Key to Enhance Drought Mitigation and Preparedness. Water Resources Management. 21(5) 663-774

- Exposure is the probability of drought occurring and the number of people and resources affected;
- Vulnerability is the potential impact and/or ability to cope with the impacts of drought. This function provides a means of assessing risk within a given context. However, these variables can be calculated in many ways depending on the context and situation and the function is not definitive scientific or mathematical construct as such.

For drought, a very good data base interpreted through verified models is needed to provide a sound assessment of risk, develop prediction indices based on high confidence levels for different locations. The variables of hazard and vulnerability are dynamic and will continue to change with changing population and development pressures as well as influences such as climate change.

2.7. Drought Preparedness Planning (DPP)

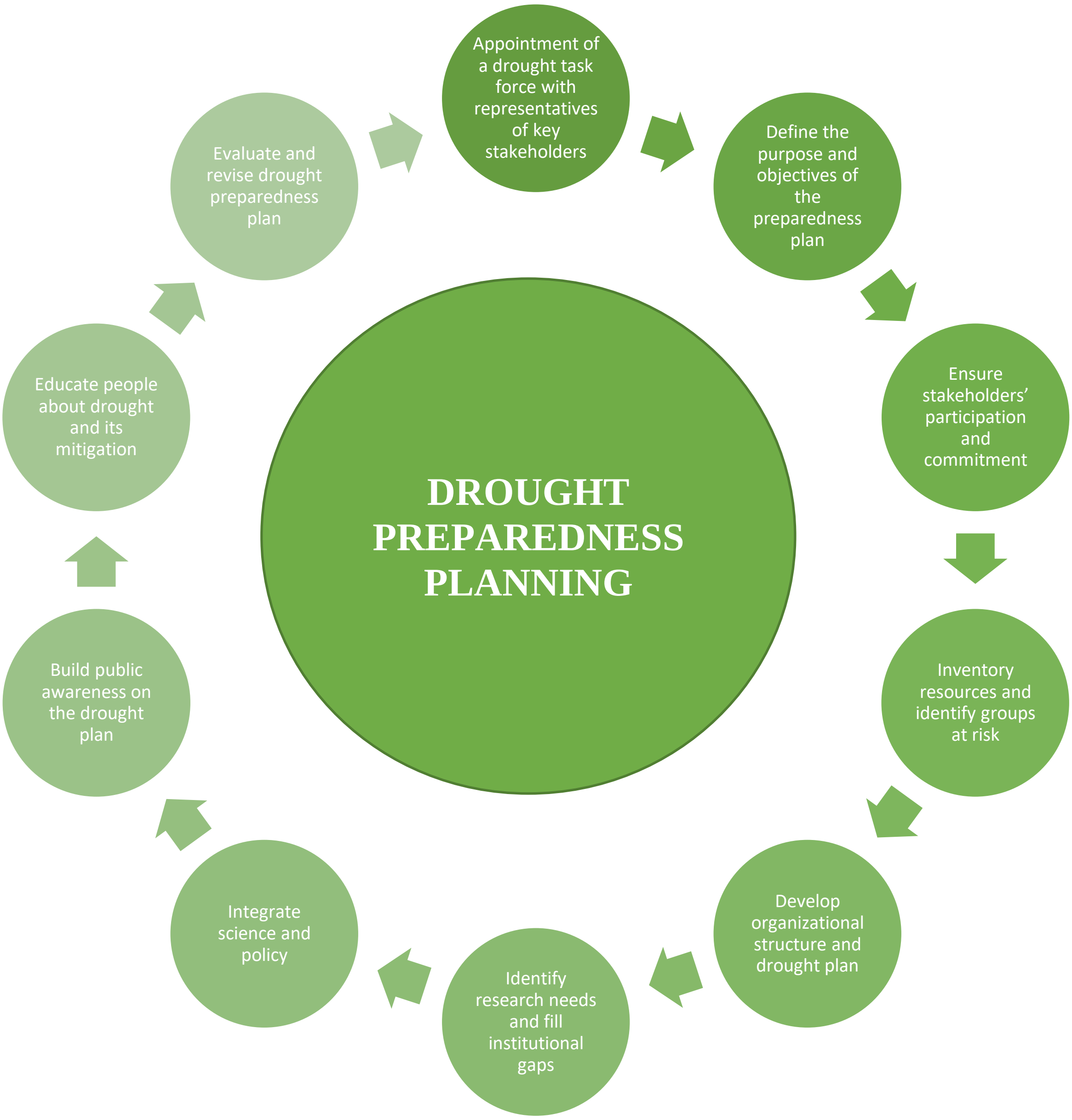
A key point of dealing with droughts ad related risks is drought preparedness planning (DPP). The purpose of the drought preparedness planning is to derive a drought management plan (DMP) that is dynamic, reflecting the changing government policies, technologies, and natural resource management practices.

Reviewing the world experience, the following steps seem relevant to Sindh province for its DPP (Figure 2.2):

- Appointment of a drought task force with representatives of key stakeholders
- Define the purpose and objectives of the preparedness plan
- Ensure stakeholders' participation and commitment
- Inventory resources and identify groups at risk
- Develop organizational structure and drought management plan
- Identify research needs and fill institutional gaps
- Integrate science and policy
- Build public awareness on the drought management plan
- Educate people on drought and its mitigation
- Evaluate and revise drought preparedness plan incorporating the lessons learnt

The above steps serve as a guideline / checklist to be addressed in DPP with appropriate modifications keeping in view the ground realities.

Figure 2.2. Steps For Drought Preparedness



2.8. Drought Management Plan (DMP) of Sindh Province

This Drought Management Plan (DMP) is an updated and improved version prepared taking into consideration the drought management plan of the Federal Government for Sindh[6]. Its main purpose is to outline the Government of Sindh's planning taking a proactive approach involving all stakeholders who have drought-related roles and responsibilities in Sindh Province. However, it may be highlighted that no single plan or response can address every situation.

This DMP is based on an integrated and well-coordinated approach ensuring participation and contribution of the key stakeholders to deal collectively with droughts from a risk

[6] Ministry of Climate Change 2022. Draft National Drought Management Plan (Annex V)

management perspective and therefore minimizing the impacts of drought on the population and resources particularly on ecosystem. It is to provide a comprehensive framework to cope with the drought through the design and application of pro-active drought mitigation measures collectively. This includes the long term and short-term measures that are to be used to prevent and mitigate the effects of drought.

The following are key guiding principles followed for the DMP.

- Based on a proactive drought policy to be used as an administrative tool for the enforcement of preventive and mitigation measures in order to achieve a reduction of drought impacts on society, environment, economy and eco-systems;
- Linkages with national / local development plans / programmes / strategies; and
- Use experiences and scientific knowledge on drought management of others.

Three main elements are crucial for effective drought management. These are:

- Drought indicators and thresholds for the classification of drought stages (i.e., normal, pre-alert, alert and emergency) coupled with a drought early warning system;
- Mitigation measures to achieve specific objectives in each of the drought stages; and
- An appropriate and effective organizational framework to deal with drought.

A key factor for establishing effective and integrated drought management is ensuring the involvement of the key decision-makers, professionals, stakeholders from all the impacted sectors, and the public i/ civil society n the process of developing and implementing a Drought Management Plan.

The proposed drought management plan has been elaborated its specific components which are:

- Institutional or Organizational;
- Operational; and
- Technical.

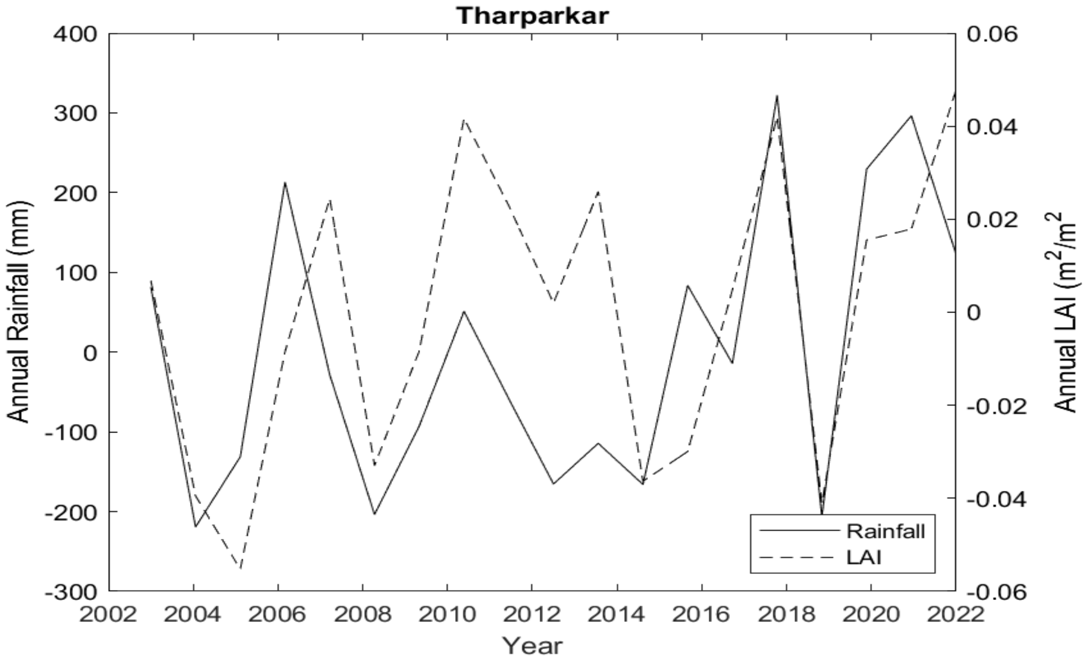
Before describing these components, a comprehensive evaluation of hydrological cycle especially the average rainfall, its probabilities, impact on soil moisture and runoff as well as terrestrial water storage anomalies are discussed.

2.9. Drought Impact on Eco-System

Annual rainfall and Leaf Area Index (LAI) anomalies are computed by subtracting their 2003-2021 average values to understand the response of vegetation (or ecosystem) to rainfall (Annex I).

Annual rainfall and LAI anomalies for all districts of Sindh province generally showed a strong correspondence. Both rainfall and LAI trends seems to be increasing (see Figure 2.3; for Tharparkar district, other districts showed similar response).

Figure 2.3: Annual LAI for Tharparkar District



At annual scale, vegetation amount (i.e., LAI) follows rainfall, years with high rainfall amounts have high vegetation amount within the district and vice versa. This indicates that rainfall may significantly impact vegetation growth in the province and to sustain healthy vegetation during dry years water will be required from other sources.

It also indicates agricultural productivity may have declined during and in the following years having below average annual rainfall. This may put the food security of the province and overall sustainability of the agroecosystems, farming community and all related entities on high risk.

Given vegetation data was only available after year 2003, impact of low rainfall that persisted for few years on the ecosystem was not studied.

However, very low agricultural and vegetation productivity during those persistently dry years or may be few following years can be imagined. Therefore, long-term storage of water during high rainfall years is required to support vegetation during persistent dry years.

2.10. Assessment of Long-Term Socio-Economic Impacts of Drought

There have been worst drought years in the Sindh Province during the years of 1871, 1881, 1899, 1931, 1942, 1951-2, 1958, 1966, 1969, 1972- 4, 1987-8, 1999-2001, 2003-4 and 2006.

Even in the District Tharparkar, which has the highest average rainfall of 258 mm (Table 3.1) suffered 16 droughts from 1968 to 2015.

District Tharparkar suffered a severe long duration drought during 1999 – 2002 that had resulted in serious consequences for ecosystem as well as human living therein. Some of the consequence reported are given below[7].

- Approximately 1.4 million persons, 5.6 million cattle and 5.06 million hectares cropped areas were affected;
- Dropout in school children was about 27%,
- Groundwater depletion in Tharparkar was up to 40 feet, springs dried up and water quality became more-poor.
- Rainfed crops were completely failed.
- Reduced supply of daily use food items resulted in increased price.
- The villagers had to sell either their livestock or get high interest loans. The decrease in market value of livestock including goat and cow in August 2002 were 50% and 53%, respectively from the average prices during good years.
- Goat and cow sale were increased by 100% and 166%, respectively.
- Sheep sale was doubled.
- Availability of drinking water and water for livestock, pasture, rangelands and fodder was reduced because of drought.
- During droughts by year 2002, about 88% cattle and 22% sheep and goat were taken to productive areas.
- Some people migrated to other parts of the country as labor.
- Due to mass migration in productive areas, labor rate decreased.
- Wheat shortage resulted in increased flour prices in Tharparkar District by about 20% in August 1999.
- During 2002, about 57% families migrated from Tharparkar to productive areas. Migration of the male family members resulted in shifting the responsibility of purchase of food and other daily use items to women and children. As more cash is required, the children also go for earning the livelihoods.
- During droughts, increased incidences of sexual exploitation were also noted.
- Drop out of primary school students was increased by 30% in 1999 due to large scale migration from drought areas.
- Malnutrition increased by about eighty percent of expected weight of Protein Calorie.
- Malnutrition resulted in night blindness and decreased weight, especially in pregnant women, lactating mothers and the children.
- Drought 2014, caused about 180 deaths of human beings. Reduced economic activities cause reduced demand for handicrafts.
- During 2014 drought in Tharparkar, the population of rare peacock was reduced causing threat of extinction.

[7] National Drought Management Plan 2021, GoP.

Considering all these above consequences of droughts both for human especially women & children, and eco-system, it is recommended that there is strong need to increase water availability which is only possible through rainwater harvesting under the prevailing conditions in most of the non-commanded arid areas of Sindh Province.

CHAPTER - 3

EVALUATION OF HYDROLOGICAL CYCLE OF SINDH PROVINCE

CHAPTER-3
EVALUATION OF HYDROLOGICAL CYCLE OF SINDH PROVINCE

3.1. Rationale

The droughts are rising globally resulting in significant human sufferings including loss of lives, infrastructure damages, environmental degradation, socioeconomic / livelihood disturbances etc. These may be anthropogenic or naturally influenced climate change related events. A developing country such as Pakistan is particularly vulnerable due to general lack of awareness, capacity and effective policy paradigms to deal with droughts efficiently and effectively.

Sindh Province is particularly amongst the ‘extreme risk’ prone area of Pakistan due to its climate change vulnerability index and the associated challenges which are major concern that transcend physical, human and national security dimensions. One of the most prudent approaches for climate change impact mitigation is to avert disasters through the judicious, focused and comprehensive scientific and technological response including climate change monitoring, proactive approach in preparing, mitigation and adaptation as well as disaster risk reduction measures.

Generally, trends and findings derived from historical climatic data for corresponding predictive analyses are used to determine the climate change impacts and forecast occurrence frequency of hydro-meteorological disasters like droughts and severe water shortages etc. This is undertaken using the state-of-the-art scientific and technologically advanced tools. These help in planning and implementing appropriate mitigation strategies to cope timely and efficiently with droughts and their consequences.

Keeping above in view, analysis of hydrological cycle of Sindh Province is undertaken using scientific and technological approach for effective climate change forecasting especially droughts and preparing a management plan accordingly for its mitigation.

In this regards, NASA’s GLDAS global datasets of hydroclimatic forcing and hydrological fluxes and states were selected and used in this evaluation. These datasets have been extensively used in the hydroclimatic studies all over the world.

GLDAS precipitation data has shown to capture spatial variations and time series anomalies (Yang et al., 2017[8]). GLDAS surface temperature has been found to have high accuracy when compared with 13,511 weather stations across the globe, except for the mountainous regions (Ji et al., 2015[9]).

[8] Yang, F., Lu, H., Yang, K., He, J., Wang, W., Wright, J. S., ... & Li, Y. (2017). Evaluation of multiple forcing data sets for precipitation and shortwave radiation over major land areas of China. *Hydrology and Earth System Sciences*, *21*(11), 5805-5821.

[9] Ji, L., Senay, G. B., & Verdin, J. P. (2015). Evaluation of the Global Land Data Assimilation System (GLDAS) air temperature data products. *Journal of Hydrometeorology*, *16*(6), 2463-2480. https://doi.org/10.1175/JHM-D-14-0230.1

Number of studies which assessed the accuracy of GLDAS simulated soil moisture in different parts of the world, concluded that GLDAS simulated soil moisture showed high correlations with in-situ remotely sensed products (e.g. Spennemann et al., 2015[10]; Wu et al., 2021[11]). GLDAS datasets have also been used in drought monitoring and propagation applications (e.g., Chen et al., 2020[12]; Zhang et al., 2021[13]). In conjunction with GRACE TWSA, GLDAS simulated soil moisture datasets have been extensively used to estimate regional groundwater depletion in arid to semi-arid regions including Central Valley in California (e.g., Famiglietti et al., 2011[14]) and Indus Basin Aquifer (Rodell et al., 2009[15]).

3.2. Data Collection and Analysis

Evaluation of hydrological cycle of 24 districts of Sindh Province is carried out using freely available global hydroclimatic datasets. The datasets used are assimilated products of global hydrology models coupled with recent satellite products. A brief description of the datasets used in evaluation of hydrological cycles and their impact is given below.

3.2.1. Rainfall and Temperature

Rainfall and temperature are the two most important parameters impacting on the climate and hydrological cycle of an area. Rainfall and temperature data were derived from the forcing dataset of National Aeronautics and Space Administration's (NASA) Global Land Data Assimilation System (GLDAS)-NOAH versions 2.0 & 2.1 land surface model. This model provides precipitation data at a spatial resolution of 0.25^o (approximately 25 km) and a temporal resolution of 1 month and air temperature at 2 meters height above the ground surface.

These long-term forcings are primarily derived from National Centers for Environmental Prediction–National Center for Atmospheric Research (NCEP–NCAR) reanalysis product. This reanalysis product is obtained by assimilating past weather forecasts with observations. The process of assimilation also ensures filling the gaps in the observations of these forcing datasets. The NCEP-NCAR reanalysis dataset is of long-duration as compared to the other similar products, therefore, it is more suitable for analyzing changes in climate including

[10] Spennemann, P. C., Rivera, J. A., Saulo, A. C., & Penalba, O. C. (2015). A comparison of GLDAS soil moisture anomalies against standardized precipitation index and multisatellite estimations over South America. *Journal of Hydrometeorology*, *16*(1), 158-171. https://doi.org/10.1175/JHM-D-13-0190.1
[11] Wu, Z., Feng, H., He, H., Zhou, J., & Zhang, Y. (2021). Evaluation of soil moisture climatology and anomaly components derived from ERA5-land and GLDAS-2.1 in China. *Water Resources Management*, *35*(2), 629-643.
[12] Chen, N., Li, R., Zhang, X., Yang, C., Wang, X., Zeng, L., ... & Niyogi, D. (2020). Drought propagation in Northern China Plain: A comparative analysis of GLDAS and MERRA-2 datasets. *Journal of Hydrology*, *588*, 125026. https://doi.org/10.1016/j.jhydrol.2020.125026
[13] Zhang, G., Su, X., Ayantobo, O. O., & Feng, K. (2021). Drought monitoring and evaluation using ESA CCI and GLDAS-Noah soil moisture datasets across China. *Theoretical and Applied Climatology*, *144*(3), 1407-1418.
[14] Famiglietti, J. S., Lo, M., Ho, S. L., Bethune, J., Anderson, K. J., Syed, T. H., ... & Rodell, M. (2011). Satellites measure recent rates of groundwater depletion in California's Central Valley. *Geophysical Research Letters*, *38*(3). https://doi.org/10.1029/2010GL046442
[15] Rodell, M., Velicogna, I., & Famiglietti, J. S. (2009). Satellite-based estimates of groundwater depletion in India. *Nature*, *460*(7258), 999-1002.

identification of trends, increasing / decreasing frequency of extreme climatic (wet, dry, hot, and cold) events and predictions of related natural disasters such as droughts.

Rainfall and temperature forcing datasets were downloaded from NASA GES DISC (https://disc.gsfc.nasa.gov/) for 74 years i.e. 888 months (January 1948-December 2021) for 24 districts of Sindh province.

For this 0.25^o monthly rainfall and temperature grids overlaying each district were extracted and averaged over the district to determine mean monthly precipitation and temperature of each district. These monthly values were accumulated over a year to determine annual rainfall for each district and mean monthly temperature values were averaged over a year to determine mean annual temperature for each district (see Figure 3.1 a & b showing mean annual rainfall in millimeters and mean annual temperature in ^{o}C).

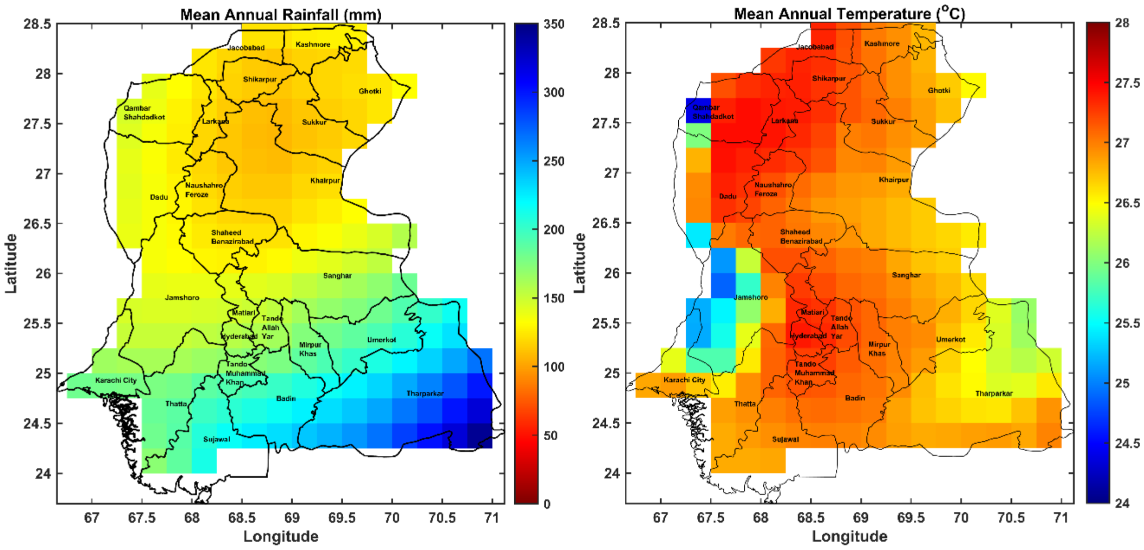


Figure 3.1 : Mean Annual a) Rainfall and b) Temperature

The rainfall and temperature data from 1948 to 2021 downloaded for each of the 24 districts of Sindh Province along with its corresponding analysis and the results obtained are attached as Annex A.

3.2.2. Soil Moisture and Runoff

Soil moisture plays a major role in vegetation patterns and type of vegetation cover, and is consequently of primary importance to the ecosystems in water limited areas such as the arid and semi-arid zones of Sindh Province. The soil moisture being part of biogeochemical and ecohydrological process of hydrological cycle is a major parameter that influences the partitioning of rainfall into infiltration and runoff, and controls evapotranspiration. In a way, soil moisture is a link between the surface energy, water and biogeochemical cycles. Soil moisture and runoff datasets for 24 districts of Sindh Province were obtained from the output of GLDAS-NOAH versions 2.1 & 2.2. The GLDAS-NOAH simulates the water and energy budget at and below land surface up to a depth of 2 meters at daily scale and a spatial resolution of 0.25º. The soil moisture and runoff products are also processed at a monthly scale for assessing long-term climatic variability and extreme events. Data were downloaded and used on the monthly soil moisture and runoff products from 1984 to 2021 (74 years).

The GLDAS-NOAH uses physically based Richards equation to model soil moisture. The soil moisture is simulated within four layers of varying thicknesses (i.e., top to bottom: layer 1; 0-10 cm, layer 2; 10-40 cm, layer 3; 40-100 cm, and layer 4; 100-200 cm), where first three layers on average represents the root zone. To arrive at the total soil moisture content in each grid cell, the soil moisture content (available as water depth in mm) of each layer were added. The GLDAS-NOAH simulates surface runoff and sub-surface runoff also. The surface runoff is simulated using two-reservoir hydrology model, whereas subsurface runoff is simulated as a gravitational drainage from the fourth soil layer. For each 0.25º grid cell analysis, surface and sub-surface runoffs were added to arrive at total runoff in each grid cell. The total runoff and soil moisture grids for 24 districts of Sindh Province were extracted and averaged to determine average runoff and soil moisture for each month for each district. The monthly runoff for each district was converted to annual runoff by accumulating runoff values over the year and annual soil moisture values were determined by averaging soil moisture values over the year. Figure 3.2 a & b show mean annual soil moisture and runoff across Sindh Province, respectively.

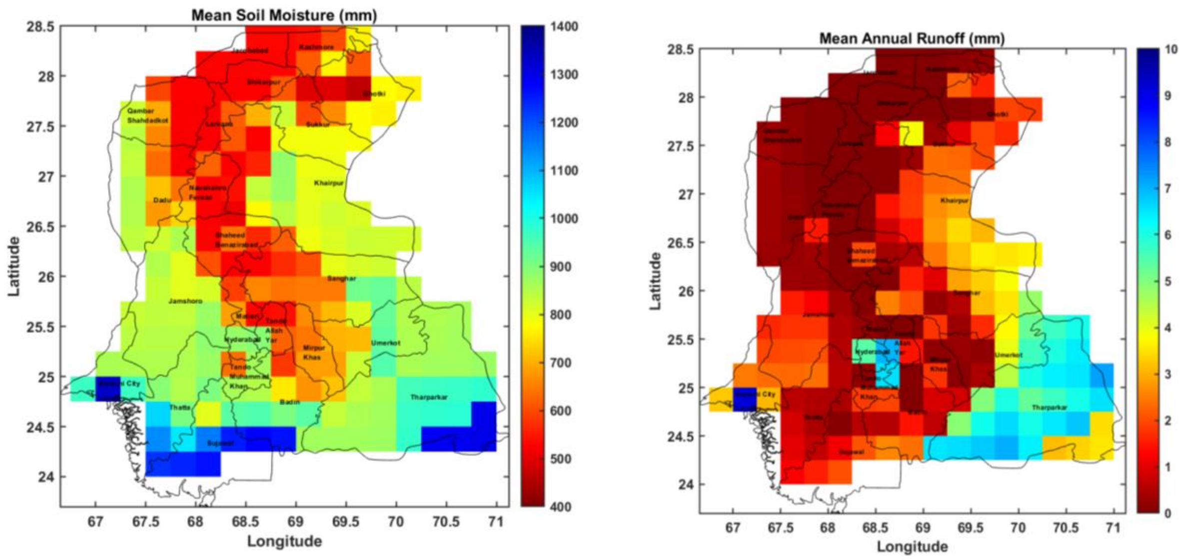


Figure 3.2: Mean Annual a) Soil Moisture up to 2 Meters Depth and b) Runoff

The soil moisture and runoff data are presented for wet and dry years in Annexes B and C, respectively.

3.2.3. Terrestrial Water Storage Anomalies (TWSA)

Land or terrestrial water storage (TWS) is a fundamental component of the hydrological cycle, and its variations can play an essential role in the climate system. Changes in TWS directly influence food and water security and can also lead to increased risk of floods and droughts

(Reager et al. 2014[16]; Thomas et al. 2014[17]). TWS variability indicates changes in soil moisture storage, groundwater, and surface water.

Terrestrial water storage is the sum of all of the water above, at or below the land surface (i.e., canopy water, soil moisture, groundwater, snow water equivalent, and surface water stored in reservoirs, rivers and lakes). However, in case of Sindh Province, soil moisture and groundwater will be the dominant components of terrestrial water storage.

Gravity Recovery and Climate Experiments (GRACE) satellite mission is observing anomalies of terrestrial water storage (i.e., changes of water storage from its long-term mean, in this case mean from 2004-2009) since April 2002.

TWSA monthly observations from GRACE are available as 0.25° grids in equivalent water thickness (in mm) for land areas. The GRACE grids for each district of the Sindh Province were extracted and averaged to obtain monthly TWSA for each district. Due to the maintenance, and withdrawal of original GRACE satellite and subsequent launching of new GRACE satellite, TWSA data for few months from GRACE is not available. Figure 3.3 below shows an example of TWSA across Sindh Province for the month of January 2004.

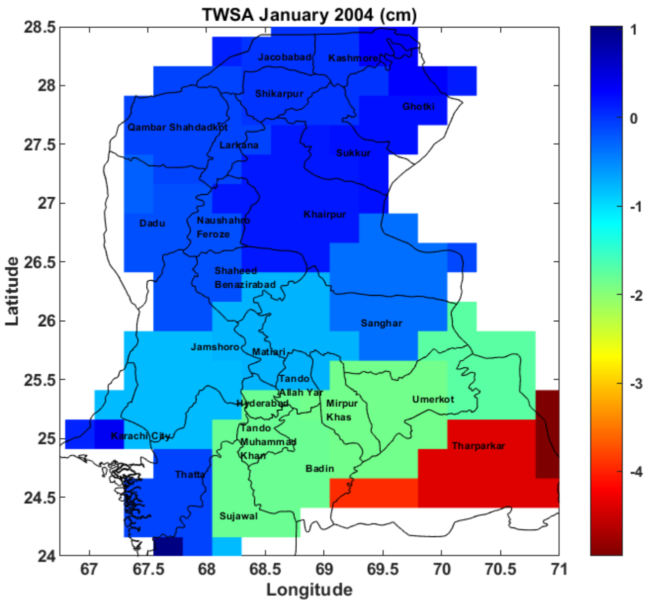


Figure 3.3 : TWSA across Sindh Province for January 2004

The downloaded data are presented in the Annex D.

[16] Reager, J. T., B. F. Thomas, and J. S. Famiglietti, 2014: River basin flood potential inferred using GRACE gravity observations at several months lead time. *Nat. Geosci.*, **7**, 588–592, https://doi.org/10.1038/ngeo2203.

[17] Thomas, A. C., J. T. Reager, J. S. Famiglietti, and M. Rodell, 2014: A GRACE-based water storage deficit approach for hydrological drought characterization. *Geophys. Res. Lett.*, **41**, 1537–1545, https://doi.org/10.1002/2014GL059323.

3.2.4. Leaf Area Index (LAI)

Leaf Area Index (LAI) is a biophysical parameter that indicates the amount of green vegetation. It is defined as the area of green leaf per unit area of the ground and is provided in the units of m^2/m^2.

The MODIS satellite provides LAI at 4-day intervals at a spatial resolution of 500 meters. LAI is estimated from MODIS surface reflectance and land cover data, and ground-based vegetation datasets. MODIS' LAI is available from July 2002.

MODIS' LAI data was downloaded and processed as other data sets for each district from July 2002 to December 2021. Figure 3.4 below shows LAI across Sindh in early July 2002.

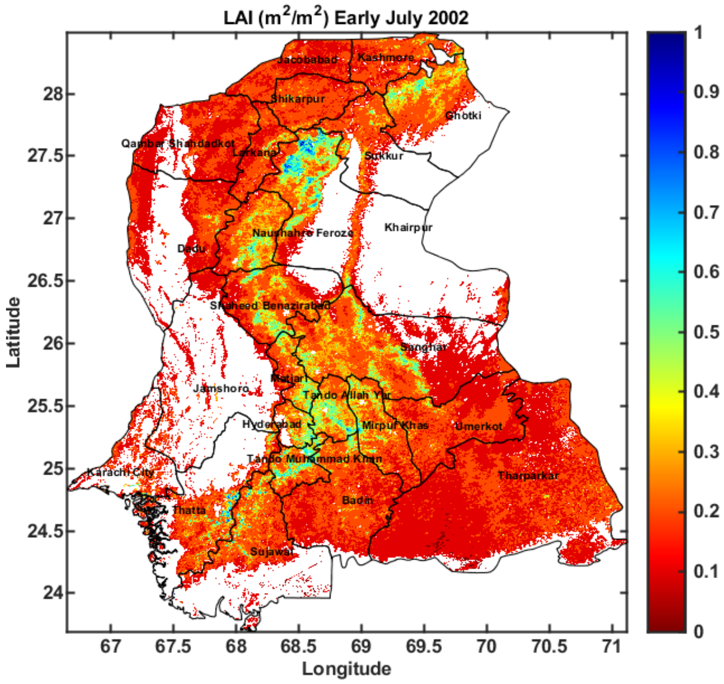


Figure 3.4 : Leaf Area Index Across Sindh in Early July 2002

White areas within districts indicate no LAI data for the 4-day interval over which image is produced.

The downloaded data is presented in the Annex E.

3.3. Annual Rainfall

The annual rainfall of an area is the single most important parameter that impacts droughts. Therefore, analysis of rainfall data of Sindh Province of 74 years (1948-2021) is undertaken (Annex A) and the results are presented in Figures 3.5 and 3.6 , and Table 3.1.

The results reveal that:

- District Sukkur received the lowest average annual rainfall of 113 mm and
- District Tharparkar received the highest average annual rainfall of 258 mm.

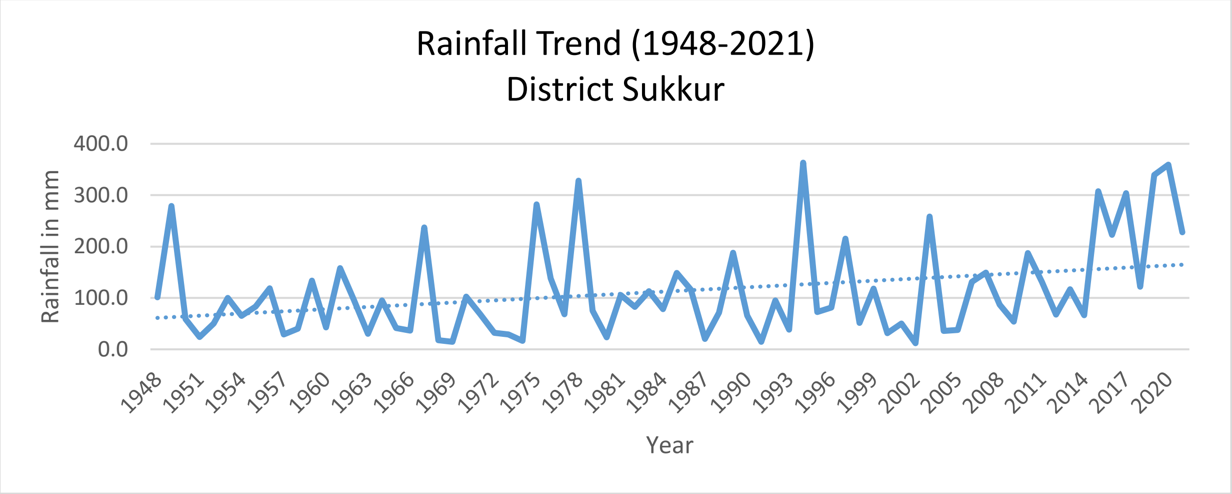


Figure 3.5 : Rainfall Trend (1948-2021) District Sukkur

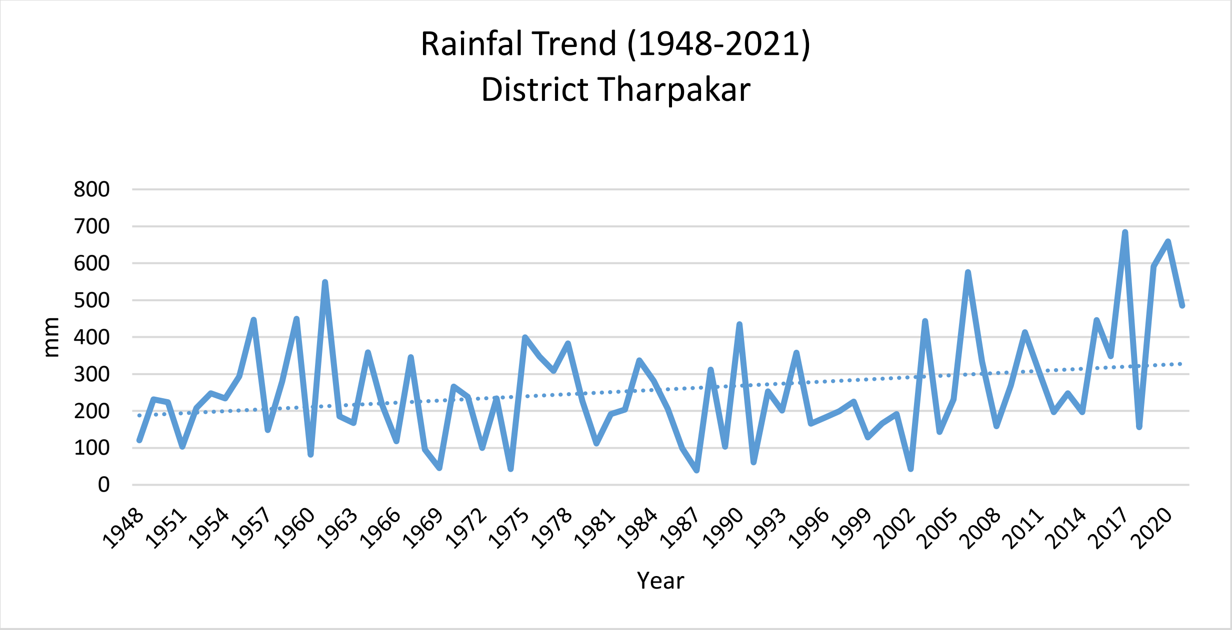


Figure 3.6 : Rainfall Trend (1948-2021) in District Tharparkar

As shown above in the Figures 3.5 and 3.6 of trend lines, it seems that rainfall has a slightly increasing trend during these years. It may be result of exceptional rainfall events in the recent years but it will be further verified during the coming years. It may be noted from the Table 3.1., that even the highest average annual rainfall of 258 mm in Tharparkar District is largely inadequate for any meaningful and secure rainfed agricultural production in non-canal commanded areas / non-irrigated areas of Sindh Province.

3.4. Rainfall Probabilities and Dry / Wet Years

Dry and wet years threshold were established using the basic information available regarding number of drought years in Tharparkar district. Tharparkar district experienced 16 drought years from 1968 to 2015 (National Drought Management Plan for Pakistan 2021). The detail on the statistical methodology employed is given in Annex F. Probabilities of wet and dry years determined for 24 districts of Sindh Province given in Annexes G and H, respectively.

The rainfall probabilities were also determined considering 75 mm rainfall as severe drought year and 300 mm rainfall as relatively wet year for 24 districts of Sindh Province. The results are shown in Table 3.2 below. As may be noted from the table, there is a strong probability of getting at least one year with severe drought and one relatively wet year in every 5 years. Probabilistic forecast of relatively wet and dry years was carried out for each district using probability distribution of their annual precipitation amounts for 74 years.

For this purpose, extreme years were defined based on the annual time series of each region (i.e., annual time series of precipitation amounts for each region were investigated to choose thresholds for defining relatively extreme wet, and dry years for each region). Once thresholds (Annex F) were identified, the risk (or probability) of occurrence "R" of an extreme year at least once in next "n" years was estimated using equation 1.

$$R = 1 - (1 - P)^n \tag{1}$$

Where, P is the probability of exceedance of threshold high annual precipitation amounts for extreme wet years. In case of extreme dry, P depicts the probability of non-exceedance of threshold low annual precipitation amounts for extreme dry years.

The probability of exceedance or non-exceedance P for threshold values was estimated by fitting a best fit probability distribution curve through a functionality available within MATLAB to the annual time series of precipitation amounts and average temperature of each district. Figure 3.7 below shows an example of distribution of annual precipitation amounts and best fit kernel distribution.

In this case, the probability of non-exceedance was determined by taking the value of cumulative distribution function (CDF) against the threshold dry annual precipitation amount and probability of exceedance was determined by subtracting value of cumulative distribution function (CDF) against the threshold wet annual precipitation amount from one (01).

Risk *R* for *n* years against the specific dry threshold indicates the probability of occurrence of at least one dry event in n years having rainfall equal to or less than the selected threshold. For example, as shown above in Table 3.2, Badin has the risk *R* of at least one occurrence of annual rainfall having amount less than or equal to 75 mm in 5 years is 66% and greater than or equal to 300 mm is 76%.

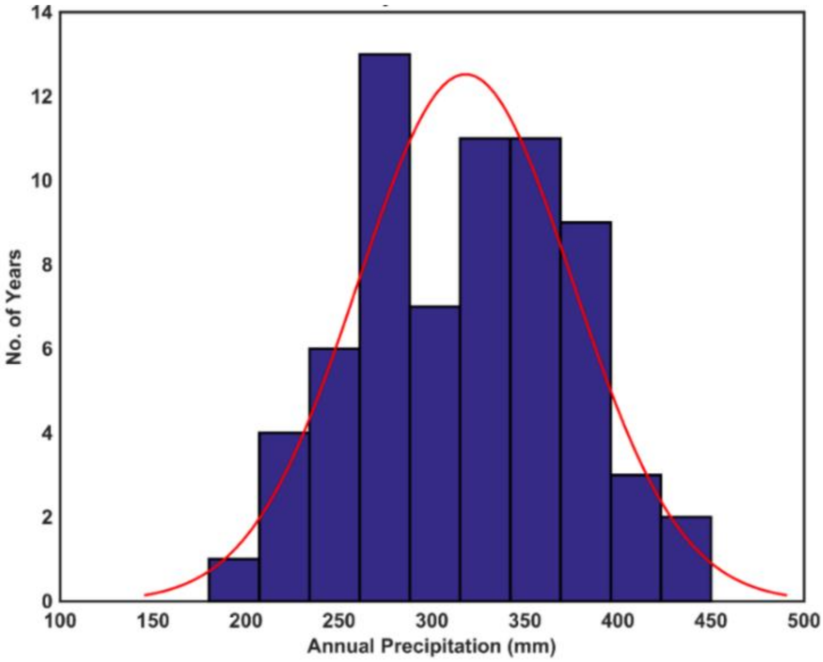


Figure 3.7 : Probability Distribution of Annual Rainfall

Probabilities charts for wet years both for Districts Sukkur (lowest average rainfall) and Tharparkar (highest average rainfall) are given below in Figures 3.8 and 3.9, respectively.

District Tharparkar has relatively high probability of receiving relatively high rainfall as compared to District Sukkur and therefore may be accorded higher priority for rainfall harvesting and runoff collection. Annexes G and H provides these probabilities for all the 24 Districts of Sindh Province.

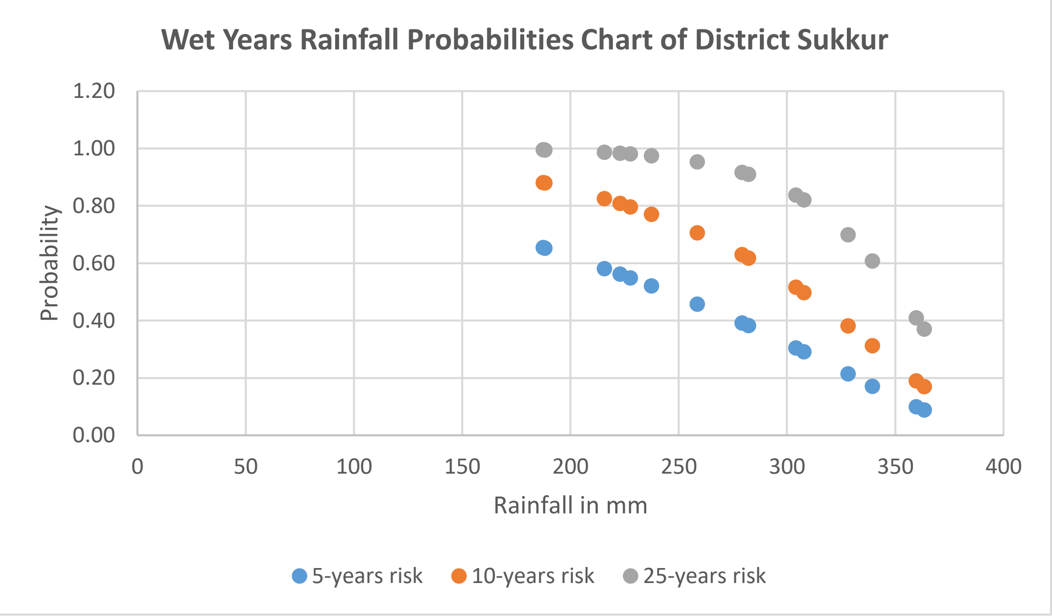


Figure 3.8: Wet Years Rainfall Probabilities Chart of District Sukkur

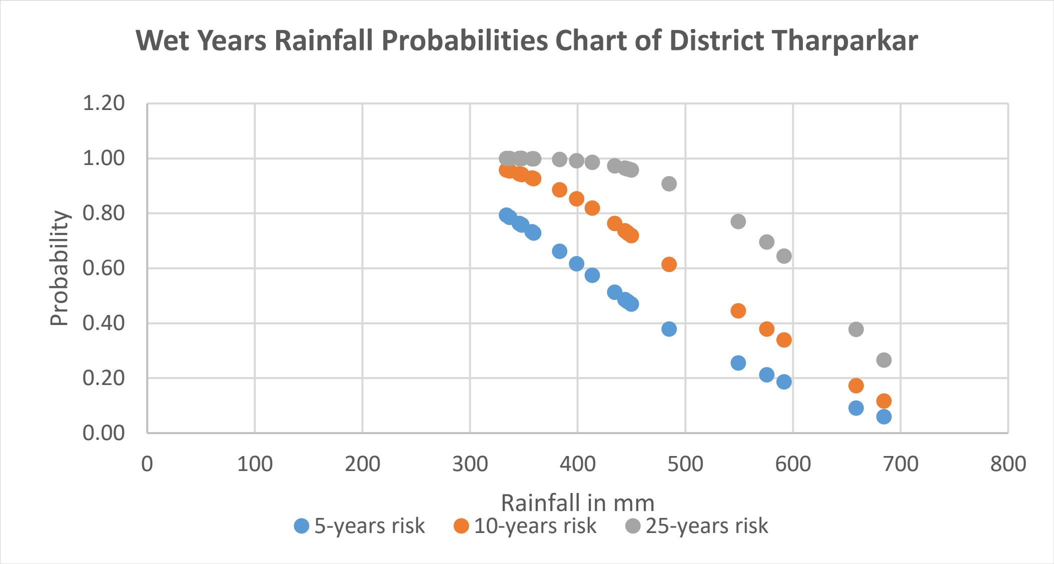


Figure 3.9: Wet Years Rainfall Probabilities Chart of District Tharparkar

3.5. Temperature

Agriculture and fisheries are highly dependent on the climate. Increases in temperature and carbon dioxide (CO_2) can increase some crop yields in some places. But to realize these benefits, nutrient levels, soil moisture, water availability, and other conditions must also be met. Changes in the frequency and severity of droughts and floods could pose challenges for farmers and ranchers and threaten food safety. Agriculture being an important sector of Sindh Province's economy, the crops, livestock, and seafood produced in the province contribute significantly to the wellbeing of population and economy.

The analysis of average annual temperature of 74 years (1948-2021) is undertaken and the results are presented below in Figures 3.10 and 3.11, and Table 3.3. Data is presented in Annex A. These reveal that mean annual temperatures are also on rise slightly as in the case of rainfall. The mean annual temperature of District Tharparkar has been slightly less than that of District Sukkur for the recent years because of higher rainfall in District Tharparkar in the recent years.

The mean annual temperatures shown above for 24 Districts of Sindh for 74 years (1948-2021) with their rising trend coupled with the scarce and unreliable rainfall is a clear evidence that agriculture production in the arid areas depends heavily on the provision of supplementary irrigation facilities through developing surface and ground water resources wherever appropriate and feasible.

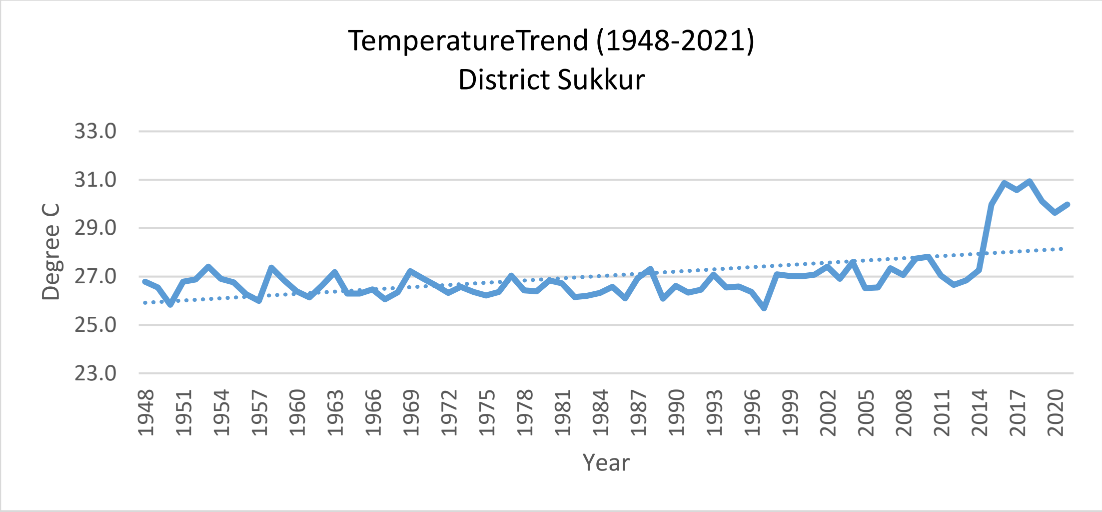


Figure 3.10: Temperature Trend (1948-2021) District Sukkur

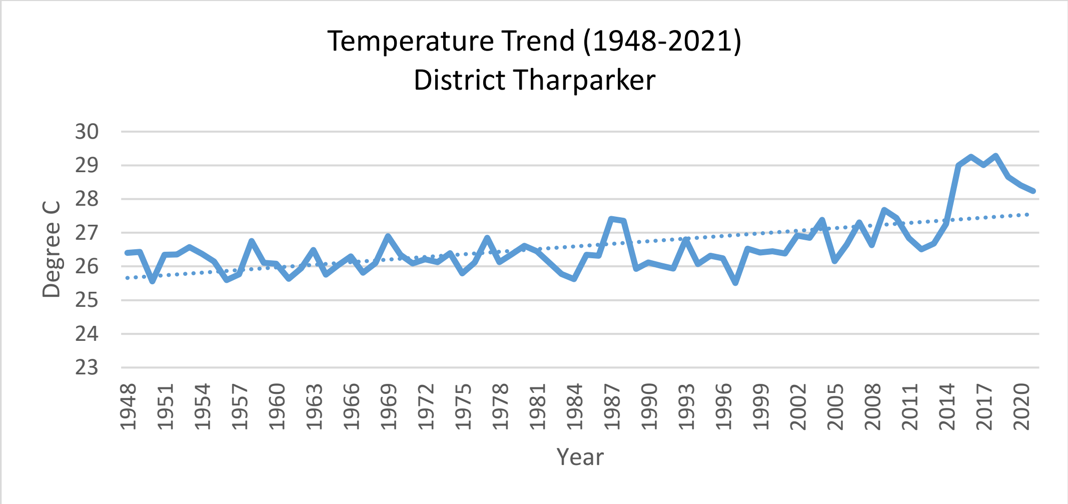


Figure 3.11: Temperature Trend (1948-2021) District Tharparkar

Considering the above constraints, small dams and reservoirs, ponds and depressions, whenever and wherever feasible, to store whatever water is available from rainfall and runoff coupled with the use of latest state-of-the-art smart agricultural practices and technologies will contribute significantly in developing and promoting meaningful agricultural production in arid areas of Sindh Province.

3.6. Soil Moisture

Soil moisture data was analyzed for 7 months (from April to October for each year) for relatively 23 dry and 21 relatively wet years of Tharparkar District out of a total of 74 years (1948-2021) data for mean surface (0-10 cm depth), root zone (0-100 cm depth) and total soil moisture (0-200 cm depth). The results are discussed below whereas the data is given in Annex D.

3.6.1. Surface Soil Moisture

Surface soil moisture during all of the wet years was higher than the dry years soil moisture (Figure 3.12). Mean of the wet years surface soil moisture is 16 mm which is almost 1.5 times the mean surface soil moisture of dry years which is 11.4 mm.

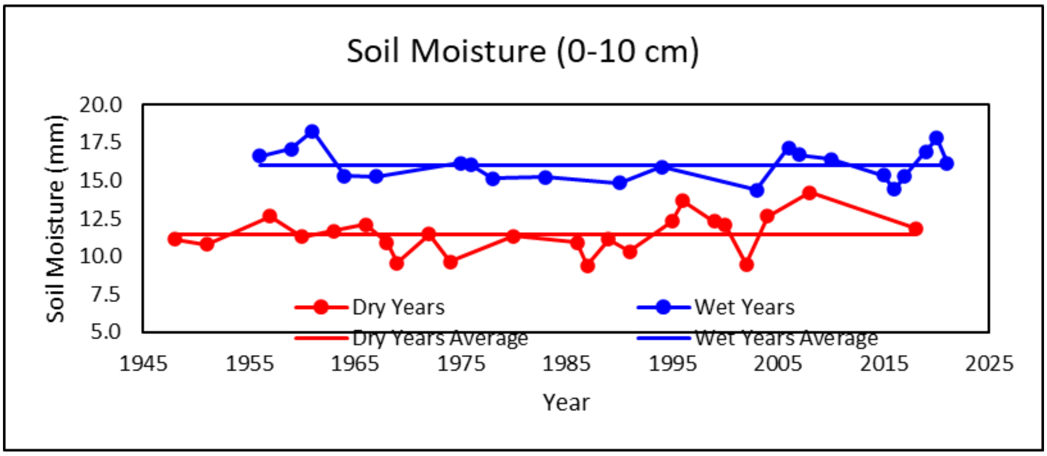


Figure 3.12: Surface Soil Moisture During Dry and Wet Years in Tharparkar District

3.6.2. Root Zone Soil Moisture

Root zone soil moisture during all of the wet years are higher than the dry years soil moisture (Figure 3.13). Mean of the wet years root zone soil moisture is 246 mm and the mean of root zone soil moisture of dry years which is 223 mm.

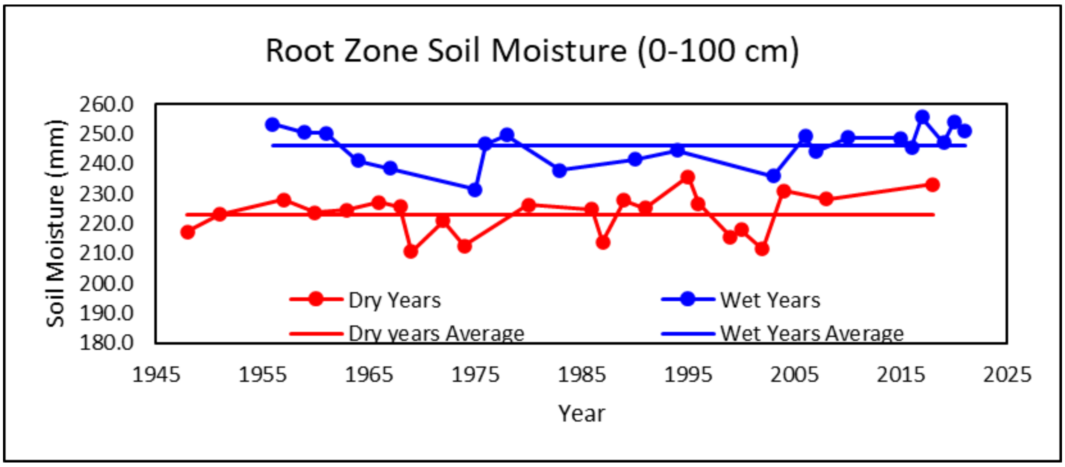


Figure 3.13: Root Zone Soil Moisture During Dry and Wet Years in Tharparkar District

3.6.3. Total Soil Moisture

Total soil moisture during majority of the wet years are higher than the dry years soil moisture (Figure 3.14). Mean of the wet years root zone soil moisture is 515 mm and the mean of root zone soil moisture of dry years which is 470 mm.

Overall, the soil moisture variations shows that dry and wet events impact soil moisture upto the depth of 200 cm. This implies that the soil moisture at various depths response to hydroclimatic variability and thus represent a very dynamic component of the hydrologic budget.

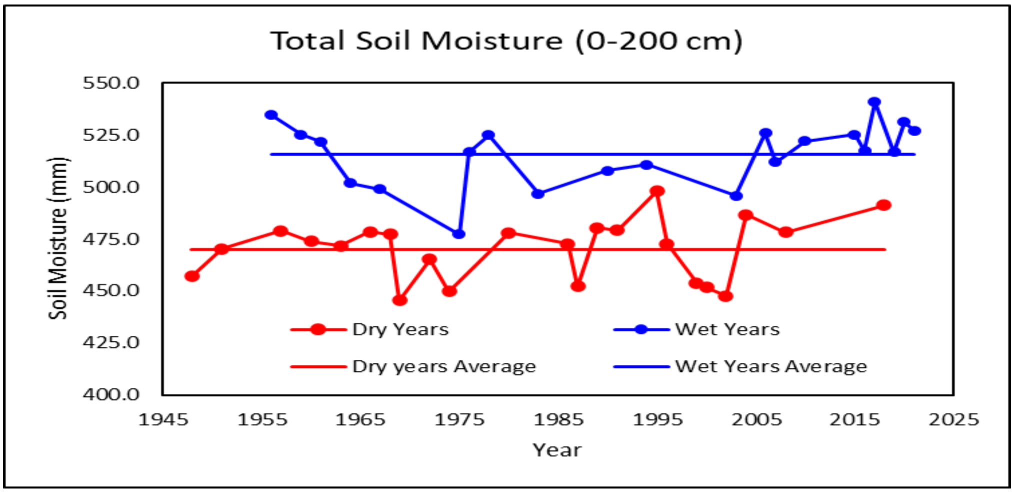


Figure 3.14: Total Soil Moisture During Dry and Wet Years in Tharparkar District

3.7. Runoff

Total runoff for dry and wet years occurred in the Tharparkar District was analyzed for 7 summer months i.e. from April – October (Annex D).

The runoff analysis shows that there is very little runoff during the dry years, however, relatively significant amount of runoff is generated during the wet years (Figure 3.15).

Mean of total runoff during wet years is 134 mm whereas the mean of total runoff during dry years is just 15 mm. Although in absolute terms wet year runoff depths may not be large, however, some of the wet years have runoff depths more than 250 mm.

Effectively capturing and storing these runoff volumes may provide a buffer storage for mild to moderately dry years. More so, these high runoff depths occurred during the last two decades, this may indicate increasing runoff depths in future as well. In this case, appreciable amount of buffer storage may be created utilizing these runoffs.

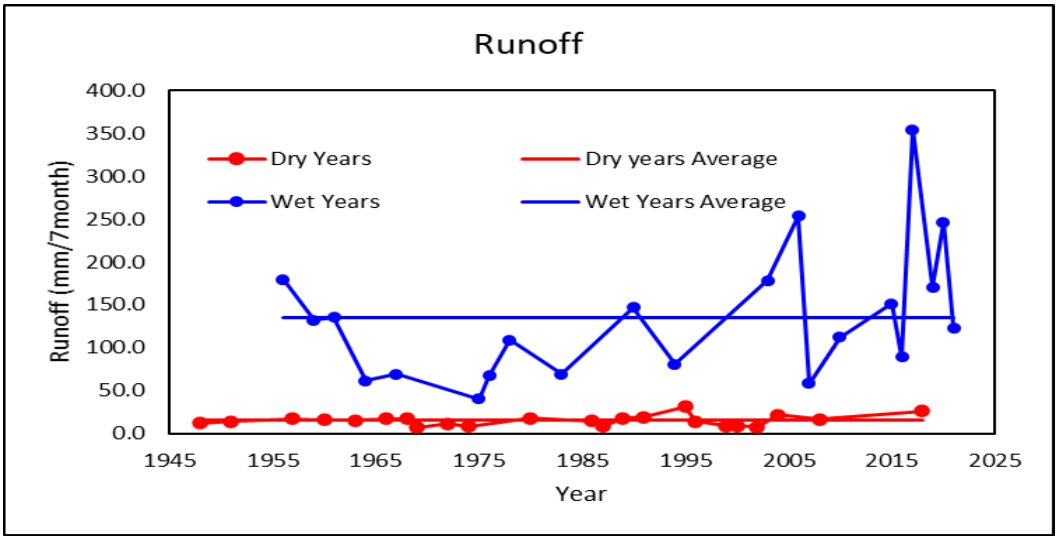


Figure 3.15: Runoff During Dry and Wet Years in Tharparkar District

3.8. Terrestrial Water Storage (TWS)

Terrestrial Water Storage (TWS) was analyzed for 7 months (April – October) for dry and wet years occurred in the Tharparkar district from 2003 – 2021 (Annex D).

Generally, TWS anomalies kept low during the dry years, however, it fluctuated during wet years between high and low values (Figure 3.16).

Groundwater, significant portion of terrestrial water storage, responds much slowly to dry and wet cycles as compared to soil moisture or other components of terrestrial water storage. Furthermore, groundwater also acts a significant supply of domestic and agricultural water in arid and semi-arid regions.

Therefore, excessive depletion of groundwater (therefore of terrestrial water) may occur during dry times, which recovers slowly.

However, terrestrial water storage may still show large increases due to increase in soil moisture and other components of terrestrial water storage which responds to wet events at a much shorter time scale than groundwater.

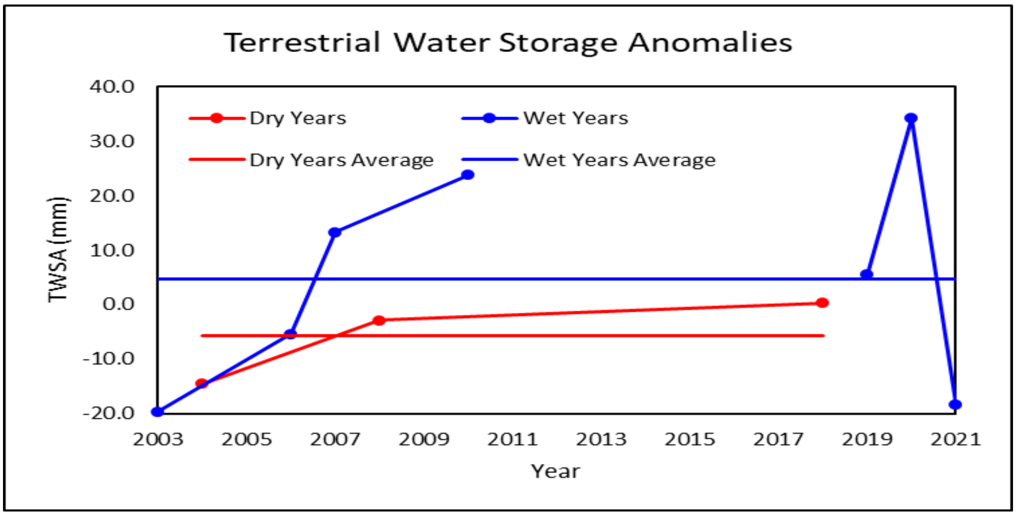


Figure 3.16: Terrestrial Water Storage During Dry and Wet Years in Tharparkar District

3.9. Drought Severity Ranking

3.9.1. Return Period Analysis

Return period of a drought year was estimated as the inverse of its probability of non-exceedance.

$$T_r = \frac{1}{P_{ne}}$$

where T_r is the return period and P_{ne} is the probability of non-exceedance. P_{ne} was estimated by fitting a best fit distribution to the annual rainfall amounts of 74 years. Best fit distribution was carried out using MATLAB, wherein kernel type distribution that follows the histogram of the annual rainfall amounts of each district was fitted. Probability of non-exceedance was then read from the kernel distribution and used to estimate the return period. Return period 50 or above corresponds to having no rainfall in a year. A complete picture of drought may be captured by including temperature data as well.

3.9.2. Ranking

Tables 3.4 to 3.6 presents present ranking of districts according to the following criteria:

i) Occurrence of drought: Districts ranked according to highest to lowest return period of droughts
ii) Severity of drought: Districts ranked according to the minimum annual rainfall
iii) Risk of occurrence: Districts ranked according to the risk of occurrence of the minimum annual rainfall in next 25 years

TABLES

Table 3.1. District-wise Summary of Rainfall 74 Years (1948-2021) in mm

District	Minimum	Maximum	Average	Standard Deviation
Badin	19	728	207	141
Dadu	23	407	137	88
Ghotki	15	356	121	91
Hyderabad	13	556	157	113
Jacobabad	20	375	120	83
Jamshoro	10	501	143	102
Karachi	9	599	166	122
Kashmore	20	386	125	86
Khairpur	11	367	122	91
Larkana	18	354	118	86
Matiari	11	557	146	108
Mirpur Khas	12	558	187	126
Nusharo F	17	394	122	87
Qambar S	22	376	134	84
Sanghar	9	459	151	104
Shaeed B	14	387	124	89
Shikarpur	16	374	115	86
Sajawal	12	753	200	139
Sukkur*	12	363	113	93
Tando AY	10	562	159	112
Tando MK	14	638	178	126
Tharparker**	39	684	258	147
Thattha	9	675	177	129
Umer Kot	15	525	192	123
NB: * Lowest Average Rainfall and ** Highest Average Rainfall				

Table 3.2: District-wise Summary of Rainfall Probabilities (1948-2021)

District	Min Mm	Max mm	Ave mm	STD	Drought Probability % (for = 75 mm)					Wet Probability % (for = 300 mm)			
					1Y	5 Y	10 Y			1Y	5 Y	10 Y	
Badin	19	728	207	141	19	66	88			25	76	94	
Dadu	23	407	137	88	30	87	98			7	29	49	
Ghotki	15	356	121	91	38	90	99			7	32	53	
Hyderabad	13	556	157	113	27	79	96			13	52	77	
Jacobabad	20	375	120	83	36	89	99			4	17	30	
Jamshoro	10	501	143	102	29	82	97			8	35	58	
Karachi	9	599	166	122	27	80	96			15	57	81	
Kashmore	20	386	125	86	35	88	99			5	24	43	
Khairpur	11	367	122	91	37	90	99			9	37	60	
Larkana	18	354	118	86	37	90	99			4	19	35	
Matiari	11	557	146	108	30	84	97			10	42	67	
Mirpur K.	12	558	187	126	22	70	91			18	63	87	
Nusharo F	17	394	122	87	36	89	99			5	24	42	
Qambar S	22	376	134	84	32	86	98			6	26	46	
Sanghar	9	459	151	104	27	79	95			11	44	69	
Shaeed B	14	387	124	89	35	89	99			7	30	50	
Shikarpur	16	374	115	86	38	91	99			4	18	33	
Sajawal	12	753	200	139	20	66	89			23	73	93	
Sukkur	12	363	113	93	38	91	99			7	30	52	
Tando AY	10	562	159	112	26	78	95			13	50	75	
Tando MK	14	638	178	126	24	75	94			19	64	87	
Tharparkar	39	684	258	147	11	43	68			27	79	96	
Thattha	9	675	177	129	26	78	95			16	58	83	
Umer Kot	15	525	192	123	17	60	84			20	67	89	
NB. Min=Minimum; Max=Maximum; Ave=Average; STD=Standard Deviation													

Table 3.3. District-wise Summary of Mean Temperatures (1948-2021) in Degree C

District	Minimum	Maximum	Average	Standard Deviation
Badin	25.91	29.71	27.06	0.80
Dadu	25.50	30.80	26.84	1.10
Ghotki	25.42	30.75	26.81	1.18
Hyderabad	26.16	30.56	27.40	0.92
Jacobabad	25.99	30.64	27.27	1.02
Jamshoro	24.89	29.49	26.16	0.99
Karachi	25.08	27.27	26.14	0.59
Kashmore	25.61	30.87	26.94	1.13
Khairpur	25.56	30.85	26.91	1.17
Larkana	26.12	31.20	27.40	1.13
Matiari	26.09	30.17	27.30	0.89
Mirpur Khas	25.86	29.92	27.03	0.90
Nusharo F	25.90	31.67	27.23	1.24
Qambar S	25.64	30.57	26.99	1.07
Sanghar	25.60	30.30	26.91	1.05
Shaeed B	25.78	31.04	27.07	1.14
Shikarpur	26.08	30.75	27.32	1.03
Sajawal	25.86	28.93	26.94	0.65
Sukkur	25.69	30.94	27.03	1.16
Tando AY	26.05	29.89	27.23	0.86
Tando MK	26.03	29.76	27.22	0.79
Tharparker	25.51	29.28	26.60	0.87
Thattha	25.68	28.92	26.83	0.70
Umer Kot	25.49	30.21	26.80	1.06

Table 3.4 Ranking Based on the Annual Rainfall - Least to Highest Minimum Annual Rainfall

District	Rainfall (mm)	Return Period	5-year Risk	10-year Risk	25-year Risk
Karachi City	8.65	13.58	0.32	0.53	0.85
Thatta	8.68	13.76	0.31	0.53	0.85
Sanghar	9.02	16.37	0.27	0.47	0.79
Tando Allah Yar	10.16	14.11	0.31	0.52	0.84
Jamshoro	10.19	13.33	0.32	0.54	0.86
Khairpur	10.51	13.76	0.31	0.53	0.85
Matiari	11.39	12.46	0.34	0.57	0.88
Sukkur	11.88	10.83	0.38	0.62	0.91
Sujawal	12.08	17.57	0.25	0.44	0.77
Mirpur Khas	12.32	15.35	0.29	0.49	0.81
Hyderabad	13.11	12.77	0.33	0.56	0.87
Tando Muhammad Khan	13.54	13.11	0.33	0.55	0.86
Shaheed Benazirabad	13.94	11.65	0.36	0.59	0.89
UmerKot	15.01	19.68	0.23	0.41	0.73
Ghotki	15.45	13.05	0.33	0.55	0.86
Shikarpur	15.63	10.97	0.38	0.62	0.91
Naushahro Feroze	17.36	10.61	0.39	0.63	0.92
Larkana	17.64	9.47	0.43	0.67	0.94
Badin	17.81	14.60	0.30	0.51	0.83
Jacobabad	20.13	12.59	0.34	0.56	0.87
Kashmore	20.26	13.45	0.32	0.54	0.86
Qambar Shahdadkot	22.02	9.91	0.41	0.65	0.93
Dadu	22.98	10.48	0.39	0.63	0.92
Tharparkar	38.97	20.40	0.22	0.39	0.72

Table 3.5 Ranking Based on the Occurrence of Drought of Highest Return Period

District	Rainfall (mm)	Return Period	5-year Risk	10-year Risk	25-year Risk
Tharparkar	38.97	20.40	0.22	0.39	0.72
UmerKot	15.01	19.68	0.23	0.41	0.73
Sujawal	12.08	17.57	0.25	0.44	0.77
Sanghar	9.02	16.37	0.27	0.47	0.79
Mirpur Khas	12.32	15.35	0.29	0.49	0.81
Badin	17.81	14.60	0.30	0.51	0.83
Tando Allah Yar	10.16	14.11	0.31	0.52	0.84
Thatta	8.68	13.76	0.31	0.53	0.85
Khairpur	10.51	13.76	0.31	0.53	0.85
Karachi City	8.65	13.58	0.32	0.53	0.85
Kashmore	20.26	13.45	0.32	0.54	0.86
Jamshoro	10.19	13.33	0.32	0.54	0.86
Tando Muhammad Khan	13.54	13.11	0.33	0.55	0.86
Ghotki	15.45	13.05	0.33	0.55	0.86
Hyderabad	13.11	12.77	0.33	0.56	0.87
Jacobabad	20.13	12.59	0.34	0.56	0.87
Matiari	11.39	12.46	0.34	0.57	0.88
Shaheed Benazirabad	13.94	11.65	0.36	0.59	0.89
Shikarpur	15.63	10.97	0.38	0.62	0.91
Sukkur	11.88	10.83	0.38	0.62	0.91
Naushahro Feroze	17.36	10.61	0.39	0.63	0.92
Dadu	22.98	10.48	0.39	0.63	0.92
Qambar Shahdadkot	22.02	9.91	0.41	0.65	0.93
Larkana	17.64	9.47	0.43	0.67	0.94

Table 3.6 Ranking Based on the Risk of Occurrence

District	Rainfall (mm)	Return Period	5-year Risk	10-year Risk	25-year Risk
Larkana	17.64	9.47	0.43	0.67	0.94
Qambar Shahdadkot	22.02	9.91	0.41	0.65	0.93
Dadu	22.98	10.48	0.39	0.63	0.92
Naushahro Feroze	17.36	10.61	0.39	0.63	0.92
Sukkur	11.88	10.83	0.38	0.62	0.91
Shikarpur	15.63	10.97	0.38	0.62	0.91
Shaheed Benazirabad	13.94	11.65	0.36	0.59	0.89
Matiari	11.39	12.46	0.34	0.57	0.88
Jacobabad	20.13	12.59	0.34	0.56	0.87
Hyderabad	13.11	12.77	0.33	0.56	0.87
Ghotki	15.45	13.05	0.33	0.55	0.86
Tando Muhammad Khan	13.54	13.11	0.33	0.55	0.86
Jamshoro	10.19	13.33	0.32	0.54	0.86
Kashmore	20.26	13.45	0.32	0.54	0.86
Karachi City	8.65	13.58	0.32	0.53	0.85
Khairpur	10.51	13.76	0.31	0.53	0.85
Thatta	8.68	13.76	0.31	0.53	0.85
Tando Allah Yar	10.16	14.11	0.31	0.52	0.84
Badin	17.81	14.60	0.30	0.51	0.83
Mirpur Khas	12.32	15.35	0.29	0.49	0.81
Sanghar	9.02	16.37	0.27	0.47	0.79
Sujawal	12.08	17.57	0.25	0.44	0.77
UmerKot	15.01	19.68	0.23	0.41	0.73
Tharparkar	38.97	20.40	0.22	0.39	0.72

CHAPTER - 4

INSTITUTIONAL / ORGANIZATIONAL MEASURES

CHAPTER-4
INSTITUTIONAL / ORGANIZATIONAL MEASURES

It is universally recognized that an Institutional or organizational mechanism is essential for efficient and effective implementation of any plan. Therefore, it is proposed to establish a dedicated institutional / organizational mechanism to deal with droughts in Sindh Province. This may be done incrementally through a stepwise approach over several years in future as feasible and appropriate.

At present, there are a number of public sector agencies and organizations dealing with drought individually in isolation in Sindh Province. In addition to these public sector agencies and organizations, there are many NGOs and private entities who are also helping communities and farmers in different drought prone areas of the province. Unfortunately, most of these organizations are working in isolation and lack systematic coordination among each other. Thus, their impact has been limited.

There is a strong need to establish a formal institutional mechanism to coordinate the efforts of all those concerned with drought in the province. This will facilitate integration and utilization of their available human and material resources most efficiently and productively to implement the DMP in Sindh Province.

Taking into consideration global experience in this regard, following institutional mechanism is proposed for Sindh Province.

4.1. Appointment of Provincial Drought Task Force or Drought Committee

It is proposed to appoint a Drought Task Force (DTF) or Drought Committee (DC) at provincial level in Sindh Province with participation and representation of key stakeholders both from public sector and NGOs / private sector for establishing and ensuring coordination among all those concerned with drought mitigation.

The DTF / DC will be the apex body responsible for implementing the DMP in collaboration with all concerned organizations with the support of its specialized sub-committees and district task forces / committees as described below.

It will facilitate and coordinate drought related activities in the province to create an enabling environment where all the concerned organizations can participate and contribute their roles as per their mandates.

A competent and well-recognized professional of Provincial Government of Sindh shall be appointed as its Convenor.

As listed below, the representatives of all the concerned departments, organizations. and PDMA Sindh will be members of the PDTF and will play their role within their mandate.

The Sindh Irrigation Department (SID) being custodian of water resources of the province shall be designated as secretariat for the DTF / DC to host it and facilitate its optimal functioning.

For appointing a DTF / DC, the SID shall initiate a consultative process involving the all concerned especially the following[18]:

i. Provincial Disaster Management Authority (PDMA) deals with early warning and post disaster issues in Sindh Province. It also examines vulnerability, undertakes monitoring, prevention or mitigation and coordinates relief activities in droughts and floods.
ii. Forest and Wildlife Department of Sindh Province implements biological measures to combat desertification, prevent land degradation and drought including afforestation, reforestation, forest management, rangelands management, arboriculture, soil and watershed management, forestry research & training and forest utilization.
iii. Sindh Wildlife Department (SWD) is conducting zoological survey, protecting & managing biodiversity and the protected areas to management of wildlife.
iv. Agriculture, Supply and Prices Department of Sindh promote soil conservation, demonstrates use of improved seeds & improved agriculture methods, efficient use of water through lining of water courses, research, dissemination of appropriate technologies and equipment.
v. Sindh Irrigation Department constructs and maintain irrigation system i.e. barrages, canals & distributaries. It is responsible for flood control, river and riverine surveys, tube wells and underground water utilization, drainage, storage of water, land and soil reclamation, water logging and salinity control. It is also helpful in implementing adaptation actions and measures for drought.
vi. Livestock Department supports reducing grazing pressure by introduction of improved and high valued breeds replacing the low valued herds. Vaccination and collection of livestock statistics are other functions of the department.
vii. Environment Climate Change & Coastal Development Department
viii. Local Government, Rural Development and Housing Town Planning Department
ix. Public Health Engineering Department
x. Health Department
xi. Planning and Development Department P&D department is responsible for overall planning and monitoring for government sector projects and approval of Annual Development Program (ADP).
xii. Arid zone research Institute, Umerkot,
xiii. Agri-Research Institutes at Tando Jam, Sakrand, Mirpurkhas and Dokri
xiv. Drip Irrigation Research Tando Jam
xv. Silviculture Research Station Miani
xvi. Sindh Rural Support Program is covering areas including Umerkot, Sanghar and Khairpur.

[18] National Drought Management Plan 2021, GoP.

xvii. Thardeep Rural Development Program is working in disaster prone areas including Tharparkar, Umerkot, Dadu, Jamshoro, Tando Allahyar through organizing communities, public-private partnership, food security, nutrition improvement and alleviation of poverty. for poorest of the poor interest free loan is provided. The TRDP has developed 120 disaster risk reduction plans

xviii. Sindh Graduate Association is working in arid and semi-arid areas of Sindh.

xix. Baanhn Beli is implementing social mobilization, poverty alleviation, desertification and drought management in districts of Hyderabad, Dadu, Jamshoro and Shaheed Benazirabad.

xx. Society for Conservation and Protection of Environment (SCOPE) is working in district Tharparkar through social mobilization, combating drought, desertification, water and sanitation, climate change adaptation and mitigation and Biodiversity conservation. It is also coordinating Drynet forum, a multi-country capacity building network to support UNCCD implementation.

xxi. Thardeep Micro-finance Foundation

xxii. Sindh Agricultural and Forestry Workers Coordinating Organization (SAFWCO) is working in areas including Umerkot and Sanghar.

xxiii. UNOCHA

xxiv. PMD

xxv. SUPARCO

4.2. Establishment of Sub-Committees Under Provincial DTF / DC

To assist the provincial DTF / DC in technical matters, several specialist sub-committees led by appropriate qualified and competent convenors and comprising of relevant stakeholders shall be established as described below (Figure 4.1).

These are considered essential to assist in identification of the most appropriate technical solutions suitable to local conditions and ground realities for adapting and implementing DMP.

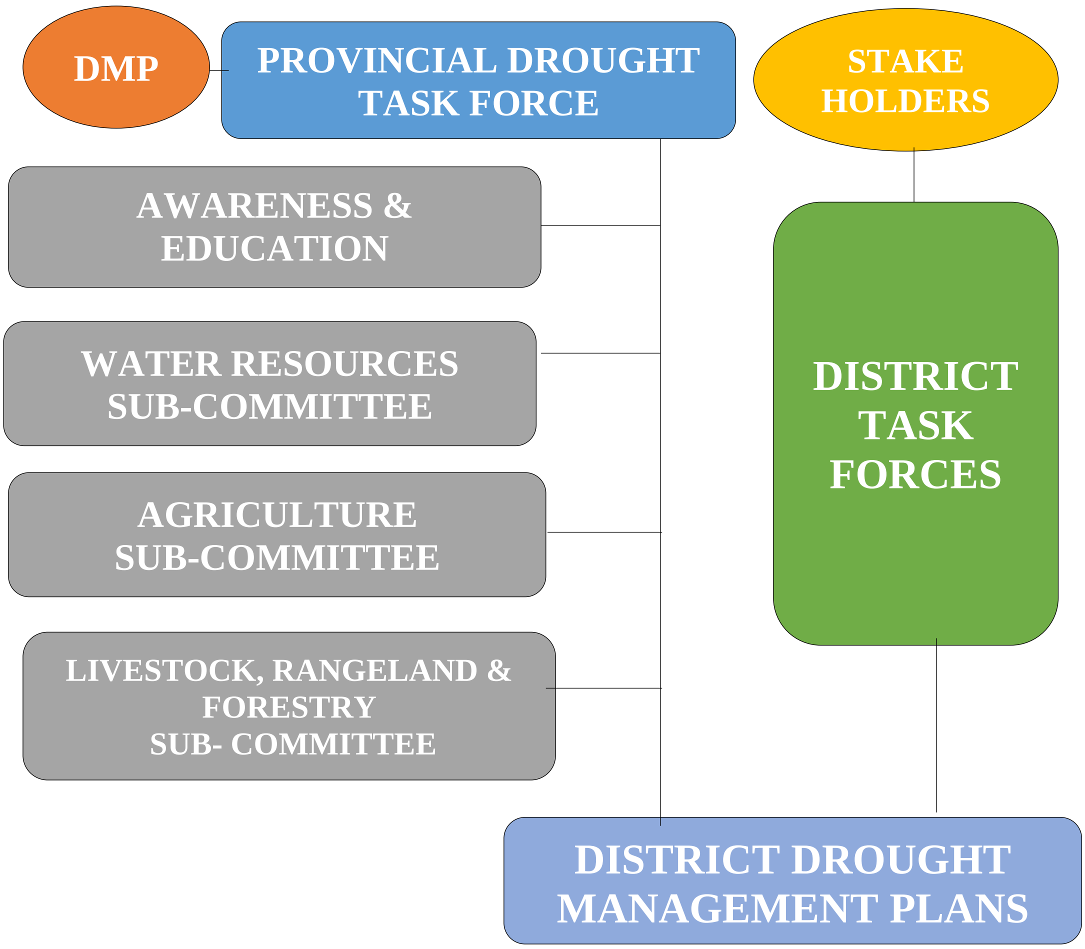
However, the provincial DTF / DC may review and revise their number, composition or mandate / key activities assigned as appropriate for its operations.

4.2.1. Awareness and Education Sub-committee

The Awareness and Education Sub-committee (A&ESC) of the provincial Drought Task Force or Committee will play lead role in creating awareness and providing education on drought management activities (including DMP) in collaboration with the relevant line agencies and organizations such as schools, colleges, universities, vocational training institutes etc. It will ensure active engagement for awareness raising, training and education of concerned drought staff, stakeholders, and the general public on managing drought-related risks through resilience planning, monitoring, and education. It will facilitate among others the following key actions.

- Arrange and supervise an awareness campaign among rural masses on DMP to motivate them for participation and contribution in drought mitigation actions specially at district level.
- Educate communities on drought response measures, climate change adaptation, water harvesting & conservation, safe drinking water, sanitation and other related topics.
- Encourage establishment of clean and green clubs in schools for awareness on tree plantation and water management for its saving for improving clean green Pakistan Index.
- Involve telecommunication companies and networks to broadcast programs focusing on drought coping techniques on electronic media including radio Pakistan and private FM channels for dissemination of information regarding drought mitigation actions.
- Educate and train youth to participate and contribute in drought mitigation activities.

Figure 4.1: Provincial Drought Task Force & Sub-Committees



4.2.2. Water Resources Sub-committee

The Water Resources Sub-committee (WRSC) of the provincial Drought Task Force or Committee will play lead role in preparing and implementing action plans under DMP to increase water resources through rain water harvesting and water conservation in collaboration with the relevant organizations particularly in highly drought prone districts of the Sindh Province. It will contribute towards the following key actions.

- Rainwater harvesting at field (in-situ), farm and watershed / catchment / sub-basin / basin levels for increasing water availability and developing new & alternative water resources.
- Conservation of available water resources and their quality particularly for sustainable water supply to meet drinking water needs in drought prone areas.
- Monitoring water quality and ensuring its judicious multiple uses.
- Review and improve regulations for groundwater usage and its most efficient and productive management in drought prone areas to reduce groundwater mining.
- Facilitate floodwater usage for recharge groundwater and animal watering points, ponds and mini dams at potential sites in rangelands.
- Arrange demonstration and promotion of efficient irrigation techniques and technologies where appropriate and feasible in collaboration with relevant entities.

4.2.3. Agriculture Sub-committee

The Agriculture Sub-committee (ASC) of the provincial Drought Task Force or Committee will play lead role in preparing and implementing action plans to increase agricultural productivity through promoting conservation and smart agricultural practices in collaboration and partnership with agricultural research and extension organizations as well as relevant NGOs and private sector service providers particularly in highly drought prone districts of the Sindh Province. It will contribute towards the following key actions.

- Facilitate applied research on drought tolerant varieties of crops in collaboration with adaptive research farms and progressive farmers.
- Arrange demonstration of drought tolerant varieties of crops in collaboration with agricultural extension service and progressive farmers.
- Promote linkages between the farmers, NGOs and private sector for provision of improved seed and technology to the farmers including seeds of drought resistant local varieties.
- Encourage and promote seed banks to store the improved seed for subsequent distribution.
- Assist in identifying and adapting appropriate crop calendars in line with drought projections.
- Arrange demonstrations of low-delta crop, shrubs and grass varieties including low delta fruits like ber (Zyziphus), olive, pomegranate, grapes, pistachio, systems including agronomic practices of low-delta cropping like Zero tillage, mulching, encourage systems utilizing indigenous knowledge and advanced water saving crop production, bio-saline agriculture, bio-gas, and honey bee production.
- Arrange urea molasses mineral / vitamin block to drought prone areas.

4.2.4. Livestock, Rangeland and Forestry Sub-Committee

The Livestock, Rangeland and Forestry Sub-committee (LRFSC) of the provincial Drought Task Force or Committee will play lead role in preparing and implementing action plans to promote livestock productivity, rangeland management and forestation through identifying and employing most appropriate practices in collaboration and partnership with relevant research and extension organizations as well as relevant NGOs and private sector service providers particularly in highly drought prone districts of the Sindh Province. It will contribute towards the following key actions.

- Promote nurseries & seed banks of local and improved grasses and shrubs at district level.
- Promote rangeland reseeding with suitable varieties of grasses and shrubs.
- Developing Micro-catchments for water harvesting at potential sites in rangelands to support vegetation.
- Establishing mechanical sand barrier like semi-buried straw checkboards for sand dune stabilization.
- Assessing rangeland carrying capacity and productivity at periodic intervals and developing local level grazing management plans in consultation with local communities.
- Facilitate agreements between Forest / Rangeland Department and local communities for controlled grazing and rangeland improvements.
- Arrange feed supplements to the livestock in drought prone areas.
- Assist in increasing coverage of protected areas in drought prone districts.
- Promote livestock vaccination and better management of poultry in drought prone areas.

4.3. Establishment of District Drought Task Forces or Committees

Considering the importance of stakeholders' participation in implementation of DMP in the field, there is a strong need to establish district level coordination mechanism in all the districts potentially prone to drought or at least in the already identified high drought risk districts.

Therefore, as a first step, these may be established in most drought prone districts which include Tharparkar, Umerkot, Mirpur Khas, Badin, Thatta, Tando Muhammad Khan, Tando Allah Yar, Sanghar, Shaheed Benazirabad, Kambar Shahdadkot, Jamshoro and Dadu[19].

The provincial DTF / DC in collaboration with the District Administration and key stakeholders at district level shall appoint district level DTFs or DCs for preparing district level drought management action plans or adapting the relevant DMP's actions according to local ground realities. All the concerned line departments and relevant organizations operational at district level will have representation on the District Drought Task Force or Committee.

The district level DTFs or DCs will be led by appropriate convenors depending upon the mandate and role of the relevant officials at district level and with consensus of the key stakeholders present at district level.

Their key role of the District Drought Task Force or Committee shall be to adapt and implement the DMP keeping in view the ground realities and local conditions with the guidance and support of both Provincial DTF / DC and Sub-committees.

[19] National Drought Management Plan 2021, GoP.

4.4. Public Participation

One of the most important and fundamental requirements for the success of DMP is the involvement of all those who impacts or getting impacted by drought especially famers, rural communities, marginalized people, women, youth at district level to ensure their participation and ownership for implementation of actions and taking responsibility after implementation.

In addition to the line departments, participation of NGOs and private sector is equally important in all activities related to implementation of DMP.

This will be undertaken through an awareness building campaign on DMP for motivating and educating people at district level for their engagement, participation and contribution.

CHAPTER - 5

OPERATIONAL MEASURES

CHAPTER-5
OPERATIONAL MEASURES

For an efficient and effective implementation of DMP, several important operational measures are required. These may include:

- An Early Warning System and Drought Monitor
- Drought Information and Education Center
- District Drought Management Plans
- Provincial Drought Management Fund

5.1. Establishment of an Early Warning Drought Monitor: Drought Monitoring Framework for Sindh Province

The development of a sound information base integrating relevant models into a monitoring and prediction system is essential to deal with the drought effectively through managing water supplies.

An Early Warning System (EWS) may be defined a system that capable of generating reliable and meaningful warning information well in advance that enables at-risk individuals, communities and organizations to prepare and act appropriately well in sufficient time to reduce harm or loss. It is an adaptive measure for climate change, using integrated communication systems to help communities prepare for hazardous climate-related events especially droughts. It generally has the following four components:

- Risk knowledge to build the baseline understanding about the risk;
- Monitoring to identify how risks evolve through time;
- Response capability;
- Warning communication which packages the monitoring information into actionable messages understood by those that need, and are prepared, to hear them.

This includes, on the one hand, the gathering, processing and presentation of information in a consistent and meaningful manner to allow the generation of alert messages and, on the other hand, the generation and transmission of alert messages

Therefore, It is suggested to establish an early warning drought monitor (e.g., see US drought monitor at https://droughtmonitor.unl.edu/) based on observations from multiple platforms i.e., *in-situ* data and remote sensing data for different hydroclimatic and ecosystem variables.

Establishment of such a drought monitor will keep the policy and decision makers, irrigation and agriculture department personnel's, provincial and local disaster management entities, and other stakeholders update on the extent and severity of the drought.

In addition to this, comprehensive information provided by the drought monitor will contribute towards improved predictions of droughts. This will also facilitate in projecting how does drought conditions can expand in time, space, and severity.

As a result, drought impacts (agricultural and/or socio-economic) can be ascertained with greater accuracy. Drought monitor may also be instrumental in quantifying damages and losses, and therefore, may provide critical insights to response of ecosystems and communities.

Drought monitor can play a pivotal role in recognizing the onset of drought conditions in a particular region. Such information if available at an appropriate time may aid in identifying the vulnerable ecosystems and communities, and in advance preparation for reducing and management of the drought related risks.

Drought monitor shall make use of hydroclimatic data already available from hydro-met stations. In addition, it is suggested to increase the number of these stations. Collection of soil moisture and groundwater levels is also important, as these are the dominant water storages in the province. Soil moisture sensors and groundwater level monitoring wells needed to be installed that can provide reliable and continuous information on these water stores.

Recently, Geographical Positioning System (GPS)-based water storages have been used to characterize and monitor droughts and related loss in water storages. Unlike soil moisture sensors and groundwater observation wells which essentially provides measurements at a point, GPS provides region-averaged changes in water storage. Therefore, including GPS equipment in the drought monitor, placing them strategically and integrating them with point measurements can provide a big picture (bird’s eye view) of the prevalent drought conditions.

Multiple satellite platforms provide information can be integrated with ground-based information to monitor drought across spatial scales. Although there is an issue of latency (i.e., satellite information is made available after some time of observations – varies from platform to platform), however, satellite information on hydroclimatic and vegetation has found to be instrumental in monitoring droughts from hydrological and ecological perspectives. When combined with ground-based observations, satellite-based information on hydroclimate and vegetation can add significant value to the drought monitor.

The drought monitor can be linked to the decision support system of relevant authorities managing drought. This will enhance the capacity of these entities in planning of the activities to reduce drought related risks, identify vulnerable communities and most importantly prioritize their operations to address most critical regions or aspects related to droughts.

The drought monitor established for Sindh province will be linked with PMD and PDMA to support their warning system at country level.

5.2. Establishment of a Drought Information and Education Center

The Government of Sindh may consider establishment of a provincial drought information and education center (DM&EC) to generate and disseminate up-to-date reliable, specific and most relevant information and provide education on drought management to all concerned using this information.

This can be done through designating one of the existing organizations which has most relevant mandate and capability, and already working on drought management.

The Center will play an important role through collecting, screening, integrating and synthesizing the drought related information gathered or generated by concerned and relevant organizations for sharing as key materials during awareness campaign as well as educating the concerned staff and communities.

The provincial drought information and education center (DM&EC) will be a dedicated center to generate and disseminate up-to-date reliable, specific and most relevant information and provide education on drought management to all concerned using this information within Sindh province. However, it will also coordinate with similar initiatives at national level.

5.3. Preparation of District Drought Management Plans

The provincial DTF / DC with the assistance of its sub-committees and in collaboration with the district DTFs / DCs shall prepare district drought management plan for their respective districts. These may be prepared initially for 12 most drought prone districts which include Tharparkar, Umerkot, Mirpur Khas, Badin, Thatta, Tando Muhammad Khan, Tando Allah Yar, Sanghar, Shaheed Benazirabad, Kambar Shahdadkot, Jamshoro and Dadu.

The district drought management plans shall be prepared using the basic information on soil types, rainfall characteristics, hydrological and irrigation profiles, watershed development, existing cropping patterns, social-economic vulnerabilities etc.

These shall identify most appropriate measures which may, inter alia, include alterations in the cropping patterns, water harvesting and conservation, efficient and sustainable exploitation of ground water / irrigation resources etc. over the short, medium and long term.

These plans shall also identify targets for various actionable recommendations to facilitate a robust monitoring of component / scheme wise progress.

The federal government is preparing a drought management plan for Sindh Province but nothing so far available at district level. Therefore, the Government of Sindh has to take initiative to prepare district level drought management plans.

5.4. Provincial Drought Management Fund

To implement the Drought Management Plan (DMP) effectively in letter and spirit, availability of adequate financial resources is required in addition to the human resources. Therefore, Government of Sindh shall consider establishment of a dedicated Provincial Drought Management Fund to support implementation of Drought Management Plan (DMP).

The fund may be kept on the disposal of the provincial DTF / DC to support implementation of DMP for drought mitigation.

The fund may be raised with contribution in terms of grants and donations from the federal government, international organizations, foundations, NGOs, Private & Corporate Sector and general public.

The federal government will be pursued to contribute as well as facilitate contributions from all potential sources.

CHAPTER - 6

TECHNICAL MEASURES

CHAPTER-6
TECHNICAL MEASURES

Most appropriate and desirable technical drought mitigation measure suitable for arid areas of Sindh Province is water resources management especially through water harvesting and conservation both at field (in-situ) and farm level (individual action), and catchment / watershed / sub-basin / basin level (collective action) to increase water supplies as much as possible.

Water harvesting and conservation is being practiced to some extent in Sindh province. However, it needs to be promoted to be undertaken systematically and adapted both intensively and extensively employing state-of-the art materials and methods using latest techniques and technologies.

Water harvesting captures rainfall and /or runoff and utilizes it for drinking or farming either directly or by storing it in surface and subsurface reservoirs. The stored water can be used for supplemental irrigation and other consumptive uses. Water Conservation emphasize most efficient and productive use of available water.

6.1. Domestic Water Supply

Provision and sustainability of domestic water supply both in rural and urban areas during drought is on the top priority in this draft drought mitigation plan. Drinking water supplies in rural and urban areas of arid zones of Sindh Province are based on groundwater which is drawn individually (using hand pumps, motor pumps, dug wells and tube wells) or collectively through water supply schemes run by the line department.

During droughts, reduced availability of surface water pushes users to increase their reliance on groundwater sources that impact on the availability of groundwater for domestic use in rural communities. A common consequence is increased reliance on groundwater during drought / dry years that results in overdraft and subsequent subsidence, which negatively affects isolated rural communities that have few supply alternatives to groundwater. Generally, during the drought, groundwater level drops significantly below normal levels in arid areas.

Therefore, community water supply systems shall have a drought management plan. One of the most significant components of a community water supply system's plan is the designation of trigger points – the points at which certain drought response actions are required as determined by that community water supply system – with identified corresponding actions. This is also valid for individual domestic water supply systems.

The district level Drought Task Forces, considering the nature and extent of drought vulnerability, shall prepare guidelines for community as well individual water supply systems. These may include a permit system whereby operations might be interrupted for some time daily to save water. The guidelines may include suggestions on drought management planning steps keeping the local conditions and ground realities for ensuring sustainable domestic water supplies.

This activity will be undertaken in collaboration with the respective district level staff of the Public Health Engineering Department that has been designing, planning & executing water supply & drainage schemes in urban & rural areas of Sindh province excluding Karachi and Hyderabad cities. The respective district level staff of the Public Health Engineering Department jointly with the district level Drought Task Forces, considering the human and financial resources available, shall prepare an action plan for sustainable O&M of each water supply scheme including guidelines for the community as well individual water supply schemes.

6.2. Rainwater Harvesting in Field (IN-SITU)

Rain water harvesting in the field (in-situ rain water harvesting), involves the use of methods that increase the amount of water stored in the soil profile by trapping or holding the rain when it falls, and it involves small movements of rainwater as surface runoff, in order to concentrate the water where it is required. Though rainwater harvesting is a very old practice dating back to 4500 BCE in the Middle East and India, it has received little attention since the modernization of agriculture. With improved in-field water harvesting, harvested rainfall stored infield can possibly sustain crop production during the mid-season dry spells and it can be considered as a supplemental water source.

In addition, rain water harvesting may also be considered as a key adaptation strategy to the impacts of climate change and variability. Potential rain water harvesting techniques include the use of infiltration pits and contour ridges with cross ties. These alternative methods of water conservation / harvesting are preferred to the standard contour ridges which were designed to safely dispose of run-off instead of retaining it. The alternative water harvesting techniques came after the realization that most of the rainfall received lost as runoff, and very little water is harvested for plant growth or future use and losses of >50% of received rainfall have been reported. High levels of runoff losses do not only limit water availability, but are also an erosion hazard as the runoff can cause nutrient loss. These alternative in-field rain water harvesting techniques can benefit farmers through:

(i) Increased run-off retention thereby improving water availability to crops;
(ii) Reduced soil erosion through reducing water flow velocities; and
(iii) Increased groundwater recharge through reduced run-off to natural water courses.

Micro-basins which supply single trees or bushes with runoff on hillsides are sometimes termed eyebrow terraces. They are also known as ‘platform terraces’ as their cultivated area is kept level. The catchment size is 5 – 50 m² and the cultivated area 1 – 5 m². This technology can be applied on slopes of up to 50%; the steeper the gradient, the more the bunds have to be reinforced by stone (where available). Eyebrow terraces can be applied in areas of 200 – 600 mm annual rainfall. (Mekdaschi & Liniger 2013).

Half-moons are semi-circular basins 2 to 6 m in diameter that are dug on gentle slopes (<3%) to retain the water. Earth from cuttings is laid on the downstream edge of these basins. The downstream side of the earth collar thus created can be strengthened with pebbles. The half-moons are laid in staggered rows with four meters between them. Compost or fertilizer is spread to improve soil fertility.

Poor soils produce better results when the half-moon system is used. This method is effective for rainfall of less than 600 mm. The effects make themselves felt in the first season. If manure is added, good production of grain per hectare can be expected.

This activity will be undertaken in collaboration with the respective district level staff of the Agricultural Department. The respective district level staff of the Agriculture Department jointly with the district level Drought Task Forces, considering the human and financial resources available, shall prepare an action plan for creating awareness among the land users to adapt appropriate measures to undertake rainwater harvesting in-situ on their fields through demonstrating simple and appropriate techniques and technologies for cultivation.

6.3. Rainwater Harvesting at Farm

Unfortunately, limited efforts have been made to promote rainwater harvesting that may be utilized for cultivation of land. Several projects like mole dam, Kacho reservoir, development of lakes, depressions and reservoirs are lying unattended and ignored for many years. These water bodies can substantially harvest the rainwater for using it for valued crops and livestock. Traditional water-harvesting and conservation practices in the Sindh Province are briefly described below. Also, discussed are some additional water harvesting practices used in similar environments worldwide.

This activity will be undertaken in collaboration with the respective district level staff of the Agricultural Department. The respective district level staff of the Agriculture Department jointly with the district level Drought Task Forces, considering the human and financial resources available, shall prepare an action plan for creating awareness among the land users to adapt appropriate measures to undertake rainwater harvesting on their farms through demonstrating simple and appropriate techniques and technologies for capturing and storing run-off water in low lying areas of the farm through Taraies, Wells and ponds for subsequent use for agriculture and livestock.

6.3.1. Taraies

The most common type of water conservation in the arid regions of Sindh Province is a dug-out commonly called “Taraie.” TARAIES collect rainwater drained from a level watershed or catchment area. These are dug cheaply in low-lying areas having clayey soils with some runoff. The depth of water in a taraie is about 3 to 4 m. However, water is lost quickly due to high evaporation rate in arid areas. A Taraie is dug with sloping sides for livestock access to water. Desilting is generally done after 3–4 years.

6.3.2. Wells

The dependable and common source of water is wells in most of the rangelands where quality of groundwater is usable Water from the well is raised manually or by animal power. The wells are usually dug along the riverbeds and channels to harvest the shallow seepage water.

6.3.3. Ponds

Farm level rainwater harvesting structures especially ponds are highly useful for rainfed farming under climate change scenario to mitigate drought impacts and had a multiplier effect on farm income. However, these are not being promoted extensively in Sindh Province.

Rainwater harvesting structures of different types and size (10x10x2.5 m, 30x30x3m, 45x45x3m; 82x26x3m) were constructed on individual farms, especially for smallholders in Maharashtra (India). The farmer's contribution to the cost of construction ranged from 10 to 80%. The farm ponds in Maharashtra (India) resulted in significant increase in farm productivity (12 to 32 %), income and cropping intensity[20].

The farm level water harvesting in ponds is highly desirable and shall be promoted extensively in arid areas of Sindh Province to mitigate drought risk against crop failures. In fact, it will be an improved and highly beneficial version of "Taraies" which is already being practiced in arid area of Sindh Province.

6.4. Rainwater Harvesting at Watershed/Catchment/Sub-Basin/Basin

Rain water is the third most important good quality source of water after canal and groundwater in Sindh Province. It becomes the only source in non-commanded arid areas having brackish groundwater. It is scarce and significantly inadequate. It is only received during monsoon and its intensity continues to decrease from coastal areas towards central and northern parts of the Sindh Province. However, it forms life and soul of agricultural activities of arid areas of Sindh Province which are not served by canals and groundwater is predominantly brackish.

At present, contribution of rain water to crops in the arid areas is estimated about 3 MAF. A substantial part of rain water is wasted in an arid environment of Thar, Kohistan and Nara zones where it is practically the only source of survival of the people, animals and plants.

Therefore, rainwater harvesting, conservation and storage at catchment / watershed level / sub-basin / basin level (collective action) to increase availability of beneficial water supplies as much as possible is the need of the hour.

[20] Kumar Shalander, B. Venkateswarlu, Khem Chand, Murari Mohan Roy. (20/11/2013). Farm level rainwater harvesting for dryland agriculture in India: Performance assessment and institutional and policy needs. Harbin, China.

Recognizing this important need, SID's Small Dams Organization has been making concrete efforts to collect and store run-off through small dams and reservoirs for recharge as well for water storage. These are being described in the next chapter.

6.5. Water Conservation

Water conservation means using limited water efficiently and wisely. Farmers should be motivated and trained in the use of emerging efficient water-use methods at farm which have proven successful in different arid environments of Pakistan. The following may be promoted.

6.5.1. Matching Cropping Pattern and Intensity to Water Availability

The land, water and climate play an important role in the adaptation of a cropping pattern but traditions affect the decision making. Many crops are still grown in places where other crops are more appropriate. Change of cropping pattern can have a significant effect on water savings. Cultivation of drought resistant crops and crop varieties coupled with scientific management practices would lead to drought mitigation for crops over a period of time.

The Agriculture SC in collaboration with Agriculture Department especially its research and extension wings, NGO and Private Sector shall ensure adequate availability of drought resistant seeds and encourage farmers to adopt better crop management practices to cope with drought impact on crop production. The Government of Sindh promoted low-deltaic crops such as sugar beet, cotton and oilseeds to replace the high-deltaic crops.

6.5.2. Zero-Till Technology and Mulching

Zero-till drill and production technology were developed by Pakistan Agricultural Research Council (PARC) during the late 1980s. The PARC worked with the local manufacturing industry to initiate the local manufacturing of zero-till drills. Zero-till technology refers to planting crops without seedbed preparation. This technology has also been introduced in the Sindh Province. It has been beneficially used for planting wheat without any seedbed preparation after the harvest of rice. It allows utilization and conservation of the antecedent soil moisture, saves time due to early planting and increases wheat yield. Around 30–40% of water can be saved with zero tillage along with precision land leveling. The area under zero tillage in Pakistan has increased significantly in the recent past.

Zero Tillage combined with mulching will further increase the amount of moisture stored in the soil especially in the rootzone. Mulches conserve the soil moisture, enhance the nutrients status of soil, control the erosion losses, suppress the weeds in crop plants, and remove the residual effects of pesticides, fertilizers, and heavy metals. Mulches improve the aesthetic value of landscapes and economic value of crops.

6.5.3. High-Efficiency Irrigation Technology

In most of Sindh Province, irrigation method commonly used by farmers is controlled flood-irrigation technique on either wide-border strips or basins. In some areas, where soil is sandy, gravity irrigation results in significant wastage of water due to seepage. Almost all fruits, vegetables and winter fodder crops are overirrigated. As much as double the amount of water required is applied. The application efficiency in fields is 25–40% (IUCN 2000). The high-efficiency irrigation methods such as drip, sprinkler and bubbler offer very high irrigation efficiencies which allows saving scarce water without compromising on production.

6.5.4. Furrow-Bed Irrigation

The basin irrigation method is commonly used in the Sindh with the highest water consumption and the lowest water use efficiency. Furrow-bed irrigation is considered the most efficient method of water application. Raising row-crops like cotton on beds with row-to-row spacing of 75 cm is gaining popularity amongst the farmers, mainly because it saves water. IWMI has conducted furrow-bed irrigation trials in cotton-wheat regions of Punjab and Sindh and results have been very encouraging. Planting of cotton on beds and furrow irrigation have resulted in a 30–35% increase in yield with around a 40–45% saving in water (IWMI 1999).

6.5.5. Agroforestry

Agroforestry is a land use management system in which trees, crops and shrubs are integrated intentionally into crop and livestock farming systems to generate environmental, economic and social benefits. Trees are grown around or among crops or pastureland. Trees may produce a wide range of useful and marketable products from fruits/nuts, medicines, wood products, etc. This intentional combination of agriculture and forestry has multiple benefits, such as greatly enhanced yields from staple food crops, enhanced farmer livelihoods from income generation, increased biodiversity, improved soil structure and health, reduced erosion, and carbon sequestration.

Agroforestry shares principles with intercropping but can also involve much more complex multi-strata agroforests containing hundreds of species. Agroforestry can also utilize nitrogen-fixing plants such as legumes to restore soil nitrogen fertility. The nitrogen-fixing plants can be planted either sequentially or simultaneously.

The plantation reduces the rate of runoff by trapping and delaying the water with associated reduction in the level of silt carried in the floodwater. This technique results in significant impact on water conservation and improvement through having sufficient soil cover.

Studies reported that an 80 mm storm of rainfall on vegetative catchments could produce a lower peak flow than that from a 20 mm storm in catchments without plantation. It is also reported that the vegetative measures can add around 33% more to the groundwater recharge (Majeed 2000).

Promoting agroforestry and/or plantation practices will be highly beneficial especially in subsistence smallholdings in non-commanded arid areas of Sindh Province.

CHAPTER - 7

CONSTRUCTION OF SMALL DAMS IN SINDH PROVINCE

CHAPTER-7
CONSTRUCTION OF SMALL DAMS IN SINDH PROVINCE

The Small Dams Project was launched by the Government of Sindh in 2007 through establishing Small Dams Organization Sindh (SDOS) at Hyderabad for constructing Small Dams, Delay Action Dams, Weirs and I.S.S.O barriers, across the river passages to store surface water and recharge sub surface water to meet the need of irrigation and potable water of the rural population of neglected suburban and remote areas of Sindh.

The SDOS has been instrumental in undertaking feasibility studies and constructing a range of different projects to use the small amount of average rainfall and the run-off generated with it.

A number of feasibility studies were completed in the past; however, a significant progress has recently been made in construction of small dams as narrated below.

7.1. Small Dams Already Constructed (94)

Considerable progress has been made in constructing small dams in Sindh Province through completion of ninety-four small dams. The salient features of these completed small dams is attached as Annex I.

7.2. Small Dams Under Construction (56)

There are fifty-six small dams under construction at present in Sindh Province. The salient features of these dams under construction are attached as Annex J.

7.3. Small Dams In Planning Stage

There are a number of small dams are in pipeline and are being planned under World Bank funded Sindh Resilience Project (SRP). Their details are attached as Annex K.

7.4. Run-Off Availability

The trend of mean annual rainfall in Sindh province (see map of annual rainfall and trends in Chapter 2) shows that southern districts generally have more rainfall than the northern districts and it is increasing which is very encouraging for soil moisture and run-off availability.

Long-term rainfall data analysis shows that Tharparkar District has the highest annual rainfall in the Sindh province. Whereas Sukkur and some parts of Shikarpur and Khairpur showed lowest annual rainfall.

Considering the mean annual runoff, Tharparkar District has higher runoff than other districts. Also, Tharparkar District has somewhat cooler annual temperatures. Tharparkar district has cycles of dry and wet years (see time series of annual rainfall of Tharparkar), including occurrences of persistent multiple dry years.

Given that there have been years with good amount of rainfall in Tharparkar, there seems a possibility of having short-term storage (e.g., small dams) and long-term storage (e.g., storage in aquifer).

Overall, the annual runoff variations suggest that there seems to have a possibility of have some short-term storage in Karachi, Sanghar, Khairpur, and Hyderabad districts.

However, northwest districts including Larkana, Jacobabad and others, have very low annual runoffs.

This suggests that water availability need to be very carefully studied before planning and designing any storage infrastructure.

The Kohistan region, Nagarparkar and Ubhan Shah Hills are main potential sites in Sindh Province, to construct, Small Dams, Delay Action Dams, Weirs and I.S.S.O Barriers to retain the run off generated from precipitation and continuous storm rainfall.

Kohistan Karoonjhar have greater land-water potentials available for development of rain/flood irrigation system. Kohistan originating from Qambar-Shahdadkot to Thatta out skirts of Karachi District, hill torrent has a mean annual run off 518,582 ac-ft and can irrigate an area of 706,572 acres of barren land and Karoonjhar hill has a mean annual run-off 94,744 ac-ft which can irrigate an area of 70,00 acres land of Nagarparkar of Thar District. The recorded average annual rainfall is 6-8 " in Kohistan and 14" in Nagarparkar.

Small Dams Organization has completed the construction of 19 Small Recharge Dams Weirs in Kohistan region and Nagarparkar. These Dams are successfully operating and initiating benefits to the inhabitant of neglected people of Nagarparkar and Kohistan areas and have shown a little hope by growing their crops, to meet the requirement of drinking water and their livestock.

CHAPTER - 8

AWARENESS RAISING, EDUCATION AND RESEARCH PLAN

CHAPTER-8
AWARENESS RAISING, EDUCATION AND RESEARCH PLAN

Public awareness raising and education plan is a critical component of a drought management plan for its effective implementation and success. To ensure most appropriate and useful awareness and education, relevant research findings are essential.

The Awareness and Education Sub-Committee (AESC) of the provincial Drought Task Force, in collaboration with relevant line organizations, such as schools, colleges, universities, vocational training institutes, will undertake awareness raising and education of concerned drought staff, stakeholders, and the general public on managing drought-related risks through resilience planning, monitoring, and undertaking appropriate measures at their level.

Considering the long-term impacts of droughts on ecosystem and human population, drought awareness raising and educational plan will be discussed and finalized in collaboration and consultation with the key stakeholders. Most appropriate and suitable materials and methods using latest techniques and technologies for awareness raising and imparting education on drought management will be identified and employed jointly with the stakeholders. However, an indicative draft awareness and education plan is discussed below.

8.1 Awareness Raising and Capacity Building Campaign

An awareness campaign is a time-bound, strategic campaign aimed entirely at increasing public visibility and mass awareness on drought management plan for their participation and contribution in its implementation. This implies planning and launching a campaign to spread the word about Drought Management Plan, explain why it matters, and motivate masses to get involved. A wide public awareness about the importance of natural resource management is a very important aspect of a long-term Drought Management Plan. Public must be informed on the importance of water conservation and harvesting, optimal water use and the need for increasing vegetative and forest cover.

The main objective of the awareness raising campaign is to maximize the impact, visibility and the main message of the Drought Management Plan. Within the context of the campaign, stakeholders / partners should spread the concept that sustainable investing is simply smart investing. That it preserves a unique and common resource i.e. ecosystem during drought, increases the sense of identity and responsibility in the inhabitants / users which is often abandoned or undeveloped.

The general output of this awareness raising campaign is the enhancement of the awareness and skills of involved stakeholders in preserving ecosystem through water harvesting and conservation. Some measures directly aim at changing local behavior, to increase knowledge, sense of belonging, awareness among different subjects and to introduce innovative tools in the preservation of ecosystem including water. It is therefore crucial to focus on dissemination and awareness raising activities among various stakeholder to build capacities for enhanced drought management and foster sustainable use of available resources.

The awareness raising and information dissemination plan will be implemented keeping in mind the appropriate levels of information to be provided to different types of audiences.

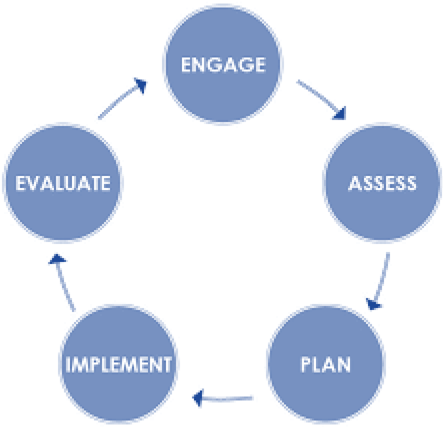
There is a general lack of social awareness and responsibility within the society for reasons ranging from education to poverty and from governance to politics. The result is that people in Pakistan are not prepared to face the force of water, let alone prepare for it.

Therefore, the AESC should take steps to create awareness on drought mitigation methods and programmes to build the capacities of farmers and village level functionaries, which would be of immense help for efficient implementation of different measures of drought proofing. People must be informed of the importance of water conservation and harvesting, optimal water use and the need for increasing forest cover. The AESC in collaboration with the relevant line agencies and organizations such as schools, colleges, universities, vocational training institutes etc will ensure active engagement for awareness raising, training and education of concerned drought staff, stakeholders, and the public on managing drought-related risks through resilience planning, monitoring, and education.

For this already available audio-visual and written materials already available with organization listed under 4.1.will be reviewed for identification of appropriate materials in English with translation in Urdu and Sindhi languages. The selected audio-visual and written materials for use in awareness raising and education will emphasize on understanding droughts, their impacts on ecosystem and their management / mitigation measures as proposed in DMP. The following key actions will form the part of plan preparation.

- Arrange and supervise an awareness campaign among rural masses on DMP to motivate them for participation and contribution at district level.
- Educate communities on drought response measures, climate change adaptation, water harvesting & conservation, safe drinking water, sanitation and other related topics.
- Encourage establishment of clean and green clubs in schools for awareness on tree plantation and water management.
- Involve telecommunication companies and networks to broadcast programs focusing on drought coping techniques on electronic media including radio Pakistan and private FM channels.
- Educate and train youth to participate and contribute in drought mitigation activities.

The awareness campaign may be undertaken in a cycle as below to keep it most efficient, effective and relevant.



8.2 Educating Drought Mitigation

There is a strong need to educate the drought concerned staff of the line agencies on latest knowledge and skills on drought management through seminars, workshops and short courses. These may be arranged in collaboration with relevant educational organizations such as universities and training centers.

The AESC will undertake a survey of the present relevant seminars, workshops and short courses offered by the universities and training centers in the province on drought management. If there are some being offered, arrangement will be made for the participation of drought concerned staff in these events. In case, there are none, efforts will be made to arrange with those organizations having capacity and willing to collaborate to offer relevant seminars, workshops and short courses on drought management.

There are several international organizations / centers which are active in imparting education and training on drought management in Australia and USA. It would be highly useful to get some concerned capable staff trained in these centers to become master trainers for imparting similar trainings to concerned staff locally for importing latest knowledge and skills on drought management.

8.3 Applied / Adaptive Research for Drought Mitigation

To support effective awareness campaign and education through seminars, workshops and short courses, there is a strong need to have reliable information backed by scientific evidence for communication to general public and concerned officials. This will require active participation and contribution of local research institutes / organizations / centers.

The AESC in collaboration with local research institutes / organizations / centers will arrange reliable information backed by scientific evidence for communication to general public and concerned officials.

The information to be communicated must be tailored to local conditions and environment to make it more useful and adaptable

8.4 Rainwater Harvesting for Urban Areas

The Awareness and Education Sub-Committee (AESC) of the provincial Drought Task Force, in collaboration with relevant line organizations, schools, colleges, universities, vocational training institutes, may also undertake awareness raising and education on rainwater harvesting in urban areas to supplement the domestic water supply.

Generally, there are two ways of harvesting rainwater, namely; surface runoff harvesting and rooftop rainwater harvesting.

Rainwater harvesting is the collection and storage of rain for reuse on-site, rather than allowing it to run off. The stored water is used for various purposes, such as gardening, irrigation, etc.

The application of an appropriate rainwater harvesting technology can make possible the utilization of rainwater as a valuable and, in many cases, necessary water resource. Rainwater harvesting has been practiced for more than 4, 000 years, and, in most developing countries, is becoming essential owing to the temporal and spatial variability of rainfall.

A rainwater harvesting system consists of three basic elements: a collection area, a conveyance system, and storage facilities. The collection area in most cases is the roof of a house or a building.

The effective roof area and the material used in constructing the roof influence the efficiency of collection and the water quality.

A conveyance system usually consists of gutters or pipes that deliver rainwater falling on the rooftop to cisterns or other storage vessels.

Both drainpipes and roof surfaces should be constructed of chemically inert materials such as wood, plastic, aluminium, or fiberglass, to avoid adverse effects on water quality.

The water ultimately is stored in a storage tank or cistern, which should also be constructed of an inert material. Reinforced concrete, fiberglass, or stainless steel are suitable materials.

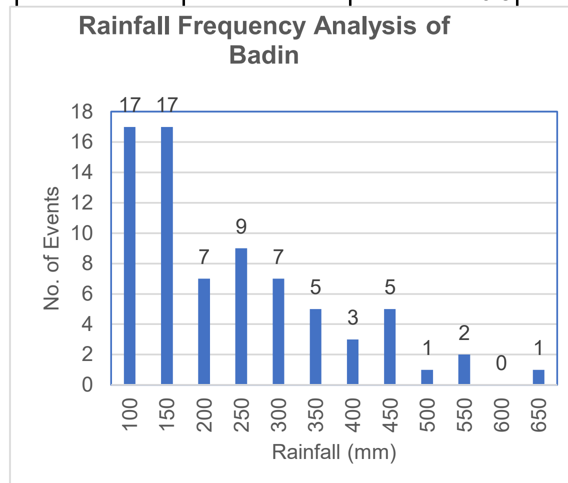
Storage tanks may be constructed as part of the building, or may be built as a separate unit located some distance away from the building.

ANNEXURE-A

ANNUAL RAINFALL & MEAN TEMPERATURE

Annexure A: Annual Rainfall & Mean Temperature of Badin (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	52	26.7
1949	245	26.7
1950	130	25.9
1951	76	26.6
1952	167	26.7
1953	224	27.0
1954	162	26.8
1955	236	26.6
1956	416	26.0
1957	105	26.2
1958	174	27.3
1959	378	26.7
1960	73	26.6
1961	404	26.2
1962	223	26.4
1963	78	27.0
1964	234	26.2
1965	168	26.6
1966	91	26.7
1967	436	26.3
1968	47	26.5
1969	18	27.2
1970	338	26.9
1971	140	26.7
1972	57	26.6
1973	129	26.7
1974	24	26.8
1975	256	26.5
1976	353	26.7
1977	213	27.4
1978	347	26.6
1979	232	26.8
1980	106	27.1
1981	53	27.0
1982	95	26.7
1983	302	26.5
1984	221	26.2
1985	142	26.9
1986	126	26.7
1987	18	27.7
1988	296	27.8
1989	134	26.3
1990	257	26.5
1991	26	26.4
1992	288	26.4
1993	109	27.3
1994	297	26.5
1995	126	26.7
1996	77	26.7
1997	149	26.1
1998	152	27.1
1999	79	27.0
2000	125	26.9
2001	121	27.0
2002	36	27.3
2003	359	27.5
2004	84	28.0
2005	165	26.8
2006	460	27.1
2007	342	27.9
2008	144	27.2
2009	268	28.1
2010	274	28.0
2011	203	27.5
2012	135	27.2
2013	170	27.3
2014	149	27.7
2015	408	29.1
2016	323	29.4
2017	542	29.1
2018	120	29.7
2019	506	28.9
2020	728	28.2
2021	414	28.6
No.	74	74
Min	18	25.9
Max	728	29.7
Average	207	27.1
STD	141	0.8

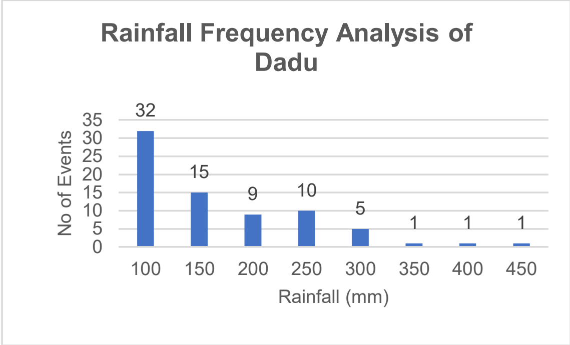


Annexure A: Annual Rainfall & Mean Temperature of Dadu (GLDAS)

Year	Rainfall (mm/yr)	Temperature (^oC)
1948	170.1	26.4
1949	192.0	26.1
1950	166.5	25.5
1951	92.5	26.3
1952	108.9	26.4
1953	192.0	27.0
1954	107.9	26.5
1955	89.8	26.3
1956	255.5	25.9
1957	70.8	25.8
1958	144.3	27.1
1959	229.8	26.6
1960	95.2	26.1
1961	270.9	25.9
1962	114.6	26.3
1963	23.0	27.0
1964	50.5	26.1
1965	56.6	26.2
1966	35.5	26.3
1967	336.7	26.0
1968	26.1	26.1
1969	45.8	26.8
1970	211.6	26.7
1971	35.6	26.4
1972	48.3	25.8
1973	58.4	26.3
1974	26.3	26.0
1975	212.3	26.1
1976	225.1	26.2
1977	146.0	26.9
1978	293.1	26.3
1979	147.0	26.2
1980	76.4	26.7
1981	146.7	26.6
1982	124.0	26.1

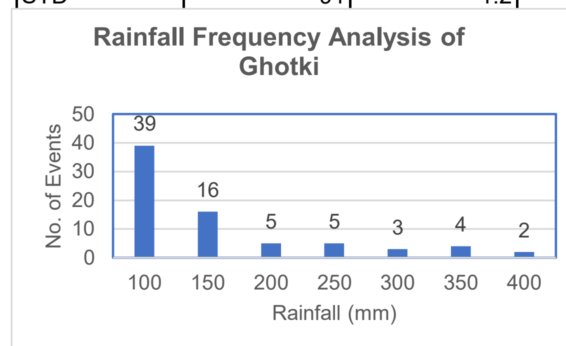
Year	Rainfall (mm/yr)	Temperature (^oC)
1983	141.6	26.1
1984	89.9	26.1
1985	179.4	26.3
1986	173.9	25.8
1987	25.7	26.6
1988	148.0	27.1
1989	175.3	26.0
1990	125.6	26.4
1991	49.8	26.3
1992	210.5	26.4
1993	42.5	27.1
1994	271.5	26.4
1995	121.5	26.6
1996	85.6	26.3
1997	211.2	25.9
1998	80.9	27.2
1999	70.1	27.1
2000	41.8	27.1
2001	87.0	27.4
2002	27.2	27.2
2003	239.1	26.9
2004	35.2	27.5
2005	83.9	26.7
2006	117.2	26.6
2007	201.0	27.3
2008	96.4	27.0
2009	85.3	27.7
2010	171.1	27.8
2011	125.1	27.2
2012	37.7	26.7
2013	86.1	26.8
2014	70.4	27.3
2015	273.7	29.9
2016	208.8	30.8
2017	246.6	30.2

Year	Rainfall (mm/yr)	Temperature (^oC)
2018	106.5	30.6
2019	373.8	29.2
2020	407.3	28.6
2021	172.0	29.3
No.	74	74
Min	23	25.5
Max	407	30.8
Average	137	26.8
STD	88	1.1



Annexure A: Annual Rainfall & Mean Temperature of Ghotki (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	108.2	26.6
1949	286.3	26.3
1950	66.1	25.6
1951	42.6	26.6
1952	53.2	26.7
1953	92.3	27.2
1954	72.0	26.7
1955	92.4	26.5
1956	148.4	26.1
1957	37.7	25.7
1958	40.9	27.2
1959	147.5	26.6
1960	47.3	26.2
1961	155.8	25.9
1962	95.0	26.4
1963	38.3	27.0
1964	102.9	26.1
1965	49.7	26.1
1966	48.1	26.2
1967	213.8	25.8
1968	21.4	26.1
1969	21.7	27.0
1970	109.8	26.7
1971	70.8	26.4
1972	44.4	26.1
1973	41.8	26.3
1974	33.7	26.1
1975	290.9	25.9
1976	165.6	26.1
1977	89.3	26.8
1978	327.7	26.2
1979	75.4	26.2
1980	26.2	26.6
1981	119.8	26.5
1982	104.3	25.9
1983	126.4	25.9
1984	89.3	26.1
1985	156.9	26.4
1986	131.7	25.9
1987	28.8	26.7
1988	59.5	27.1
1989	179.1	25.9
1990	100.7	26.5
1991	21.9	26.2
1992	93.8	26.3
1993	48.0	26.9
1994	342.3	26.4
1995	65.8	26.4
1996	95.9	26.2
1997	230.4	25.4
1998	69.2	26.9
1999	112.6	26.9
2000	37.9	26.8
2001	66.2	26.8
2002	15.4	27.2
2003	256.5	26.6
2004	48.5	27.4
2005	57.4	26.3
2006	128.7	26.3
2007	154.3	27.1
2008	104.3	26.8
2009	61.7	27.5
2010	215.7	27.6
2011	131.2	26.8
2012	74.9	26.4
2013	143.8	26.6
2014	87.5	26.7
2015	340.6	29.7
2016	236.3	30.7
2017	308.5	30.4
2018	138.2	30.8
2019	352.8	30.0
2020	356.4	29.6
2021	224.3	29.9
No.	74	74
Min	15	25.4
Max	356	30.8
Average	121	26.8
STD	91	1.2

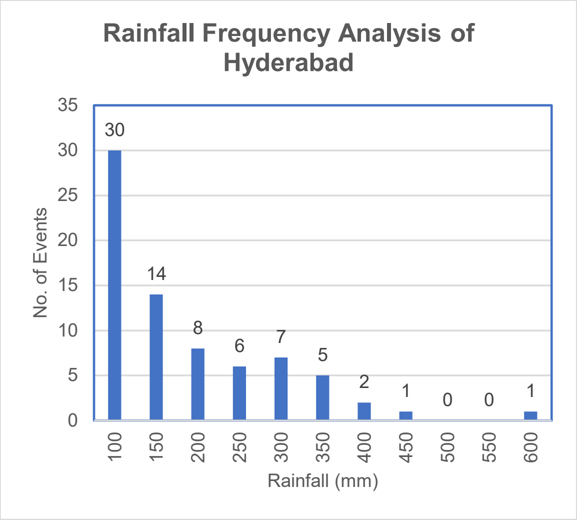


Annexure A: Annual Rainfall & Mean Temperature of Hyderabad (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	55.7	27.0
1949	216.7	26.9
1950	91.3	26.2
1951	52.6	27.0
1952	111.8	27.0
1953	166.9	27.3
1954	124.0	27.2
1955	198.5	26.9
1956	375.7	26.3
1957	65.6	26.5
1958	127.8	27.6
1959	272.2	27.1
1960	66.4	26.9
1961	316.2	26.5
1962	204.4	26.8
1963	35.3	27.3
1964	127.1	26.5
1965	118.0	26.8
1966	67.0	27.0
1967	396.8	26.6
1968	27.5	26.7
1969	13.1	27.5
1970	262.9	27.2
1971	73.1	27.1
1972	30.0	26.9
1973	84.3	27.0
1974	17.8	27.0
1975	185.8	26.9
1976	314.0	27.0
1977	191.3	27.7
1978	339.0	26.9
1979	169.3	27.1
1980	85.6	27.4
1981	67.4	27.4
1982	80.4	27.0
1983	254.2	26.9
1984	181.6	26.6

Year	Rainfall (mm/yr)	Temperature (°C)
1985	109.8	27.2
1986	139.0	26.9
1987	13.2	27.9
1988	241.8	28.1
1989	146.5	26.5
1990	151.3	26.7
1991	13.8	26.7
1992	247.7	26.7
1993	60.6	27.5
1994	297.3	26.6
1995	93.5	26.9
1996	41.3	26.9
1997	98.3	26.3
1998	63.8	27.3
1999	57.6	27.3
2000	67.0	27.2
2001	108.2	27.4
2002	19.3	27.6
2003	298.5	27.8
2004	37.0	28.3
2005	92.2	27.1
2006	314.8	27.3
2007	250.2	28.2
2008	95.0	27.6
2009	179.2	28.5
2010	148.2	28.4
2011	126.5	28.0
2012	104.2	27.5
2013	139.6	27.7
2014	88.9	28.0
2015	257.3	29.4
2016	246.6	29.9
2017	339.9	29.9
2018	131.0	30.6
2019	410.9	29.7
2020	555.6	29.3
2021	243.7	29.6

Year	Rainfall (mm/yr)	Temperature (°C)
No.	74	74
Min	13	26.2
Max	556	30.6
Average	157	27.4
STD	113	0.9

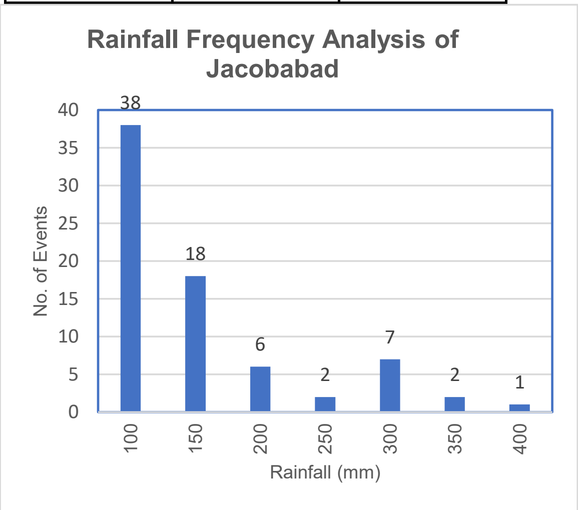


Annexure A: Annual Rainfall & Mean Temperature of Jacobabad (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	135.4	27.1
1949	280.4	26.7
1950	103.4	26.0
1951	75.0	27.0
1952	59.0	27.1
1953	98.2	27.7
1954	77.4	27.1
1955	91.8	27.0
1956	188.6	26.5
1957	60.0	26.2
1958	55.7	27.7
1959	146.5	27.3
1960	64.7	26.7
1961	140.9	26.5
1962	72.1	27.0
1963	31.4	27.6
1964	61.5	26.6
1965	45.8	26.6
1966	35.3	26.7
1967	254.6	26.4
1968	32.3	26.6
1969	22.3	27.5
1970	132.1	27.3
1971	65.3	27.1
1972	39.0	26.5
1973	26.8	26.9
1974	21.7	26.5
1975	285.7	26.5
1976	173.7	26.6
1977	79.0	27.3
1978	329.0	26.7
1979	123.5	26.6
1980	24.4	27.1
1981	157.3	27.0
1982	117.2	26.3
1983	107.9	26.5
1984	74.8	26.7

Year	Rainfall (mm/yr)	Temperature (°C)
1985	185.1	26.8
1986	153.7	26.2
1987	35.3	27.0
1988	84.7	27.5
1989	219.4	26.3
1990	133.6	27.0
1991	41.0	26.6
1992	140.3	26.8
1993	45.6	27.3
1994	375.5	26.9
1995	109.9	26.9
1996	96.6	26.6
1997	259.8	26.1
1998	71.6	27.4
1999	137.8	27.4
2000	30.1	27.4
2001	86.7	27.5
2002	20.1	27.7
2003	253.3	27.1
2004	51.2	27.9
2005	66.6	26.9
2006	97.3	26.9
2007	150.3	27.6
2008	112.6	27.4
2009	57.7	27.9
2010	219.8	28.2
2011	146.7	27.3
2012	57.2	26.9
2013	117.1	27.1
2014	77.6	27.7
2015	256.0	29.8
2016	136.7	30.6
2017	139.6	30.2
2018	79.5	30.6
2019	312.8	29.7
2020	264.7	29.4
2021	144.8	30.1

Year	Rainfall (mm/yr)	Temperature (°C)
No.	74	74
Min	20	26.0
Max	375	30.6
Average	120	27.3
STD	83	1.0

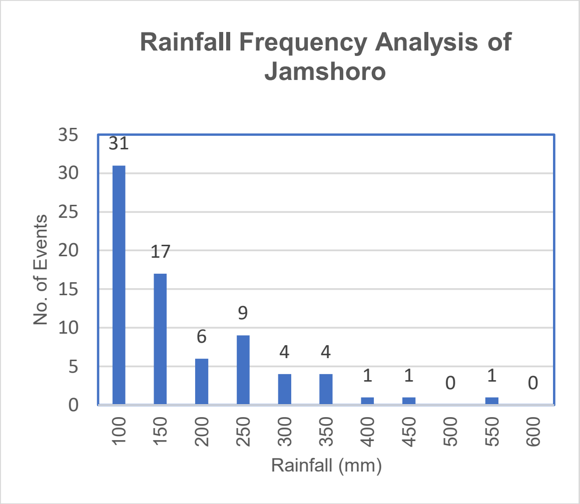


Annexure A: Annual Rainfall & Mean Temperature of Jamshoro (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	118.1	25.7
1949	203.5	25.6
1950	108.9	24.9
1951	51.1	25.7
1952	108.8	25.7
1953	177.2	26.2
1954	134.3	25.9
1955	136.0	25.6
1956	319.7	25.2
1957	53.5	25.2
1958	124.2	26.4
1959	248.5	25.8
1960	81.0	25.6
1961	310.9	25.2
1962	163.6	25.5
1963	24.4	26.1
1964	79.7	25.3
1965	86.7	25.6
1966	49.3	25.6
1967	406.8	25.3
1968	25.6	25.4
1969	25.1	26.1
1970	225.6	25.9
1971	55.7	25.7
1972	27.7	25.3
1973	82.7	25.7
1974	22.8	25.5
1975	169.3	25.5
1976	267.8	25.6
1977	220.1	26.3
1978	328.6	25.6
1979	182.7	25.7
1980	90.9	26.1
1981	133.2	26.0
1982	94.7	25.6
1983	186.6	25.5
1984	140.6	25.3

Year	Rainfall (mm/yr)	Temperature (°C)
1985	139.3	25.7
1986	131.7	25.4
1987	10.2	26.2
1988	183.7	26.7
1989	111.3	25.4
1990	114.0	25.6
1991	21.2	25.6
1992	203.1	25.6
1993	43.0	26.5
1994	259.2	25.6
1995	72.0	25.9
1996	61.4	25.7
1997	130.7	25.3
1998	47.5	26.4
1999	55.3	26.4
2000	48.2	26.3
2001	95.0	26.5
2002	28.9	26.4
2003	254.0	26.4
2004	32.1	27.0
2005	73.3	26.0
2006	207.8	26.0
2007	223.0	26.8
2008	90.6	26.3
2009	149.2	27.1
2010	142.5	27.1
2011	80.1	26.6
2012	77.8	26.2
2013	113.2	26.3
2014	63.2	26.7
2015	251.7	28.8
2016	238.5	29.4
2017	306.0	29.2
2018	114.5	29.5
2019	382.1	28.4
2020	500.7	27.9
2021	247.3	28.2

Year	Rainfall (mm/yr)	Temperature (°C)
No.	74	74
Min	10	24.9
Max	501	29.5
Average	143	26.2
STD	102	1.0

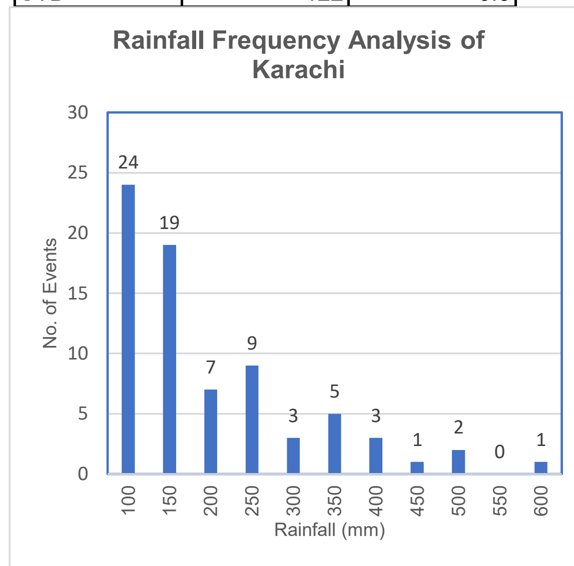


Annexure A: Annual Rainfall & Mean Temperature of Karachi (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	196.1	25.9
1949	228.3	25.7
1950	127.8	25.1
1951	52.2	25.8
1952	134.9	25.8
1953	200.6	26.3
1954	232.5	26.0
1955	122.3	25.7
1956	345.9	25.4
1957	55.3	25.4
1958	154.6	26.4
1959	314.5	25.9
1960	102.7	25.7
1961	465.5	25.4
1962	217.2	25.5
1963	27.3	26.1
1964	100.5	25.4
1965	99.0	25.7
1966	57.1	25.8
1967	472.0	25.5
1968	39.2	25.4
1969	43.0	26.1
1970	254.3	25.9
1971	58.8	25.8
1972	46.0	25.3
1973	128.2	25.7
1974	29.3	25.5
1975	134.1	25.5
1976	306.3	25.7
1977	360.0	26.4
1978	362.7	25.8
1979	264.7	25.9
1980	128.3	26.1
1981	126.3	26.1
1982	128.3	25.9
1983	173.6	25.7
1984	165.4	25.5

Year	Rainfall (mm/yr)	Temperature (°C)
1985	148.0	25.9
1986	120.5	25.6
1987	8.7	26.3
1988	196.7	26.8
1989	39.4	25.7
1990	130.5	25.8
1991	32.1	25.9
1992	195.1	25.8
1993	37.2	26.8
1994	360.8	25.9
1995	32.4	26.2
1996	111.3	25.9
1997	135.2	25.7
1998	77.4	26.8
1999	48.4	26.6
2000	62.9	26.6
2001	102.0	26.8
2002	61.1	26.4
2003	247.1	26.5
2004	41.6	27.0
2005	83.3	26.3
2006	209.7	26.1
2007	266.8	26.8
2008	104.5	26.4
2009	232.7	27.1
2010	160.6	27.1
2011	39.5	26.7
2012	94.0	26.3
2013	139.0	26.4
2014	81.8	26.6
2015	228.4	27.4
2016	241.4	27.6
2017	347.6	27.5
2018	104.2	27.7
2019	403.1	27.1
2020	599.4	26.7
2021	300.0	26.8

Year	Rainfall (mm/yr)	Temperature (°C)
No.	74	74
Min	9	25.1
Max	599	27.7
Average	166	26.1
STD	122	0.6

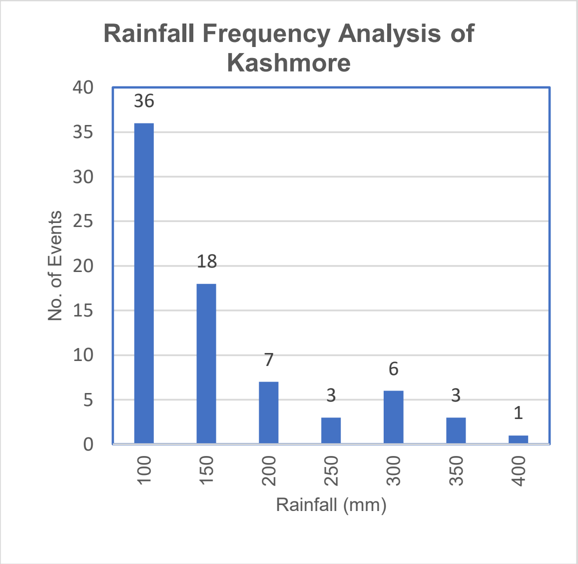


Annexure A: Annual Rainfall & Mean Temperature of Kashmore (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	118.5	26.7
1949	290.7	26.3
1950	80.8	25.6
1951	68.0	26.7
1952	50.5	26.8
1953	101.2	27.4
1954	65.6	26.8
1955	95.7	26.6
1956	185.9	26.2
1957	54.6	25.9
1958	39.0	27.4
1959	146.1	26.9
1960	54.2	26.3
1961	133.5	26.1
1962	75.6	26.7
1963	43.5	27.2
1964	81.4	26.3
1965	55.4	26.3
1966	44.5	26.3
1967	244.7	26.0
1968	28.8	26.3
1969	20.3	27.1
1970	127.5	26.9
1971	77.7	26.6
1972	40.3	26.1
1973	43.2	26.5
1974	37.8	26.2
1975	302.7	26.1
1976	184.3	26.2
1977	89.6	26.9
1978	334.5	26.4
1979	109.6	26.3
1980	27.3	26.8
1981	158.6	26.7
1982	109.6	26.0
1983	109.1	26.1
1984	87.6	26.3

Year	Rainfall (mm/yr)	Temperature (°C)
1985	180.5	26.5
1986	146.8	25.9
1987	41.7	26.7
1988	72.2	27.1
1989	210.5	25.9
1990	134.6	26.6
1991	36.6	26.3
1992	108.9	26.4
1993	53.7	27.0
1994	386.1	26.5
1995	106.6	26.5
1996	100.4	26.3
1997	257.9	25.6
1998	72.0	27.1
1999	139.2	27.1
2000	33.0	27.0
2001	97.6	27.0
2002	21.8	27.3
2003	253.0	26.7
2004	59.8	27.5
2005	76.5	26.5
2006	105.0	26.5
2007	159.2	27.2
2008	124.9	27.0
2009	62.2	27.5
2010	255.9	27.7
2011	144.1	26.9
2012	73.7	26.6
2013	143.1	26.8
2014	82.1	26.9
2015	290.9	30.0
2016	199.2	30.9
2017	206.4	30.4
2018	96.3	30.7
2019	304.5	29.7
2020	282.7	29.2
2021	189.7	29.9

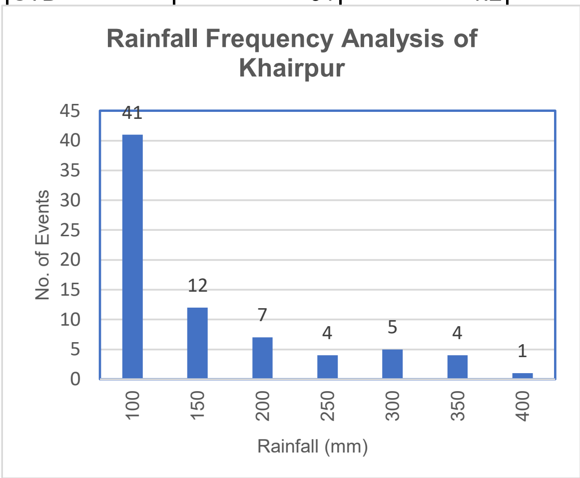
Year	Rainfall (mm/yr)	Temperature (°C)
No.	74	74
Min	20	25.6
Max	386	30.9
Average	125	26.9
STD	86	1.1



Annexure A: Annual Rainfall & Mean Temperature of Khairpur (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	71.2	26.6
1949	256.7	26.4
1950	76.2	25.7
1951	30.2	26.6
1952	66.2	26.7
1953	122.6	27.1
1954	77.7	26.8
1955	118.3	26.5
1956	142.6	26.0
1957	34.5	25.9
1958	60.3	27.2
1959	164.7	26.6
1960	50.2	26.3
1961	209.6	25.9
1962	115.7	26.4
1963	31.8	26.9
1964	135.4	26.1
1965	58.1	26.2
1966	43.8	26.3
1967	240.8	25.9
1968	18.8	26.2
1969	14.9	27.1
1970	114.4	26.7
1971	83.7	26.5
1972	34.9	26.2
1973	52.3	26.4
1974	17.8	26.3
1975	263.3	26.1
1976	160.3	26.3
1977	93.4	27.0
1978	340.2	26.3
1979	98.4	26.3
1980	38.1	26.8
1981	94.4	26.7
1982	94.1	26.1
1983	157.2	26.1
1984	78.3	26.1
1985	114.8	26.5
1986	93.0	26.1
1987	19.8	27.0
1988	120.1	27.3
1989	175.5	25.9
1990	81.4	26.4
1991	11.8	26.1
1992	107.5	26.2
1993	72.5	26.9
1994	336.5	26.3
1995	90.0	26.4
1996	72.9	26.2
1997	188.2	25.6
1998	62.0	26.9
1999	97.1	26.8
2000	40.8	26.8
2001	64.0	26.8
2002	10.5	27.2
2003	283.0	26.9
2004	35.8	27.6
2005	42.8	26.4
2006	203.3	26.5
2007	160.4	27.4
2008	80.2	27.0
2009	89.0	27.7
2010	191.4	27.8
2011	147.5	27.1
2012	78.1	26.7
2013	125.5	26.8
2014	61.0	27.4
2015	265.6	29.8
2016	253.8	30.6
2017	334.2	30.4
2018	116.6	30.9
2019	349.5	30.2
2020	366.9	29.6
2021	223.3	29.9

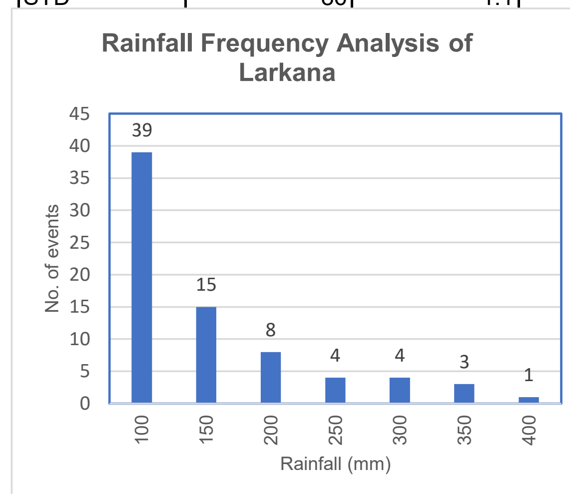
Year	Rainfall (mm/yr)	Temperature (°C)
No.	74	74
Min	11	25.6
Max	367	30.9
Average	122	26.9
STD	91	1.2



Annexure A: Annual Rainfall & Mean Temperature of Larkana (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	135.5	27.1
1949	248.2	26.7
1950	112.6	26.1
1951	57.7	27.0
1952	69.7	27.1
1953	138.9	27.7
1954	81.8	27.2
1955	76.0	27.0
1956	149.5	26.6
1957	51.5	26.4
1958	72.2	27.7
1959	162.0	27.3
1960	63.5	26.7
1961	181.3	26.6
1962	94.9	27.0
1963	20.9	27.6
1964	61.9	26.7
1965	40.3	26.7
1966	31.8	26.9
1967	271.1	26.5
1968	24.5	26.7
1969	27.2	27.5
1970	138.6	27.4
1971	49.7	27.1
1972	31.4	26.6
1973	24.4	27.0
1974	17.7	26.7
1975	257.9	26.6
1976	161.0	26.7
1977	75.3	27.4
1978	317.0	26.8
1979	100.1	26.7
1980	36.7	27.2
1981	137.9	27.1
1982	93.8	26.5
1983	110.9	26.6
1984	69.8	26.7
1985	167.6	26.9
1986	147.8	26.4
1987	24.4	27.2
1988	101.5	27.6
1989	195.7	26.4
1990	93.7	27.0
1991	33.5	26.7
1992	148.3	26.9
1993	39.9	27.5
1994	354.1	26.9
1995	108.9	27.0
1996	82.1	26.7
1997	219.2	26.2
1998	60.8	27.5
1999	102.7	27.5
2000	31.0	27.4
2001	72.6	27.6
2002	17.6	27.8
2003	248.1	27.3
2004	32.2	28.0
2005	52.9	27.0
2006	104.8	27.0
2007	165.8	27.7
2008	92.6	27.5
2009	54.7	28.1
2010	180.3	28.3
2011	128.5	27.5
2012	40.4	27.1
2013	83.6	27.2
2014	59.8	27.9
2015	271.4	30.4
2016	187.6	31.2
2017	263.8	30.8
2018	96.4	31.2
2019	323.1	30.0
2020	343.5	29.7
2021	202.8	30.4

Year	Rainfall (mm/yr)	Temperature (°C)
No.	74	74
Min	18	26.1
Max	354	31.2
Average	118	27.4
STD	86	1.1

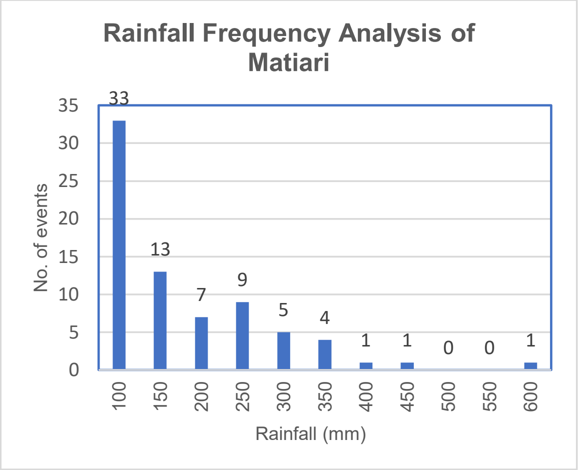


Annexure A: Annual Rainfall & Mean Temperature of Matiari (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	45.1	26.9
1949	217.4	26.8
1950	85.4	26.1
1951	50.5	26.9
1952	92.7	26.9
1953	155.4	27.3
1954	95.4	27.1
1955	182.4	26.8
1956	317.6	26.2
1957	57.0	26.4
1958	112.0	27.6
1959	237.4	27.0
1960	61.4	26.8
1961	279.7	26.4
1962	181.7	26.7
1963	30.3	27.3
1964	121.9	26.4
1965	102.8	26.7
1966	60.4	26.9
1967	354.3	26.5
1968	24.1	26.7
1969	12.5	27.4
1970	232.7	27.2
1971	67.6	27.0
1972	28.1	26.8
1973	71.2	26.9
1974	16.4	26.9
1975	195.1	26.8
1976	280.5	26.9
1977	157.2	27.6
1978	341.3	26.8
1979	145.1	27.0
1980	71.9	27.4
1981	74.7	27.3
1982	81.4	26.9
1983	235.7	26.8
1984	150.2	26.5

Year	Rainfall (mm/yr)	Temperature (°C)
1985	106.2	27.1
1986	135.9	26.8
1987	14.4	27.8
1988	219.2	28.0
1989	152.1	26.4
1990	127.4	26.7
1991	11.4	26.5
1992	211.2	26.6
1993	62.0	27.4
1994	300.9	26.6
1995	97.0	26.8
1996	40.9	26.8
1997	109.4	26.2
1998	54.2	27.2
1999	63.0	27.2
2000	55.3	27.2
2001	99.8	27.3
2002	13.2	27.5
2003	292.9	27.7
2004	31.6	28.2
2005	76.1	27.0
2006	284.6	27.2
2007	218.9	28.0
2008	85.8	27.5
2009	148.7	28.4
2010	136.5	28.4
2011	130.7	27.8
2012	92.8	27.4
2013	131.0	27.6
2014	74.1	27.9
2015	256.7	29.5
2016	246.2	30.2
2017	339.4	29.7
2018	130.7	30.0
2019	410.6	29.2
2020	557.2	28.8
2021	239.7	29.2

Year	Rainfall (mm/yr)	Temperature (°C)
No.	74	74
Min	11	26.1
Max	557	30.2
Average	146	27.3
STD	108	0.9

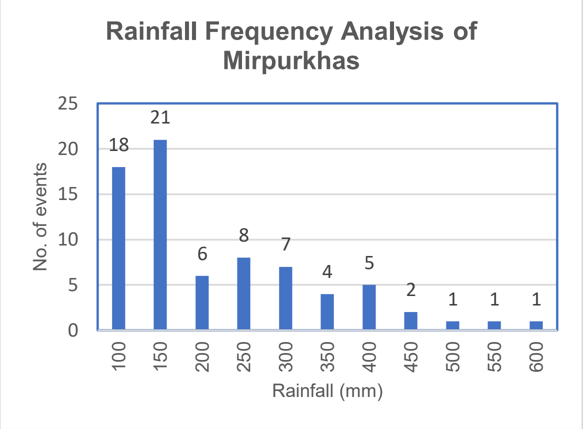


Annexure A: Annual Rainfall & Mean Temperature of Mirpurkhas (GLDAS)

Year	Rainfall (mm/yr)	Temperature (^oC)
1948	29.4	26.7
1949	227.1	26.7
1950	122.2	25.9
1951	64.1	26.6
1952	132.6	26.7
1953	194.2	27.0
1954	107.5	26.8
1955	234.3	26.5
1956	353.2	26.0
1957	97.6	26.1
1958	142.0	27.2
1959	313.4	26.6
1960	62.0	26.5
1961	372.5	26.1
1962	179.3	26.4
1963	67.3	26.9
1964	244.8	26.1
1965	146.5	26.4
1966	80.9	26.6
1967	339.9	26.2
1968	51.9	26.4
1969	12.3	27.2
1970	280.4	26.8
1971	135.4	26.6
1972	63.1	26.6
1973	121.2	26.6
1974	17.4	26.7
1975	259.3	26.4
1976	314.4	26.6
1977	172.7	27.3
1978	364.0	26.5
1979	162.5	26.7
1980	65.0	27.1
1981	38.9	27.0
1982	124.0	26.6
1983	292.9	26.4
1984	205.6	26.1

Year	Rainfall (mm/yr)	Temperature (^oC)
1985	135.3	26.8
1986	112.5	26.7
1987	22.4	27.7
1988	271.1	27.8
1989	103.4	26.2
1990	269.3	26.4
1991	17.9	26.3
1992	204.7	26.3
1993	127.6	27.1
1994	256.1	26.3
1995	131.0	26.6
1996	84.0	26.6
1997	156.6	25.9
1998	133.2	26.9
1999	76.7	26.9
2000	100.5	26.8
2001	101.5	26.8
2002	19.1	27.3
2003	372.1	27.4
2004	71.7	27.9
2005	123.0	26.6
2006	454.7	27.0
2007	270.8	27.8
2008	117.7	27.2
2009	216.1	28.2
2010	248.4	28.0
2011	214.8	27.5
2012	128.9	27.1
2013	173.4	27.2
2014	129.4	27.7
2015	408.2	29.5
2016	337.3	29.9
2017	500.7	29.5
2018	148.8	29.9
2019	448.5	29.2
2020	558.5	28.7
2021	378.3	29.0

Year	Rainfall (mm/yr)	Temperature (^oC)
No.	74	74
Min	12	25.9
Max	558	29.9
Average	187	27.0
STD	126	0.9

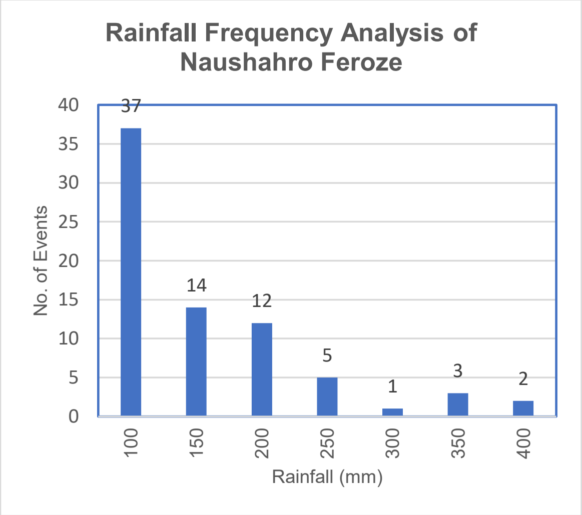


Annexure A: Annual Rainfall & Mean Temperature of Naushahro Feroze (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	108.6	26.8
1949	227.4	26.6
1950	108.8	25.9
1951	57.9	26.8
1952	77.0	26.8
1953	157.1	27.4
1954	76.9	26.9
1955	90.0	26.7
1956	171.5	26.3
1957	46.1	26.2
1958	92.9	27.5
1959	185.2	27.0
1960	67.0	26.5
1961	214.0	26.3
1962	117.0	26.7
1963	22.1	27.3
1964	75.7	26.4
1965	52.9	26.5
1966	34.8	26.7
1967	308.6	26.3
1968	17.9	26.5
1969	25.9	27.2
1970	164.7	27.1
1971	51.0	26.8
1972	29.5	26.4
1973	42.0	26.7
1974	20.7	26.5
1975	232.9	26.5
1976	184.7	26.6
1977	109.4	27.3
1978	321.4	26.6
1979	125.5	26.6
1980	57.1	27.0
1981	140.3	26.9
1982	86.0	26.4
1983	134.1	26.5

Year	Rainfall (mm/yr)	Temperature (°C)
1984	73.4	26.4
1985	148.7	26.7
1986	140.7	26.3
1987	17.6	27.1
1988	127.2	27.5
1989	177.6	26.2
1990	74.5	26.7
1991	25.4	26.5
1992	152.0	26.6
1993	43.4	27.3
1994	316.9	26.6
1995	107.4	26.8
1996	64.8	26.6
1997	189.4	26.1
1998	52.0	27.3
1999	85.5	27.3
2000	33.4	27.2
2001	79.3	27.4
2002	17.4	27.5
2003	247.9	27.3
2004	28.1	27.9
2005	59.5	26.9
2006	133.5	26.8
2007	183.3	27.6
2008	86.8	27.3
2009	77.7	28.0
2010	169.3	28.1
2011	120.1	27.4
2012	48.7	27.0
2013	85.8	27.1
2014	50.3	27.7
2015	238.3	30.7
2016	199.3	31.7
2017	284.5	31.1
2018	102.1	31.4
2019	355.4	30.2

Year	Rainfall (mm/yr)	Temperature (°C)
2020	394.1	29.7
2021	188.8	30.4
No.	74	74
Min	17	25.9
Max	394	31.7
Average	122	27.2
STD	87	1.2

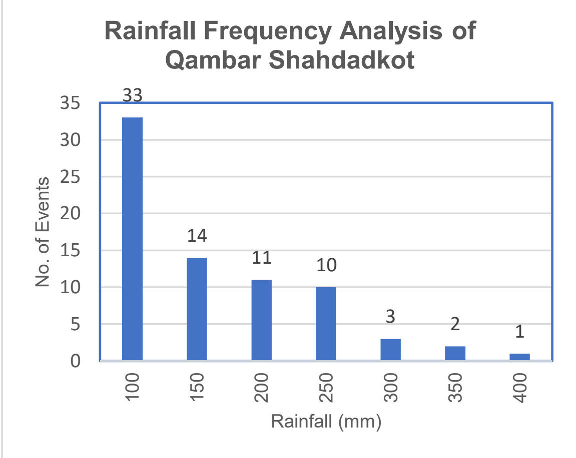


Annexure A: Annual Rainfall & Mean Temperature of Qambar Shahdadkot (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	184.6	26.6
1949	216.4	26.3
1950	177.3	25.6
1951	105.8	26.5
1952	104.1	26.6
1953	179.0	27.2
1954	114.2	26.7
1955	91.2	26.5
1956	224.3	26.1
1957	83.1	25.9
1958	119.1	27.3
1959	207.3	26.8
1960	93.8	26.2
1961	225.4	26.2
1962	94.9	26.6
1963	22.1	27.2
1964	48.9	26.2
1965	47.1	26.3
1966	36.9	26.5
1967	277.9	26.2
1968	32.4	26.3
1969	48.4	27.1
1970	186.5	27.0
1971	33.7	26.7
1972	50.1	26.0
1973	31.7	26.5
1974	22.0	26.2
1975	245.2	26.2
1976	199.6	26.3
1977	91.5	27.1
1978	293.9	26.5
1979	116.0	26.3
1980	49.4	26.8
1981	131.3	26.7
1982	135.8	26.1
1983	129.3	26.3

Year	Rainfall (mm/yr)	Temperature (°C)
1984	68.9	26.4
1985	193.3	26.5
1986	187.0	26.0
1987	35.8	26.7
1988	131.8	27.2
1989	205.7	26.0
1990	147.8	26.7
1991	62.8	26.4
1992	212.5	26.5
1993	46.5	27.1
1994	322.0	26.6
1995	130.1	26.6
1996	98.2	26.4
1997	236.4	25.9
1998	96.1	27.2
1999	89.3	27.2
2000	42.8	27.2
2001	85.6	27.4
2002	29.0	27.5
2003	245.2	27.0
2004	43.6	27.6
2005	79.9	26.8
2006	102.7	26.7
2007	178.3	27.4
2008	104.2	27.2
2009	68.3	27.8
2010	183.1	28.0
2011	142.1	27.2
2012	28.4	26.8
2013	93.9	26.8
2014	82.5	27.5
2015	272.3	29.8
2016	209.9	30.6
2017	198.9	30.1
2018	95.5	30.6
2019	375.8	29.4

Year	Rainfall (mm/yr)	Temperature (°C)
2020	339.6	29.1
2021	166.5	29.9
No.	74	74
Min	22	25.6
Max	376	30.6
Average	134	27.0
STD	84	1.1

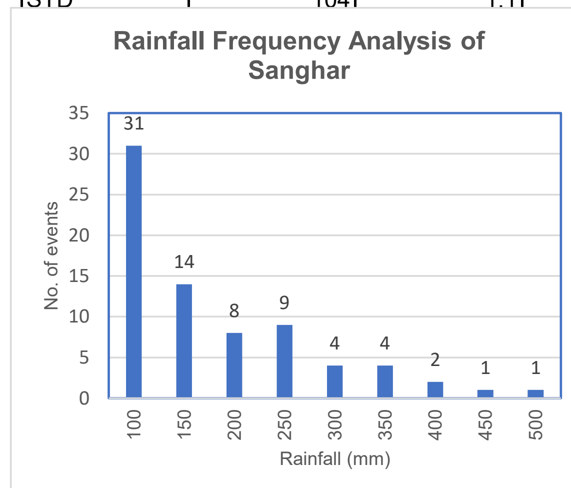


Annexure A: Annual Rainfall & Mean Temperature of Sanghar (GLDAS)

Year	Rainfall (mm/yr)	Temperature (^{o}C)
1948	41.6	26.6
1949	225.4	26.5
1950	93.2	25.7
1951	47.4	26.6
1952	94.5	26.6
1953	141.5	27.0
1954	86.7	26.8
1955	188.7	26.5
1956	246.6	25.9
1957	61.5	25.9
1958	97.7	27.1
1959	225.2	26.5
1960	56.6	26.3
1961	304.9	25.9
1962	146.9	26.3
1963	45.5	26.8
1964	200.7	26.0
1965	99.8	26.2
1966	62.0	26.4
1967	262.5	25.9
1968	37.4	26.2
1969	13.3	27.1
1970	171.4	26.7
1971	110.1	26.4
1972	55.5	26.4
1973	91.9	26.4
1974	17.6	26.5
1975	249.9	26.2
1976	233.8	26.4
1977	144.4	27.1
1978	356.3	26.4
1979	120.1	26.5
1980	50.3	26.9
1981	67.2	26.8
1982	122.8	26.3
1983	239.6	26.2

Year	Rainfall (mm/yr)	Temperature (^{o}C)
1984	145.6	26.1
1985	107.1	26.7
1986	90.4	26.4
1987	21.6	27.4
1988	201.0	27.6
1989	133.0	26.0
1990	179.4	26.3
1991	9.9	26.2
1992	138.6	26.2
1993	112.5	26.9
1994	285.7	26.2
1995	111.2	26.4
1996	73.6	26.3
1997	151.4	25.6
1998	91.2	26.8
1999	79.1	26.7
2000	64.0	26.7
2001	90.0	26.7
2002	9.0	27.2
2003	334.3	27.1
2004	48.4	27.7
2005	70.5	26.4
2006	341.7	26.7
2007	188.9	27.5
2008	85.8	27.0
2009	151.6	28.0
2010	231.2	27.9
2011	186.3	27.3
2012	107.1	26.8
2013	159.1	27.0
2014	87.8	27.5
2015	316.0	29.6
2016	294.5	30.2
2017	400.2	29.9
2018	134.3	30.3
2019	393.4	29.7

Year	Rainfall (mm/yr)	Temperature (^{o}C)
2020	458.7	29.2
2021	286.8	29.4
No.	74	74
Min	9	25.6
Max	459	30.3
Average	151	26.9
STD	104	1.1

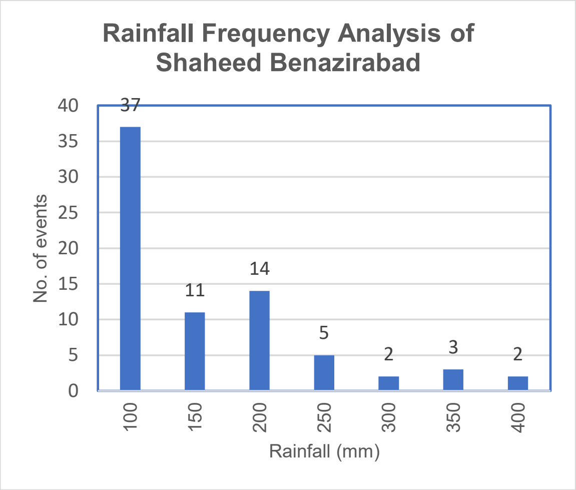


Annexure A: Annual Rainfall & Mean Temperature of Shaheed Benazirabad (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	63.6	26.6
1949	227.6	26.5
1950	86.6	25.8
1951	50.0	26.6
1952	75.1	26.7
1953	151.3	27.1
1954	74.8	26.8
1955	126.5	26.6
1956	197.2	26.0
1957	41.4	26.1
1958	90.3	27.3
1959	194.0	26.8
1960	61.5	26.5
1961	223.1	26.1
1962	140.2	26.5
1963	25.3	27.1
1964	104.9	26.2
1965	71.3	26.4
1966	44.6	26.5
1967	319.2	26.2
1968	15.9	26.3
1969	16.6	27.1
1970	178.2	26.9
1971	60.9	26.7
1972	24.1	26.4
1973	52.6	26.6
1974	19.0	26.4
1975	217.3	26.4
1976	206.7	26.5
1977	122.8	27.2
1978	338.5	26.5
1979	135.0	26.6
1980	61.4	27.0
1981	119.0	26.9
1982	76.4	26.4
1983	172.5	26.4
1984	84.3	26.2

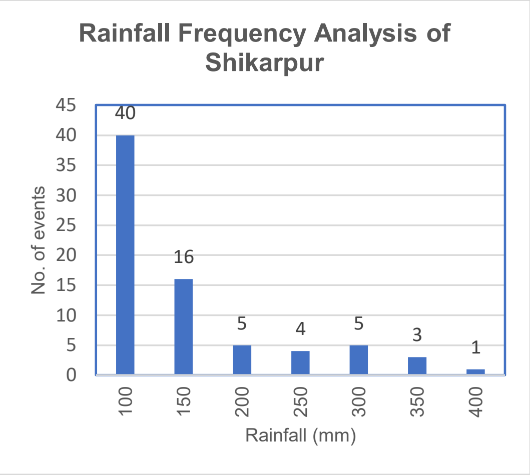
Year	Rainfall (mm/yr)	Temperature (°C)
1985	118.1	26.7
1986	127.7	26.3
1987	14.2	27.2
1988	159.6	27.5
1989	164.8	26.1
1990	69.9	26.4
1991	13.9	26.3
1992	152.3	26.4
1993	53.6	27.1
1994	315.8	26.4
1995	98.1	26.6
1996	49.6	26.4
1997	151.2	25.9
1998	43.0	27.0
1999	78.2	27.0
2000	39.5	27.0
2001	86.4	27.1
2002	15.5	27.3
2003	264.6	27.2
2004	27.8	27.8
2005	60.4	26.7
2006	193.4	26.8
2007	188.3	27.6
2008	82.3	27.2
2009	106.1	28.0
2010	153.6	28.0
2011	120.6	27.4
2012	69.4	27.0
2013	106.6	27.1
2014	49.1	27.6
2015	191.3	30.1
2016	202.6	31.0
2017	298.1	30.6
2018	97.9	30.8
2019	372.0	29.9
2020	386.8	29.3
2021	191.2	29.9

Year	Rainfall (mm/yr)	Temperature (°C)
No.	74	74
Min	14	25.8
Max	387	31.0
Average	124	27.1
STD	89	1.1



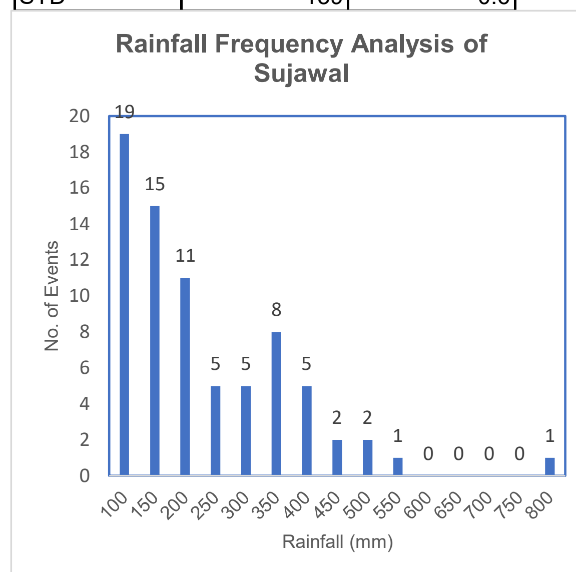
Annexure A: Annual Rainfall & Mean Temperature of Shikarpur (GLDAS)

Year	Rainfall (mm/yr)	Temperature (^oC)
1948	127	27.1
1949	276	26.7
1950	91	26.1
1951	55	27.1
1952	54	27.2
1953	100	27.7
1954	71	27.1
1955	80	27.1
1956	152	26.6
1957	48	26.3
1958	49	27.7
1959	138	27.3
1960	56	26.7
1961	146	26.6
1962	78	27.0
1963	26	27.6
1964	63	26.7
1965	38	26.7
1966	31	26.8
1967	255	26.5
1968	27	26.7
1969	19	27.5
1970	120	27.3
1971	62	27.1
1972	31	26.6
1973	22	26.9
1974	17	26.6
1975	278	26.6
1976	156	26.7
1977	69	27.4
1978	328	26.8
1979	105	26.6
1980	23	27.1
1981	148	27.0
1982	97	26.4
1983	103	26.6
1984	73	26.7
1985	173	26.8
1986	141	26.3
1987	28	27.1
1988	81	27.6
1989	207	26.3
1990	104	27.0
1991	31	26.7
1992	126	26.8
1993	40	27.4
1994	374	26.9
1995	100	26.9
1996	89	26.7
1997	240	26.1
1998	59	27.5
1999	129	27.4
2000	27	27.4
2001	74	27.5
2002	16	27.7
2003	251	27.2
2004	40	27.9
2005	52	26.9
2006	98	26.9
2007	149	27.6
2008	100	27.4
2009	50	28.0
2010	201	28.2
2011	136	27.4
2012	53	27.0
2013	100	27.1
2014	66	27.8
2015	266	29.9
2016	171	30.6
2017	222	30.3
2018	91	30.7
2019	320	29.7
2020	317	29.5
2021	186	30.1
No.	74	74
Min	16	26.1
Max	374	30.7
Average	115	27.3
STD	86	1.0



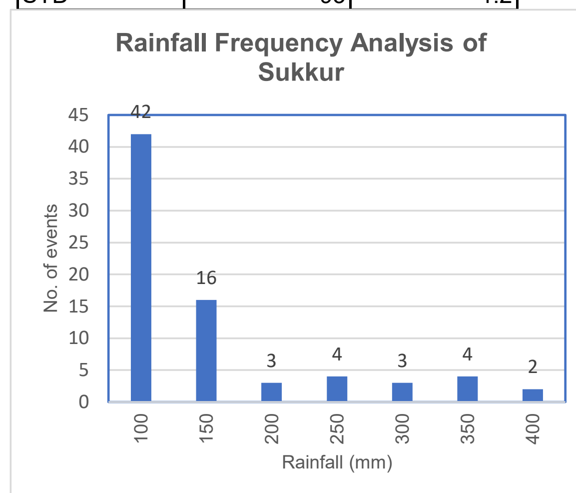
Annexure A: Annual Rainfall & Mean Temperature of Sujawal (GLDAS)

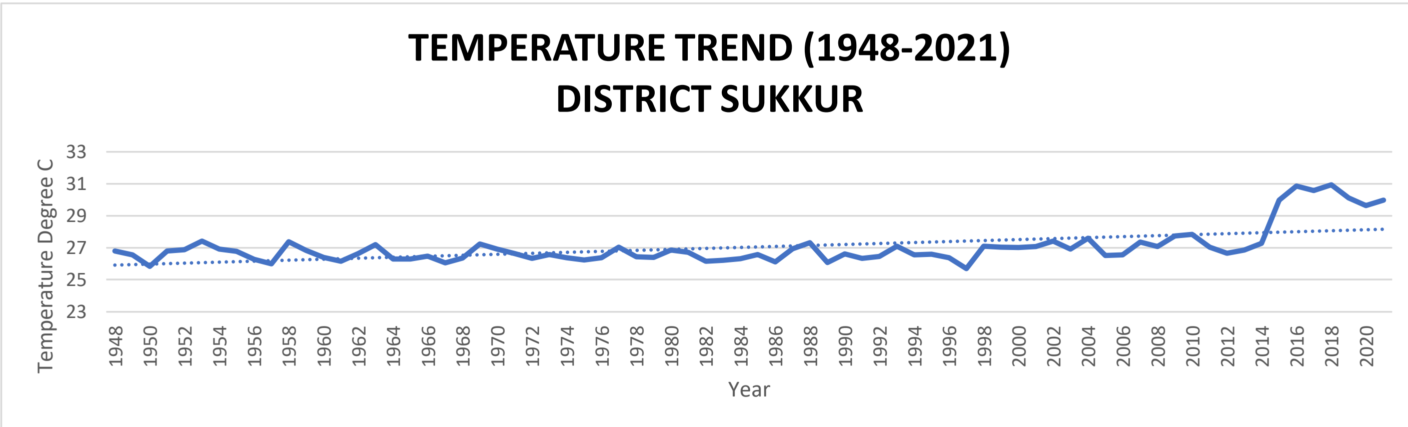
Year	Rainfall (mm/yr)	Temperature (°C)
1948	121	26.6
1949	234	26.6
1950	115	25.9
1951	66	26.6
1952	185	26.5
1953	220	27.0
1954	213	26.7
1955	189	26.5
1956	384	26.1
1957	82	26.2
1958	168	27.2
1959	356	26.6
1960	83	26.5
1961	445	26.1
1962	253	26.3
1963	63	26.9
1964	180	26.1
1965	153	26.5
1966	81	26.6
1967	497	26.2
1968	43	26.3
1969	41	26.9
1970	317	26.7
1971	107	26.6
1972	62	26.3
1973	141	26.5
1974	33	26.6
1975	188	26.4
1976	319	26.6
1977	318	27.3
1978	312	26.6
1979	275	26.7
1980	163	26.9
1981	95	26.8
1982	96	26.7
1983	247	26.5
1984	225	26.2
1985	134	26.7
1986	123	26.5
1987	12	27.3
1988	262	27.6
1989	117	26.4
1990	166	26.5
1991	30	26.5
1992	278	26.5
1993	72	27.4
1994	295	26.6
1995	72	26.8
1996	79	26.7
1997	117	26.4
1998	129	27.3
1999	56	27.2
2000	114	27.1
2001	137	27.2
2002	52	27.1
2003	308	27.3
2004	74	27.8
2005	158	26.9
2006	354	27.0
2007	356	27.7
2008	136	27.1
2009	302	27.9
2010	303	27.8
2011	120	27.4
2012	118	27.1
2013	158	27.2
2014	151	27.5
2015	371	28.6
2016	301	28.7
2017	505	28.5
2018	110	28.9
2019	495	28.3
2020	753	27.6
2021	402	27.9
No.	74	74
Min	12	25.9
Max	753	28.9
Average	200	26.9
STD	139	0.6

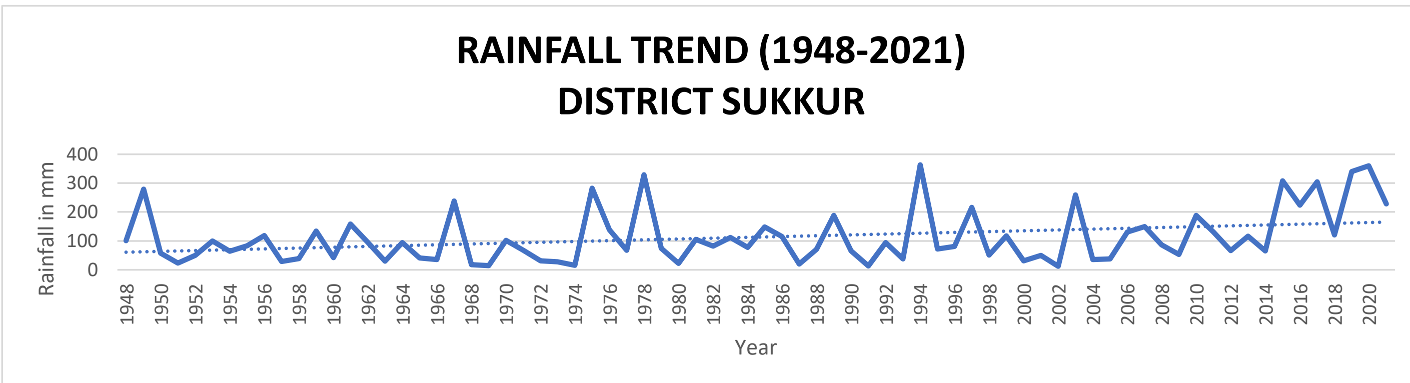


Annexure A: Annual Rainfall & Mean Temperature of Sukkur (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	101	26.8
1949	279	26.5
1950	59	25.8
1951	24	26.8
1952	50	26.9
1953	100	27.4
1954	65	26.9
1955	83	26.8
1956	119	26.3
1957	29	26.0
1958	40	27.4
1959	134	26.8
1960	43	26.4
1961	158	26.1
1962	96	26.6
1963	30	27.2
1964	95	26.3
1965	42	26.3
1966	37	26.5
1967	237	26.1
1968	18	26.3
1969	15	27.2
1970	102	26.9
1971	68	26.6
1972	32	26.3
1973	29	26.6
1974	16	26.4
1975	282	26.2
1976	138	26.4
1977	69	27.0
1978	328	26.4
1979	75	26.4
1980	23	26.8
1981	106	26.7
1982	82	26.1
1983	113	26.2
1984	79	26.3
1985	149	26.6
1986	116	26.1
1987	21	26.9
1988	71	27.3
1989	188	26.1
1990	66	26.6
1991	14	26.3
1992	95	26.5
1993	39	27.1
1994	363	26.5
1995	73	26.6
1996	81	26.4
1997	216	25.7
1998	51	27.1
1999	118	27.0
2000	32	27.0
2001	50	27.1
2002	12	27.4
2003	259	26.9
2004	36	27.6
2005	38	26.5
2006	131	26.5
2007	149	27.3
2008	87	27.1
2009	54	27.7
2010	187	27.8
2011	131	27.0
2012	68	26.7
2013	117	26.8
2014	67	27.3
2015	308	30.0
2016	223	30.9
2017	304	30.6
2018	122	30.9
2019	339	30.1
2020	360	29.6
2021	228	30.0
No.	74	74
Min	12	25.7
Max	363	30.9
Average	113	27.0
STD	93	1.2




TEMPERATURE TREND (1948-2021)
DISTRICT SUKKUR
Temperature Degree C
33
31
29
27
25
23
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Year

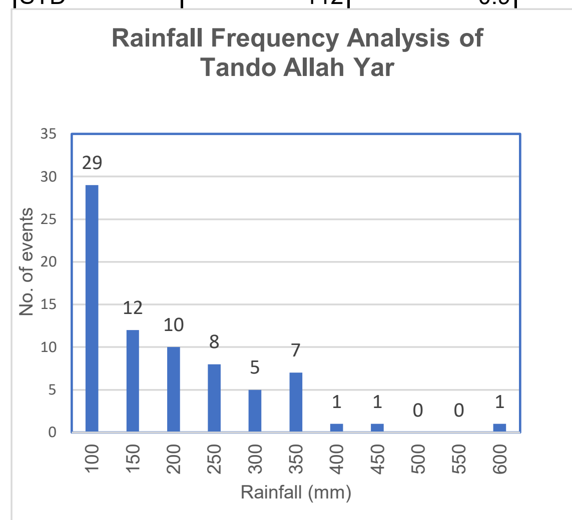

RAINFALL TREND (1948-2021)
DISTRICT SUKKUR
Rainfall in mm
400
300
200
100
0
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Year

Annexure A: Annual Rainfall & Mean Temperature of Tando Allah Yar (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	27.7	26.9
1949	221.9	26.8
1950	93.0	26.0
1951	55.0	26.8
1952	107.1	26.9
1953	166.1	27.2
1954	95.2	27.1
1955	212.5	26.7
1956	347.7	26.2
1957	73.0	26.3
1958	120.9	27.5
1959	266.5	26.9
1960	59.2	26.7
1961	316.7	26.3
1962	191.8	26.6
1963	41.6	27.2
1964	170.7	26.3
1965	123.1	26.7
1966	69.7	26.8
1967	349.5	26.4
1968	33.8	26.6
1969	10.2	27.4
1970	259.2	27.1
1971	91.4	26.9
1972	41.9	26.8
1973	90.0	26.9
1974	15.1	26.9
1975	213.8	26.7
1976	304.6	26.8
1977	162.0	27.6
1978	348.8	26.7
1979	146.9	26.9
1980	69.9	27.3
1981	43.6	27.2
1982	93.6	26.8
1983	269.2	26.7

Year	Rainfall (mm/yr)	Temperature (°C)
1984	185.3	26.4
1985	108.8	27.1
1986	130.4	26.8
1987	17.7	27.8
1988	249.7	28.0
1989	142.3	26.3
1990	182.0	26.6
1991	11.3	26.5
1992	216.5	26.5
1993	86.6	27.3
1994	287.1	26.5
1995	112.4	26.8
1996	48.2	26.7
1997	116.3	26.1
1998	83.2	27.1
1999	65.2	27.1
2000	72.9	27.0
2001	102.4	27.1
2002	13.0	27.5
2003	327.8	27.6
2004	43.7	28.2
2005	93.4	26.9
2006	362.6	27.2
2007	241.0	28.0
2008	95.4	27.5
2009	178.8	28.4
2010	182.0	28.3
2011	166.2	27.8
2012	109.3	27.4
2013	152.4	27.5
2014	98.1	27.9
2015	257.5	29.4
2016	246.6	29.9
2017	340.1	29.4
2018	131.2	29.7
2019	410.7	29.2

Year	Rainfall (mm/yr)	Temperature (°C)
2020	562.2	28.8
2021	245.0	29.2
No.	74	74
Min	10	26.0
Max	562	29.9
Average	159	27.2
STD	112	0.9

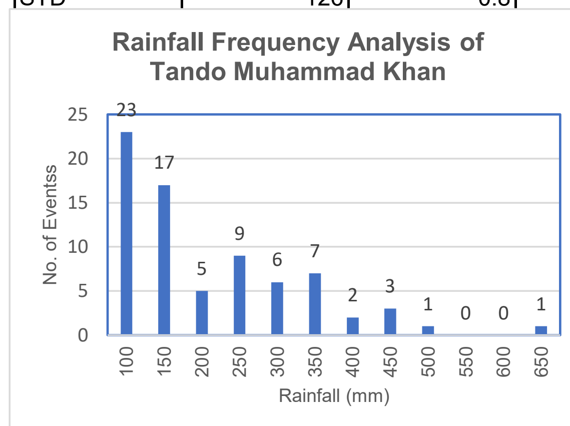


Annexure A: Annual Rainfall & Mean Temperature of Tando Muhammad Khan (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	59	26.8
1949	228	26.8
1950	102	26.0
1951	60	26.8
1952	138	26.8
1953	187	27.2
1954	150	27.0
1955	215	26.7
1956	407	26.2
1957	79	26.4
1958	145	27.5
1959	318	26.9
1960	71	26.7
1961	356	26.3
1962	225	26.6
1963	49	27.2
1964	164	26.3
1965	138	26.7
1966	75	26.8
1967	433	26.4
1968	33	26.6
1969	14	27.3
1970	295	27.0
1971	95	26.9
1972	39	26.7
1973	104	26.8
1974	20	26.9
1975	201	26.7
1976	337	26.8
1977	217	27.6
1978	341	26.8
1979	201	27.0
1980	99	27.3
1981	57	27.2
1982	79	26.9
1983	273	26.8

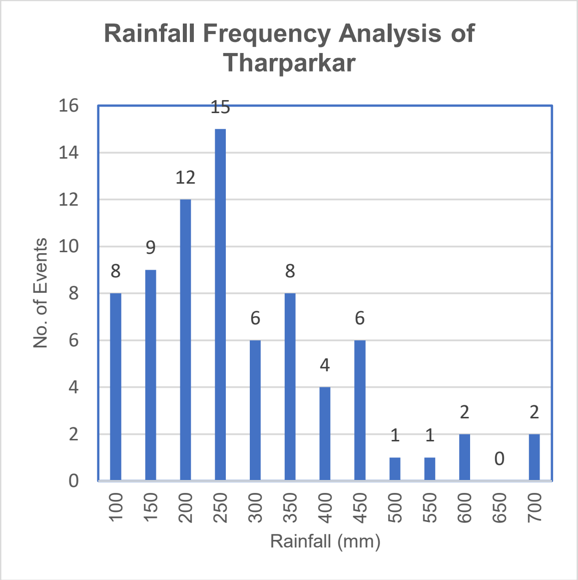
Year	Rainfall (mm/yr)	Temperature (°C)
1984	209	26.4
1985	117	27.0
1986	136	26.8
1987	14	27.7
1988	266	28.0
1989	149	26.4
1990	184	26.6
1991	18	26.6
1992	273	26.6
1993	71	27.4
1994	302	26.6
1995	103	26.9
1996	47	26.8
1997	108	26.3
1998	92	27.2
1999	62	27.2
2000	88	27.1
2001	117	27.2
2002	29	27.4
2003	317	27.6
2004	51	28.2
2005	121	27.0
2006	365	27.2
2007	296	28.0
2008	114	27.4
2009	222	28.3
2010	206	28.2
2011	144	27.8
2012	120	27.4
2013	154	27.5
2014	113	27.9
2015	326	29.2
2016	278	29.5
2017	422	29.2
2018	122	29.8
2019	453	29.0

Year	Rainfall (mm/yr)	Temperature (°C)
2020	638	28.4
2021	313	28.7
No.	74	74
Min	14	26.0
Max	638	29.8
Average	178	27.2
STD	126	0.8



Annexure A: Annual Rainfall & Mean Temperature of Tharparkar (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	120	26.4
1949	231	26.4
1950	224	25.6
1951	104	26.3
1952	208	26.4
1953	248	26.6
1954	234	26.4
1955	294	26.1
1956	447	25.6
1957	148	25.8
1958	280	26.8
1959	450	26.1
1960	82	26.1
1961	549	25.6
1962	186	25.9
1963	167	26.5
1964	359	25.8
1965	215	26.0
1966	118	26.3
1967	346	25.8
1968	96	26.1
1969	45	26.9
1970	266	26.3
1971	238	26.1
1972	100	26.2
1973	234	26.1
1974	43	26.4
1975	399	25.8
1976	348	26.1
1977	308	26.9
1978	383	26.1
1979	227	26.4
1980	112	26.6
1981	191	26.4
1982	204	26.1
1983	337	25.8
1984	282	25.6
1985	206	26.4
1986	99	26.3
1987	39	27.4
1988	312	27.4
1989	103	25.9
1990	435	26.1
1991	61	26.0
1992	253	25.9
1993	201	26.8
1994	357	26.1
1995	166	26.3
1996	182	26.2
1997	199	25.5
1998	225	26.5
1999	128	26.4
2000	166	26.5
2001	192	26.4
2002	43	26.9
2003	444	26.8
2004	143	27.4
2005	231	26.2
2006	576	26.7
2007	334	27.3
2008	159	26.6
2009	270	27.7
2010	414	27.4
2011	304	26.8
2012	197	26.5
2013	248	26.7
2014	196	27.3
2015	446	29.0
2016	348	29.3
2017	684	29.0
2018	156	29.3
2019	592	28.7
2020	659	28.4
2021	485	28.2
No.	74	74
Min	39	25.5
Max	684	29.3
Average	258	26.6
STD	147	0.9

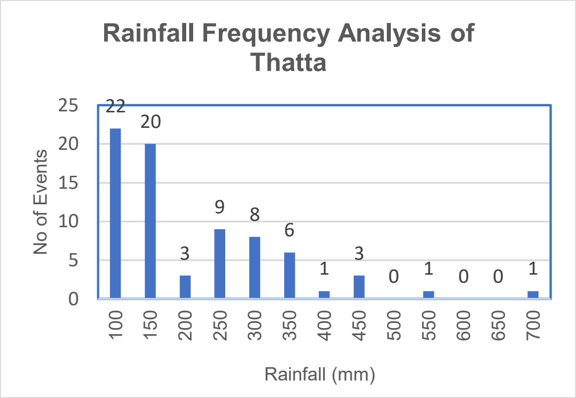


Annexure A: Annual Rainfall & Mean Temperature of Thatta (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	144	26.5
1949	221	26.4
1950	113	25.7
1951	48	26.4
1952	160	26.4
1953	200	26.9
1954	223	26.6
1955	171	26.4
1956	381	25.9
1957	67	26.0
1958	141	27.1
1959	322	26.5
1960	87	26.3
1961	436	26.0
1962	238	26.2
1963	40	26.7
1964	133	26.0
1965	127	26.3
1966	69	26.4
1967	504	26.1
1968	37	26.1
1969	35	26.7
1970	272	26.6
1971	79	26.4
1972	47	26.1
1973	128	26.4
1974	28	26.3
1975	153	26.2
1976	313	26.4
1977	340	27.1
1978	343	26.4
1979	250	26.6
1980	137	26.8
1981	107	26.7
1982	107	26.6
1983	218	26.3
1984	207	26.1

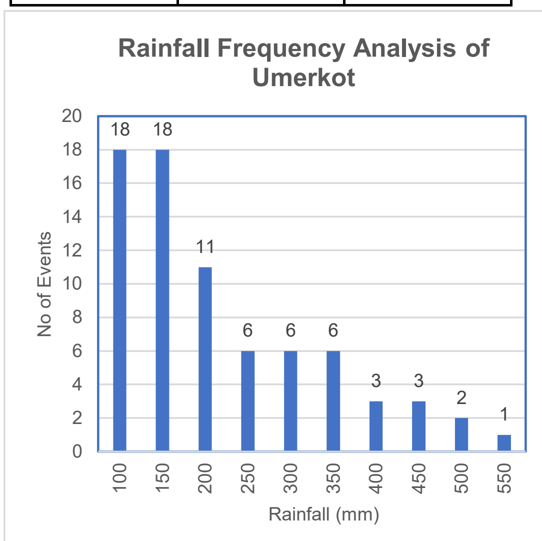
Year	Rainfall (mm/yr)	Temperature (°C)
1985	135	26.5
1986	123	26.3
1987	9	27.1
1988	229	27.5
1989	83	26.3
1990	145	26.3
1991	25	26.4
1992	246	26.4
1993	49	27.4
1994	285	26.4
1995	52	26.7
1996	86	26.5
1997	109	26.3
1998	79	27.3
1999	40	27.2
2000	80	27.1
2001	121	27.3
2002	48	27.0
2003	279	27.3
2004	49	27.7
2005	113	26.9
2006	288	26.8
2007	311	27.6
2008	112	27.0
2009	251	27.8
2010	207	27.8
2011	64	27.4
2012	113	27.0
2013	150	27.1
2014	111	27.4
2015	255	28.6
2016	251	28.8
2017	407	28.6
2018	111	28.9
2019	440	28.2
2020	675	27.6
2021	337	27.8

Year	Rainfall (mm/yr)	Temperature (°C)
No.	74	74
Min	9	25.7
Max	675	28.9
Average	177	26.8
STD	129	0.7



Annexure A: Annual Rainfall & Mean Temperature of Umerkot (GLDAS)

Year	Rainfall (mm/yr)	Temperature (°C)
1948	65	26.5
1949	199	26.5
1950	129	25.6
1951	67	26.5
1952	137	26.5
1953	160	26.8
1954	126	26.6
1955	244	26.3
1956	325	25.8
1957	102	25.8
1958	160	26.9
1959	307	26.3
1960	64	26.2
1961	421	25.7
1962	157	26.1
1963	86	26.6
1964	285	25.8
1965	145	26.1
1966	84	26.3
1967	277	25.8
1968	70	26.2
1969	19	27.0
1970	202	26.5
1971	161	26.2
1972	88	26.3
1973	138	26.3
1974	21	26.4
1975	290	26.0
1976	284	26.2
1977	200	27.0
1978	371	26.2
1979	142	26.5
1980	56	26.8
1981	87	26.7
1982	167	26.3
1983	304	26.0
1984	218	25.8
1985	146	26.6
1986	84	26.4
1987	26	27.5
1988	258	27.5
1989	82	26.0
1990	329	26.2
1991	21	26.1
1992	172	26.0
1993	155	26.8
1994	260	26.1
1995	136	26.3
1996	114	26.3
1997	150	25.5
1998	146	26.6
1999	90	26.6
2000	102	26.6
2001	121	26.5
2002	15	27.1
2003	394	27.0
2004	82	27.6
2005	121	26.3
2006	479	26.7
2007	232	27.5
2008	109	26.9
2009	210	27.9
2010	314	27.7
2011	248	27.1
2012	146	26.7
2013	190	26.9
2014	136	27.4
2015	411	29.7
2016	342	30.2
2017	498	29.8
2018	154	30.1
2019	437	29.5
2020	525	29.1
2021	383	29.1
No.	74	74
Min	15	25.5
Max	525	30.2
Average	192	26.8
STD	123	1.1



ANNEXURE-B

SOIL MOISTURE & RUN-OFF WET YEARS

Annexure B: Wet Years Soil Moisture & Runoff of Badin

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1956	413.83	43.03	18.39	70.44	139.36	262.72	228.18	490.91
1959	376.29	30.44	19.01	68.56	130.93	274.77	218.50	493.27
1961	391.48	29.55	18.61	67.39	128.30	273.27	214.30	487.57
1967	388.91	42.16	18.42	68.36	128.97	275.86	215.75	491.61
1970	323.89	18.96	17.96	60.54	110.55	270.28	189.04	459.33
1976	342.63	22.10	17.92	64.36	118.86	265.20	201.14	466.34
1978	339.56	28.95	17.28	66.58	128.14	271.92	212.00	483.92
1983	297.28	17.17	17.36	57.88	108.19	260.90	183.43	444.33
1988	295.76	18.31	16.23	60.92	117.13	261.68	194.28	455.96
1992	284.91	17.30	16.79	61.74	115.17	261.14	193.70	454.84
1994	295.15	16.96	17.41	60.18	109.63	257.41	187.21	444.63
2003	351.44	34.93	16.39	60.97	119.59	265.10	196.95	462.05
2006	451.36	53.27	19.03	65.73	128.88	285.94	213.64	499.58
2007	306.72	28.13	18.33	70.07	137.56	290.05	225.97	516.02
2015	392.84	58.63	17.39	68.05	133.81	294.86	219.25	514.11
2016	320.10	34.88	16.37	65.48	129.84	293.83	211.68	505.51
2017	528.82	91.36	18.35	73.50	144.78	301.90	236.63	538.52
2019	473.98	60.50	18.41	65.49	125.39	291.14	209.30	500.43
2020	708.21	189.81	20.55	74.92	147.15	309.48	242.62	552.10
2021	397.56	33.84	18.22	73.99	142.46	301.90	234.67	536.57

Annexure B: Wet Years Soil Moisture & Runoff of Dadu

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	184.15	2.84	12.55	55.06	106.18	204.61	173.78	378.39
1953	178.70	2.69	13.23	53.93	103.53	203.95	170.68	374.63
1956	220.08	3.68	14.04	57.72	111.54	210.43	183.30	393.73
1959	188.94	3.91	13.60	56.87	111.16	211.83	181.63	393.46
1961	184.72	2.17	14.62	57.72	111.30	212.97	183.64	396.61
1967	238.32	6.48	14.14	59.29	111.88	204.70	185.31	390.01
1970	133.66	2.72	13.05	57.45	109.97	212.74	180.47	393.20
1975	157.09	1.94	12.87	52.31	99.18	196.14	164.36	360.50
1976	145.56	2.23	13.43	57.27	109.76	208.22	180.45	388.67
1978	268.93	6.37	14.06	60.30	120.00	219.77	194.36	414.13
1992	156.36	1.40	13.98	54.10	103.00	202.99	171.09	374.08
1994	249.46	4.54	14.31	56.32	109.44	205.20	180.07	385.28
1997	168.04	1.73	13.57	54.98	104.23	202.10	172.79	374.88
2003	210.68	2.83	12.95	54.57	104.28	195.80	171.80	367.60
2007	121.39	1.22	12.38	54.19	101.62	197.48	168.19	365.67
2015	225.10	3.88	16.10	60.16	116.12	221.98	192.38	414.36
2016	182.10	3.15	14.84	58.19	113.28	219.96	186.31	406.28
2017	226.63	5.18	14.60	58.77	116.13	222.84	189.50	412.34
2019	266.57	8.81	16.73	62.22	119.04	222.41	197.98	420.40
2020	345.34	22.33	17.25	63.27	125.77	235.27	206.29	441.56

Annexure B: Wet Years Soil Moisture & Runoff of Ghotki

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	263.86	14.74	13.05	52.37	96.80	200.16	162.22	362.38
1967	164.89	7.43	12.43	48.50	84.99	184.47	145.93	330.39
1975	282.90	11.31	13.51	48.82	89.81	183.60	152.14	335.74
1978	315.07	34.81	13.91	55.48	108.47	210.09	177.86	387.95
1989	157.50	8.24	11.87	49.88	92.91	196.30	154.66	350.95
1994	331.08	22.13	14.26	54.76	103.13	197.66	172.15	369.82
1997	205.05	12.14	13.17	50.18	94.31	199.60	157.67	357.26
2003	233.64	10.41	12.93	51.61	94.71	193.55	159.25	352.79
2010	210.67	9.33	13.40	51.39	93.13	191.18	157.93	349.10
2015	305.65	50.81	14.16	60.96	112.84	226.97	187.95	414.92
2016	218.99	24.72	13.48	55.57	107.26	223.76	176.32	400.07
2017	289.15	32.88	14.02	57.95	110.15	224.65	182.12	406.77
2019	266.72	19.45	14.75	56.65	102.62	216.30	174.01	390.31
2020	290.40	31.74	14.72	58.79	108.77	220.62	182.28	402.91
2021	200.34	18.19	13.51	56.93	105.67	218.52	176.12	394.64

Annexure B: Wet Years Soil Moisture & Runoff of Hyderabad

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	215.77	58.30	18.99	62.66	120.39	247.87	202.04	449.91
1956	369.14	135.50	21.27	69.94	142.67	267.20	233.87	501.08
1959	267.89	84.42	20.58	67.14	133.37	262.81	221.09	483.90
1961	296.52	95.63	21.09	67.36	132.09	261.59	220.54	482.13
1967	332.50	119.29	21.58	69.95	135.66	263.65	227.20	490.85
1970	235.00	63.38	19.89	63.36	122.16	252.67	205.41	458.08
1976	295.43	97.78	20.66	66.62	131.46	256.26	218.74	475.00
1978	328.98	114.01	20.73	68.85	138.29	262.82	227.88	490.70
1983	248.21	70.92	20.20	63.40	122.32	249.89	205.92	455.81
1988	241.60	62.89	19.15	64.30	126.56	247.66	210.01	457.67
1992	235.96	63.46	19.67	64.46	125.52	247.14	209.65	456.79
1994	292.61	84.06	20.31	64.30	126.42	248.02	211.03	459.06
2003	285.85	91.10	19.63	63.71	127.32	250.69	210.66	461.35
2006	310.69	96.39	20.69	66.06	130.11	258.29	216.86	475.16
2007	205.10	68.28	20.53	66.38	130.18	259.10	217.09	476.19
2015	247.84	82.36	20.00	65.90	132.89	268.04	218.79	486.83
2016	243.43	81.49	19.46	66.62	133.23	267.24	219.30	486.54
2017	330.67	113.99	20.40	70.20	139.73	271.75	230.33	502.07
2019	369.21	131.91	20.95	67.71	135.65	265.37	224.31	489.68
2020	533.08	225.51	21.95	72.00	144.71	280.41	238.65	519.06
2021	229.57	68.11	20.28	68.85	135.12	277.81	224.26	502.07

Annexure B: Wet Years Soil Moisture & Runoff of Jacobabad

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	244.01	4.36	11.70	32.30	50.93	193.34	94.93	288.27
1956	134.39	0.79	11.34	31.71	43.82	192.21	86.86	279.07
1967	183.85	1.51	11.24	33.49	44.51	191.73	89.23	280.96
1975	267.04	3.12	11.84	31.79	51.03	191.19	94.66	285.85
1976	141.43	0.70	10.90	29.30	43.95	190.11	84.16	274.27
1978	305.60	3.90	12.88	35.73	64.37	191.56	112.98	304.54
1985	172.49	3.93	10.85	30.84	52.24	192.13	93.93	286.06
1989	165.95	1.31	10.82	32.67	47.06	191.10	90.55	281.65
1994	355.20	5.77	13.51	38.99	64.68	192.13	117.18	309.31
1997	219.30	2.24	12.11	33.13	46.60	193.33	91.85	285.18
2003	222.77	1.39	11.61	32.22	50.00	191.85	93.82	285.67
2010	215.40	1.53	12.06	34.26	50.62	190.99	96.94	287.93
2015	197.09	3.00	12.35	40.21	52.01	212.62	104.57	317.19
2019	178.30	2.09	12.46	37.84	45.96	209.54	96.26	305.80
2020	197.05	3.73	12.41	39.22	47.53	208.73	99.16	307.89

Annexure B: Wet Years Soil Moisture & Runoff of Jamshoro

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	200.89	4.09	13.70	63.07	123.62	208.01	200.39	408.40
1956	303.51	35.21	16.38	69.14	139.69	238.26	225.21	463.47
1959	231.04	12.42	15.39	65.74	132.46	224.48	213.60	438.08
1961	261.83	10.09	17.19	66.43	132.65	224.35	216.27	440.62
1967	326.29	32.96	17.41	69.03	138.61	233.34	225.05	458.39
1970	167.98	6.06	14.91	64.28	128.44	218.97	207.63	426.59
1976	227.13	11.85	15.55	66.75	133.40	224.54	215.69	440.23
1977	210.27	12.97	15.72	67.82	137.11	234.60	220.65	455.25
1978	309.43	26.77	16.20	71.43	144.46	244.91	232.09	476.99
1992	175.49	5.53	14.50	63.50	126.71	216.30	204.71	421.00
1994	244.23	12.36	15.04	64.51	129.48	221.25	209.03	430.28
2003	234.53	6.90	14.27	61.68	122.12	207.64	198.07	405.71
2006	200.10	4.72	14.92	62.58	124.60	213.58	202.09	415.68
2007	166.58	7.04	14.54	63.87	128.52	220.98	206.93	427.90
2015	227.79	12.79	15.85	67.53	137.24	237.40	220.63	458.03
2016	225.81	22.43	15.08	69.66	141.55	245.01	226.30	471.31
2017	290.89	28.87	15.86	72.36	146.97	253.27	235.19	488.47
2019	323.69	38.00	17.15	69.70	141.58	243.71	228.43	472.13
2020	464.62	96.59	18.83	72.47	148.38	256.22	239.68	495.90
2021	230.70	17.25	16.45	70.44	143.59	246.86	230.49	477.34

Annexure B: Wet Years Soil Moisture & Runoff of Karachi

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	225.17	42.99	16.45	74.49	150.91	254.97	241.86	496.83
1954	176.84	35.06	16.62	73.40	149.44	253.62	239.47	493.09
1956	315.01	70.74	19.07	77.01	157.15	267.27	253.24	520.51
1959	297.62	57.46	18.54	74.62	152.63	259.33	245.79	505.12
1961	381.46	82.29	20.82	77.03	157.17	266.34	255.01	521.35
1967	376.40	103.04	20.43	78.37	160.35	272.28	259.15	531.43
1970	173.26	31.71	17.39	72.27	147.29	247.95	236.95	484.90
1976	252.48	47.81	17.74	73.93	150.39	253.29	242.06	495.35
1977	345.04	73.62	19.60	78.05	159.57	271.18	257.22	528.39
1978	327.25	80.39	18.84	78.66	161.25	275.96	258.75	534.72
1979	213.94	52.68	16.14	75.53	154.22	263.06	245.90	508.96
1994	335.69	89.36	17.44	73.77	150.13	253.54	241.34	494.88
2003	224.81	30.40	16.85	69.04	138.44	229.77	224.33	454.10
2007	207.60	39.73	16.85	71.98	146.81	249.57	235.63	485.20
2009	221.73	35.10	17.26	73.10	148.50	250.66	238.86	489.52
2015	204.27	35.49	17.76	73.04	149.38	254.38	240.18	494.56
2016	227.69	49.75	17.67	75.43	154.15	262.20	247.25	509.45
2017	327.48	85.20	18.83	78.64	160.82	274.24	258.29	532.53
2019	358.76	95.36	19.57	75.98	155.59	264.49	251.13	515.62
2020	571.79	246.89	21.34	79.39	162.99	279.37	263.72	543.09
2021	281.52	53.13	19.26	77.58	158.52	269.07	255.36	524.43

Annexure B: Wet Years Soil Moisture & Runoff of Kashmore

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	256.41	4.01	14.20	44.23	74.00	202.93	132.43	335.36
1956	134.56	0.87	13.71	44.01	67.30	202.45	125.03	327.47
1967	187.23	2.87	13.77	44.83	69.03	201.16	127.63	328.79
1975	291.33	3.81	14.81	44.82	75.25	201.50	134.89	336.39
1976	166.01	1.90	13.80	42.18	71.36	204.04	127.34	331.38
1978	317.46	6.98	15.08	48.42	88.88	206.65	152.39	359.03
1985	173.11	4.81	13.03	42.94	75.59	204.99	131.57	336.56
1989	165.89	1.44	13.20	43.12	69.40	203.73	125.72	329.44
1994	367.14	7.99	16.07	51.68	88.16	205.44	155.91	361.35
1997	219.17	2.46	14.73	43.74	69.69	206.78	128.17	334.94
2003	223.58	1.92	14.02	44.86	72.43	205.65	131.31	336.96
2010	250.54	3.16	14.87	47.64	75.92	203.18	138.43	341.61
2015	233.48	6.67	14.84	53.26	79.79	220.15	147.88	368.03
2016	178.40	2.67	14.24	42.94	70.28	219.10	127.46	346.57
2017	183.09	3.39	14.03	43.44	69.57	217.96	127.03	344.99
2019	203.46	3.64	14.94	46.04	68.13	215.94	129.11	345.05
2020	201.84	6.02	14.68	47.29	71.58	215.57	133.55	349.12
2021	166.95	2.32	14.15	44.15	69.21	215.73	127.50	343.23

Annexure B: Wet Years Soil Moisture & Runoff of Khairpur

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	245.27	13.34	11.97	57.41	112.07	206.78	181.45	388.22
1961	192.80	10.05	12.59	57.07	111.72	210.12	181.38	391.49
1967	196.43	6.30	12.19	56.88	108.39	200.42	177.45	377.88
1975	253.91	9.42	12.69	54.63	107.28	196.67	174.60	371.27
1978	326.56	39.35	13.38	62.49	124.45	225.74	200.31	426.05
1989	165.27	13.91	10.87	58.93	117.08	218.54	186.88	405.42
1994	330.04	42.05	13.32	60.91	122.14	221.24	196.37	417.61
1997	172.91	11.31	11.85	57.17	113.66	214.97	182.68	397.66
2003	268.35	17.35	12.68	58.74	114.03	210.37	185.45	395.83
2006	200.66	12.53	12.71	56.01	111.20	211.27	179.92	391.19
2010	184.98	10.59	12.28	58.99	115.28	214.95	186.54	401.50
2015	241.83	27.62	13.02	61.25	121.55	228.94	195.82	424.76
2016	245.70	46.78	12.23	61.94	124.19	235.57	198.37	433.93
2017	315.73	62.35	13.15	64.24	127.87	241.12	205.26	446.38
2019	284.81	23.32	14.00	62.21	121.45	227.22	197.66	424.87
2020	316.37	40.48	14.05	63.73	125.74	233.71	203.52	437.23
2021	205.47	21.59	12.98	61.89	122.68	232.31	197.56	429.87

Annexure B: Wet Years Soil Moisture & Runoff of Larkana

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	229.00	6.28	12.30	32.10	54.86	196.21	99.27	295.48
1959	139.44	1.58	11.61	32.04	50.27	195.66	93.92	289.58
1961	141.65	1.05	12.05	31.68	47.99	195.55	91.72	287.27
1967	197.61	2.62	12.18	36.63	51.96	195.45	100.77	296.22
1975	229.45	4.98	12.33	32.50	54.09	195.18	98.91	294.10
1976	112.80	0.44	11.52	29.85	48.62	194.90	89.99	284.89
1978	299.00	3.99	13.56	37.53	65.86	195.09	116.94	312.03
1985	159.58	3.41	11.60	32.28	54.85	194.96	98.74	293.69
1989	157.18	1.72	11.55	32.65	51.18	194.68	95.38	290.06
1994	339.10	6.73	14.16	40.19	66.69	194.45	121.04	315.50
1997	191.81	2.19	12.44	31.59	50.06	193.89	94.08	287.97
2003	225.47	1.83	12.61	35.45	54.60	193.73	102.65	296.38
2007	98.74	0.35	11.36	29.04	47.09	193.54	87.49	281.03
2010	175.17	1.26	12.31	33.41	50.56	193.51	96.28	289.79
2015	218.44	3.48	13.07	38.01	58.18	201.06	109.27	310.33
2016	171.46	2.79	12.25	33.16	52.99	200.31	98.40	298.71
2017	233.53	3.81	13.11	36.42	55.06	199.90	104.58	304.48
2019	236.86	5.25	13.67	39.17	52.62	199.35	105.46	304.81
2020	271.99	4.46	14.11	40.23	56.94	198.94	111.28	310.22
2021	181.90	2.03	13.20	34.29	50.19	198.41	97.68	296.09

Annexure B: Wet Years Soil Moisture & Runoff of Matiari

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	215.16	1.98	11.61	39.48	65.38	196.58	116.47	313.05
1956	313.37	10.03	13.59	46.37	90.45	205.41	150.42	355.82
1959	231.63	3.84	12.90	42.87	74.61	204.05	130.38	334.42
1961	261.82	2.45	13.72	42.98	74.44	201.59	131.13	332.73
1967	291.18	4.24	14.01	46.39	78.22	198.85	138.62	337.47
1970	208.08	3.03	12.53	39.06	65.15	196.06	116.74	312.80
1976	259.15	5.35	13.18	42.59	73.74	195.41	129.51	324.92
1978	332.12	7.92	13.64	46.15	87.10	201.92	146.89	348.81
1983	230.26	1.61	12.98	39.12	65.67	195.72	117.77	313.49
1988	218.79	3.43	11.51	40.96	71.99	196.32	124.46	320.78
1992	198.34	2.57	12.04	40.45	66.17	193.74	118.65	312.39
1994	296.53	6.22	13.56	42.49	76.15	195.21	132.20	327.41
2003	280.11	7.10	12.52	41.75	78.40	198.15	132.66	330.82
2006	281.86	4.78	13.41	42.60	77.10	202.91	133.11	336.02
2007	173.51	1.22	12.72	39.11	66.04	200.60	117.87	318.47
2015	247.13	7.68	12.60	41.11	78.55	228.12	132.26	360.37
2016	242.91	8.67	11.94	42.64	79.66	227.25	134.24	361.49
2017	330.24	12.14	13.11	47.54	87.12	226.93	147.77	374.70
2019	368.55	18.68	14.13	45.09	85.01	218.89	144.23	363.12
2020	534.32	42.41	15.63	50.60	96.20	235.77	162.43	398.20
2021	227.19	5.53	12.86	43.85	75.68	244.54	132.40	376.94

Annexure B: Wet Years Soil Moisture & Runoff of Mirpurkhas

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1956	352.60	27.24	15.47	55.53	110.60	219.78	181.61	401.39
1959	311.52	20.07	15.60	52.43	100.88	219.31	168.90	388.21
1961	361.55	22.58	15.82	54.06	104.66	223.15	174.54	397.69
1967	296.56	20.25	14.76	53.29	96.69	215.18	164.73	379.92
1970	269.97	12.20	14.31	45.37	81.65	206.62	141.34	347.95
1975	254.69	9.21	13.76	41.12	73.77	196.74	128.65	325.39
1976	306.52	18.78	15.09	51.79	99.01	204.74	165.90	370.64
1978	358.36	28.58	14.91	55.32	105.84	219.54	176.06	395.60
1983	289.47	16.18	14.67	46.72	87.08	211.82	148.47	360.29
1988	271.02	13.91	13.30	47.19	92.07	207.24	152.57	359.80
1990	260.70	17.11	13.33	46.46	89.87	210.27	149.66	359.93
1994	255.45	12.03	14.38	46.35	84.21	202.64	144.94	347.58
2003	364.04	31.07	14.01	48.94	94.19	215.92	157.14	373.06
2006	449.88	50.65	16.53	53.49	105.35	241.19	175.37	416.56
2007	233.97	15.63	15.41	57.66	110.74	235.98	183.80	419.78
2015	392.67	40.94	15.35	57.65	110.39	239.45	183.39	422.84
2016	333.04	27.39	14.66	55.95	108.90	238.89	179.51	418.40
2017	486.81	72.36	15.86	60.56	120.26	250.61	196.68	447.29
2019	413.24	36.48	16.07	52.27	101.39	235.21	169.73	404.94
2020	534.30	81.03	17.36	59.50	114.01	246.22	190.88	437.09
2021	362.31	26.25	15.76	59.28	112.18	243.30	187.22	430.52

Annexure B: Wet Years Soil Moisture & Runoff of Naushahro Feroze

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	218.02	7.83	13.44	37.70	61.97	200.44	113.11	313.55
1956	157.50	4.64	13.51	38.28	57.97	199.96	109.77	309.73
1959	161.66	4.76	13.26	38.71	59.31	199.84	111.28	311.12
1961	171.72	4.70	14.03	39.05	57.02	199.76	110.09	309.85
1967	231.77	9.72	13.99	45.26	67.05	199.64	126.30	325.94
1975	203.56	6.95	13.55	36.73	61.43	198.85	111.72	310.56
1976	132.89	3.71	13.28	36.44	56.83	198.70	106.55	305.25
1978	306.06	10.06	14.74	44.14	77.59	199.48	136.47	335.95
1989	154.15	4.38	12.60	37.25	60.33	199.78	110.19	309.97
1994	304.00	9.51	14.88	44.20	72.92	199.72	131.99	331.71
1997	164.52	3.55	13.49	35.82	56.10	199.50	105.41	304.91
2003	228.59	5.43	13.89	41.48	65.10	199.35	120.47	319.82
2007	122.10	3.07	12.88	34.72	54.32	199.05	101.91	300.96
2010	163.86	3.90	13.33	36.96	58.43	198.88	108.72	307.60
2015	204.29	7.12	14.28	40.13	63.81	241.91	118.22	360.12
2016	187.71	7.26	13.57	38.76	62.19	240.60	114.51	355.11
2017	264.41	9.19	14.53	42.29	68.89	239.30	125.71	365.01
2019	276.28	12.77	15.35	44.93	66.79	237.01	127.07	364.08
2020	339.59	16.54	15.82	46.47	78.04	236.05	140.34	376.39
2021	171.39	4.40	14.21	38.52	59.62	235.04	112.36	347.40

Annexure B: Wet Years Soil Moisture & Runoff of Qambar Shahdadkot

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	80.65	0.57	11.41	42.21	72.45	196.06	126.07	322.13
1949	197.98	3.83	11.87	40.53	74.22	194.64	126.62	321.26
1950	120.54	0.78	11.17	41.23	74.09	196.91	126.49	323.40
1953	165.59	1.42	12.11	38.65	66.20	191.11	116.97	308.07
1956	162.98	1.07	12.71	43.05	72.24	192.66	128.00	320.66
1959	167.72	2.36	12.27	41.17	73.25	191.73	126.69	318.42
1961	146.55	1.02	12.57	42.61	71.71	192.37	126.90	319.27
1967	188.67	2.47	12.07	45.17	69.76	186.28	127.00	313.28
1970	113.84	1.18	11.19	41.29	68.41	189.98	120.88	310.87
1975	188.95	2.40	11.96	40.09	66.48	186.23	118.53	304.76
1976	123.29	0.83	11.84	42.89	72.75	190.25	127.49	317.74
1978	267.73	3.47	13.05	44.65	83.99	193.34	141.69	335.03
1985	180.59	2.21	11.97	42.88	72.98	189.10	127.83	316.93
1986	153.27	2.98	11.52	39.46	73.47	191.80	124.45	316.25
1989	147.17	1.56	11.24	44.54	76.65	193.96	132.42	326.38
1992	151.45	0.74	12.77	40.92	67.66	188.78	121.35	310.14
1994	300.71	5.25	13.82	44.42	81.77	191.30	140.01	331.31
1997	196.12	1.47	12.55	41.79	70.11	189.51	124.45	313.96
2003	214.68	2.02	12.15	41.95	71.26	185.54	125.36	310.91
2007	93.49	0.48	11.13	40.28	65.75	186.17	117.16	303.33
2010	175.39	1.56	12.26	39.95	66.88	184.50	119.10	303.59
2015	213.52	2.37	14.37	49.79	83.23	200.01	147.39	347.40
2016	167.91	1.69	13.32	45.96	77.93	197.42	137.21	334.63
2017	170.49	2.35	12.58	42.51	75.74	195.59	130.82	326.41
2019	254.50	5.85	14.99	52.32	85.74	195.93	153.05	348.98
2020	267.74	6.53	14.58	50.07	86.86	200.01	151.50	351.51

Annexure B: Wet Years Soil Moisture & Runoff of Sanghar

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	221.76	10.66	11.69	51.00	96.11	204.73	158.79	363.52
1956	245.87	22.44	13.07	56.46	110.03	218.39	179.56	397.95
1959	218.46	14.32	13.05	53.23	102.12	210.98	168.41	379.38
1961	291.59	20.57	14.35	54.94	106.16	215.41	175.46	390.86
1967	223.70	9.97	13.12	52.87	97.06	201.65	163.05	364.70
1975	244.07	7.29	12.99	48.06	90.22	193.26	151.26	344.52
1976	217.84	14.76	13.23	54.44	103.59	208.55	171.26	379.82
1978	346.74	41.87	13.70	58.89	115.35	221.65	187.94	409.59
1983	237.27	13.93	13.20	51.80	98.21	208.90	163.21	372.11
1994	283.71	20.57	13.67	55.04	105.65	211.87	174.36	386.23
2003	323.66	31.76	12.91	53.67	103.94	211.31	170.52	381.83
2006	339.49	40.67	14.25	54.67	107.30	221.87	176.22	398.09
2010	224.47	13.06	13.42	53.68	99.79	214.27	166.89	381.16
2015	301.76	50.55	13.34	57.87	114.45	242.28	185.65	427.93
2016	289.81	51.70	12.66	58.74	116.97	244.33	188.37	432.70
2017	386.22	86.75	13.44	61.70	123.10	249.83	198.24	448.07
2019	346.07	37.43	14.35	58.16	113.99	234.15	186.50	420.65
2020	424.35	67.78	14.92	61.40	121.30	241.80	197.63	439.42
2021	270.11	28.06	13.58	59.29	115.87	242.64	188.74	431.38

Annexure B: Wet Years Soil Moisture & Runoff of Shaheed Benazirabad

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	221.29	6.39	11.67	36.54	57.56	193.73	105.77	299.50
1956	193.27	5.49	11.87	38.53	61.27	191.53	111.67	303.20
1959	180.05	5.52	11.75	36.80	59.27	189.98	107.82	297.81
1961	198.06	4.96	12.81	37.37	57.23	188.72	107.41	296.13
1967	253.26	8.80	12.91	43.21	65.23	187.51	121.35	308.86
1970	149.72	3.00	11.59	33.53	50.56	185.56	95.67	281.23
1975	199.14	6.20	11.54	32.76	55.37	184.70	99.68	284.38
1976	171.02	4.70	12.13	38.20	60.92	185.07	111.25	296.33
1978	326.10	12.47	13.20	43.50	78.36	189.27	135.05	324.32
1983	168.82	3.80	11.88	33.99	52.85	189.26	98.73	287.99
1994	307.83	13.69	12.89	40.81	70.98	189.59	124.67	314.26
2003	249.95	7.01	12.23	39.51	66.44	191.31	118.18	309.49
2006	189.86	4.02	12.19	34.34	55.75	189.09	102.28	291.37
2007	139.05	4.02	11.61	35.39	55.45	188.61	102.44	291.05
2015	174.81	6.94	11.80	38.09	65.02	219.64	114.91	334.56
2016	195.73	10.08	11.38	38.51	66.71	216.74	116.60	333.34
2017	281.06	10.76	12.85	42.19	77.13	216.37	132.17	348.54
2019	308.10	13.34	13.78	44.58	74.54	213.00	132.90	345.90
2020	343.93	17.18	13.88	46.65	85.17	217.16	145.71	362.87
2021	167.70	5.53	12.38	40.37	68.91	216.38	121.67	338.05

Annexure B: Wet Years Soil Moisture & Runoff of Shikarpur

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	246.22	4.57	11.32	30.31	48.23	194.31	89.86	284.16
1967	188.06	1.36	10.85	30.89	42.88	193.27	84.62	277.89
1975	262.30	3.97	11.33	30.06	48.85	193.00	90.24	283.24
1978	308.69	3.86	12.57	33.78	60.36	193.11	106.72	299.82
1985	163.36	4.42	10.39	28.00	49.50	193.36	87.88	281.24
1989	164.05	1.50	10.46	29.06	44.49	192.76	84.00	276.76
1994	357.38	6.33	13.07	37.31	61.92	192.84	112.30	305.14
1997	207.99	2.10	11.50	29.29	43.41	192.77	84.21	276.98
2003	225.51	1.48	11.34	30.65	47.75	192.37	89.74	282.11
2010	196.67	1.22	11.42	30.92	46.50	191.97	88.83	280.80
2015	211.35	2.96	11.85	35.34	49.72	201.62	96.91	298.53
2016	152.52	3.21	10.84	28.03	43.17	200.65	82.03	282.68
2017	190.34	3.14	11.24	29.99	45.19	200.18	86.42	286.60
2019	217.05	3.91	12.21	34.71	44.41	199.52	91.34	290.85
2020	246.75	4.61	12.47	36.07	46.93	199.01	95.48	294.49
2021	161.13	1.83	11.49	30.13	41.26	198.45	82.87	281.33

Annexure B: Wet Years Soil Moisture & Runoff of Sujawal

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1956	374.52	38.97	20.12	89.27	179.25	312.26	288.64	600.90
1959	350.07	28.46	20.55	87.14	174.41	314.59	282.11	596.70
1961	418.55	26.65	21.44	87.13	172.33	311.97	280.90	592.87
1967	435.23	69.81	21.29	88.32	176.71	321.47	286.31	607.79
1970	286.91	13.54	20.12	81.57	159.98	305.14	261.68	566.82
1976	298.00	13.64	19.20	81.60	158.20	299.31	259.01	558.32
1977	304.54	16.72	19.68	86.76	172.47	313.91	278.90	592.81
1978	294.79	24.77	18.65	88.57	177.20	321.67	284.42	606.09
1979	239.23	33.28	16.88	88.18	177.87	325.55	282.93	608.48
1992	271.67	15.82	18.04	82.56	162.53	302.68	263.12	565.81
1994	287.59	16.84	18.81	81.75	161.30	302.97	261.85	564.82
2003	299.30	24.26	17.69	80.89	160.15	297.73	258.73	556.46
2006	343.86	27.71	19.90	83.79	165.06	306.42	268.75	575.17
2007	317.05	29.73	19.90	86.99	175.70	317.30	282.59	599.89
2009	300.22	14.71	19.59	83.14	164.67	307.71	267.40	575.10
2010	296.45	15.33	19.43	85.57	168.60	312.79	273.61	586.40
2015	352.34	73.83	18.59	90.78	183.54	336.30	292.91	629.21
2016	296.94	47.34	17.61	90.11	182.72	337.23	290.43	627.66
2017	489.95	105.80	19.81	94.64	191.67	347.84	306.12	653.97
2019	462.79	77.16	20.19	88.47	177.51	331.11	286.18	617.28
2020	731.59	279.25	22.11	95.04	192.67	349.65	309.82	659.47
2021	384.89	37.92	19.93	94.63	190.88	341.62	305.45	647.06

Annexure B: Wet Years Soil Moisture & Runoff of Sukkur

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	258.22	17.71	13.36	55.20	103.05	207.87	171.61	379.48
1967	184.97	8.78	12.97	51.55	93.45	194.88	157.96	352.84
1975	273.99	13.56	13.66	51.47	97.43	194.96	162.56	357.51
1978	314.51	31.63	14.42	57.46	112.44	215.01	184.32	399.33
1989	168.10	10.74	12.43	52.98	100.67	207.04	166.08	373.11
1994	352.52	32.09	14.80	57.11	110.14	208.71	182.05	390.77
1997	194.74	12.31	13.35	52.18	99.15	207.44	164.68	372.12
2003	238.56	11.57	13.58	53.68	100.05	202.19	167.31	369.50
2010	182.25	9.56	13.08	53.67	100.82	204.10	167.57	371.67
2015	268.24	34.01	14.49	60.08	113.95	225.57	188.52	414.10
2016	207.29	22.49	13.79	56.58	110.10	224.53	180.47	405.00
2017	280.79	28.06	14.61	59.15	112.75	224.59	186.52	411.11
2019	255.91	18.54	15.14	57.66	105.48	215.88	178.27	394.16
2020	294.72	30.79	15.45	59.74	111.89	220.45	187.07	407.53
2021	198.87	16.48	14.32	57.19	106.80	218.44	178.31	396.75

Annexure B: Wet Years Soil Moisture & Runoff of Tando Allah Yar

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1949	220.78	30.98	14.88	46.22	82.88	222.47	143.97	366.45
1956	346.27	68.96	16.74	52.00	102.25	228.84	170.98	399.82
1959	264.76	46.76	16.48	49.65	90.82	234.04	156.96	390.99
1961	305.18	53.11	16.78	51.27	95.34	230.07	163.39	393.45
1967	294.76	58.55	16.80	52.54	93.13	228.12	162.46	390.59
1970	243.56	35.00	15.85	46.17	81.55	222.21	143.57	365.78
1976	291.38	53.93	16.44	48.99	88.38	222.01	153.80	375.81
1978	342.35	64.47	16.57	51.42	97.38	223.99	165.37	389.36
1983	263.75	41.69	16.50	47.29	85.51	227.00	149.30	376.29
1988	249.56	37.30	15.09	47.42	89.23	220.79	151.74	372.54
1992	209.90	31.41	15.23	46.18	78.97	217.86	140.38	358.25
1994	285.78	45.56	16.50	47.65	86.59	218.19	150.74	368.93
2003	317.40	56.93	15.87	48.83	95.07	225.92	159.77	385.69
2006	359.71	64.65	17.19	51.59	99.36	242.58	168.14	410.73
2007	199.70	37.25	16.23	47.11	79.17	241.51	142.51	384.02
2015	247.82	45.76	15.82	45.24	86.28	246.98	147.35	394.33
2016	243.40	45.62	15.33	45.86	85.69	242.24	146.87	389.11
2017	330.92	61.87	16.28	50.69	93.16	239.67	160.13	399.80
2019	368.75	78.81	17.00	49.40	93.19	235.46	159.59	395.05
2020	539.49	126.23	18.26	54.45	102.39	250.59	175.09	425.68
2021	230.85	38.06	16.03	46.18	78.06	262.23	140.27	402.50

Annexure B: Wet Years Soil Moisture & Runoff of Tando Muhammad Khan

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1956	401.41	81.13	19.12	62.35	123.64	247.87	205.10	452.97
1959	315.09	57.29	18.71	59.83	113.35	255.73	191.88	447.61
1961	338.16	60.70	19.03	59.20	110.14	251.70	188.37	440.07
1967	373.46	73.50	19.55	62.45	117.07	255.31	199.07	454.39
1970	271.37	44.55	17.93	54.95	99.52	254.25	172.40	426.65
1976	321.20	60.64	18.43	57.50	105.23	252.44	181.16	433.60
1978	330.46	65.07	18.29	58.90	113.19	253.78	190.37	444.15
1983	266.91	44.45	17.99	53.10	98.09	246.40	169.18	415.58
1988	265.80	41.57	16.95	55.29	103.94	242.68	176.18	418.86
1992	266.16	42.31	17.42	55.68	103.10	241.23	176.20	417.43
1994	298.15	49.30	17.97	55.05	101.65	240.87	174.67	415.54
2003	306.06	60.55	17.38	54.60	107.31	244.59	179.29	423.88
2006	358.86	69.71	18.86	58.00	110.41	255.15	187.27	442.42
2007	253.53	47.83	18.36	57.26	107.58	256.15	183.19	439.35
2015	313.87	61.20	17.94	57.56	112.97	270.27	188.47	458.74
2016	275.62	52.66	17.19	56.43	109.87	268.08	183.49	451.56
2017	411.04	83.10	18.58	63.10	121.59	270.41	203.28	473.68
2019	416.28	87.85	18.95	58.82	112.96	266.04	190.72	456.76
2020	616.43	184.02	20.51	65.32	126.80	283.24	212.63	495.87
2021	300.11	51.00	18.35	60.79	111.75	286.75	190.88	477.63

Annexure B: Wet Years Soil Moisture & Runoff of Tharparkar

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1956	445.87	179.50	16.62	76.96	159.86	281.27	253.44	534.71
1959	431.37	132.38	17.10	76.03	157.43	274.66	250.56	525.21
1961	539.93	135.78	18.26	75.77	156.42	271.46	250.46	521.92
1964	358.78	61.87	15.30	74.10	151.68	260.77	241.08	501.85
1967	331.23	69.06	15.25	72.97	150.39	260.46	238.61	499.07
1975	398.04	40.35	16.15	70.86	144.50	245.78	231.51	477.29
1976	343.04	67.55	16.03	75.22	155.39	270.09	246.65	516.74
1978	378.27	108.95	15.15	76.57	158.06	275.23	249.77	525.01
1983	335.74	69.39	15.22	72.94	149.82	258.84	237.98	496.82
1990	432.16	146.84	14.84	73.90	152.75	266.27	241.49	507.76
1994	357.02	80.66	15.89	74.79	153.83	266.29	244.52	510.81
2003	439.32	178.51	14.39	72.56	149.13	259.66	236.09	495.75
2006	571.45	253.92	17.19	75.34	156.75	276.55	249.28	525.83
2007	306.17	58.67	16.72	74.03	153.35	267.89	244.09	511.98
2010	407.85	112.15	16.39	75.91	156.61	273.19	248.91	522.09
2015	428.79	151.53	15.34	75.95	157.26	276.61	248.55	525.16
2016	342.35	88.97	14.40	75.45	155.69	271.90	245.54	517.44
2017	673.08	354.64	15.29	78.32	162.03	285.20	255.64	540.84
2019	551.19	170.89	16.91	75.33	154.98	269.53	247.22	516.74
2020	640.20	246.34	17.81	77.17	158.99	277.36	253.97	531.33
2021	464.90	123.18	16.16	76.86	158.30	275.70	251.33	527.03

Annexure B: Wet Years Soil Moisture & Runoff of Thatta

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1956	363.51	33.54	18.62	77.82	157.19	271.57	253.63	525.20
1959	313.45	18.24	17.86	74.68	150.65	262.92	243.19	506.12
1961	391.71	21.17	19.39	76.22	151.90	264.81	247.52	512.33
1967	425.49	54.93	19.88	78.08	156.74	277.58	254.69	532.27
1970	222.20	8.60	17.07	69.92	138.87	253.55	225.86	479.41
1976	284.79	13.29	17.10	70.65	138.75	251.66	226.49	478.15
1977	328.66	17.86	18.25	77.14	154.90	272.28	250.29	522.56
1978	318.52	22.91	17.78	79.50	160.89	283.05	258.16	541.21
1979	210.59	21.87	14.35	76.49	154.98	275.14	245.82	520.97
1992	234.11	9.31	15.68	69.00	136.77	248.51	221.45	469.97
1994	271.67	12.53	16.21	70.31	139.74	252.77	226.27	479.05
2003	265.87	10.82	15.64	67.10	131.30	239.41	214.04	453.45
2006	277.88	9.66	17.01	70.15	136.95	246.92	224.11	471.03
2007	262.29	14.56	17.03	73.16	147.94	261.81	238.13	499.94
2009	248.13	6.65	16.70	71.80	142.36	254.25	230.86	485.11
2015	231.29	15.05	15.71	74.58	151.54	274.00	241.82	515.82
2016	242.71	20.86	15.51	77.17	156.09	280.96	248.76	529.73
2017	390.71	48.53	17.29	82.20	167.13	295.70	266.62	562.32
2019	401.86	46.30	18.12	77.11	156.47	280.14	251.70	531.84
2020	651.31	213.15	19.95	83.26	169.99	300.66	273.21	573.87
2021	317.27	20.62	17.78	81.77	165.20	291.12	264.75	555.87

Annexure B: Wet Years Soil Moisture & Runoff of Umerkot

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1956	324.23	50.77	15.21	67.99	139.63	247.68	222.83	470.52
1959	296.50	31.15	14.96	64.86	131.84	236.83	211.65	448.48
1961	409.09	44.61	16.62	66.26	134.86	243.03	217.74	460.77
1964	284.40	16.71	13.67	63.26	126.35	227.43	203.28	430.70
1967	249.21	12.72	13.84	62.43	124.20	224.08	200.47	424.55
1975	288.64	9.87	13.96	56.86	112.48	207.19	183.30	390.48
1976	279.50	28.85	14.45	65.14	133.32	234.74	212.92	447.66
1978	364.80	65.99	14.35	68.62	139.92	249.91	222.88	472.79
1983	302.95	34.99	14.22	62.19	125.59	231.61	202.00	433.61
1988	258.18	15.16	12.66	61.47	123.93	224.59	198.07	422.66
1990	323.68	66.46	12.99	63.31	129.32	237.98	205.63	443.61
1994	259.92	20.83	14.36	62.97	125.80	230.81	203.13	433.94
2003	386.51	71.94	13.62	61.67	123.80	230.53	199.09	429.62
2006	476.10	107.50	16.13	65.73	134.81	250.39	216.67	467.06
2010	308.46	30.84	15.11	66.34	133.00	238.57	214.44	453.01
2015	396.53	82.45	14.67	69.74	142.66	258.62	227.08	485.70
2016	335.80	62.01	14.00	70.56	145.05	260.47	229.62	490.09
2017	482.57	147.37	14.49	72.89	150.16	269.84	237.54	507.37
2019	395.61	55.52	15.52	66.80	137.13	248.61	219.45	468.06
2020	496.12	106.80	16.42	70.06	142.96	257.64	229.44	487.08
2021	364.03	42.55	15.36	70.89	144.99	256.75	231.24	487.99

ANNEXURE-C

SOIL MOISTURE & RUN-OFF DURING DRY YEARS

Annexure C: Drought Years Soil Moisture & Runoff of Badin

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	36.63	1.47	13.08	43.46	87.48	231.86	144.02	375.89
1950	129.96	10.42	14.24	56.91	106.45	238.30	177.59	415.89
1951	75.09	3.07	13.39	49.75	94.26	235.62	157.40	393.02
1957	87.14	4.67	14.76	56.87	112.06	271.52	183.69	455.22
1960	71.19	4.75	14.03	58.30	113.92	268.48	186.25	454.74
1963	58.71	2.93	13.09	51.00	102.07	265.95	166.16	432.11
1966	89.90	4.66	14.08	54.16	99.61	263.41	167.85	431.26
1968	42.93	3.40	13.40	54.61	110.39	276.10	178.40	454.50
1969	11.83	1.61	11.62	46.10	93.22	268.92	150.94	419.86
1972	54.08	2.52	13.40	49.04	95.65	264.78	158.08	422.87
1973	128.01	4.09	14.61	52.55	92.27	261.87	159.43	421.29
1974	22.37	1.43	12.10	44.65	89.08	259.74	145.83	405.57
1980	84.12	6.09	13.85	59.06	110.07	269.54	182.98	452.52
1981	29.77	2.29	13.04	48.72	95.14	262.10	156.91	419.01
1982	82.24	2.44	14.38	47.84	89.15	257.84	151.37	409.21
1986	123.98	6.33	14.53	54.42	100.68	260.33	169.63	429.96
1987	12.51	1.82	12.04	46.85	93.80	257.82	152.69	410.50
1989	130.82	8.54	14.48	58.55	110.51	262.31	183.55	445.86
1991	20.30	2.82	12.31	51.58	103.75	260.28	167.63	427.92
1993	77.90	4.61	13.58	54.56	101.91	257.99	170.06	428.04
1995	120.47	7.91	13.78	58.70	108.29	258.28	180.78	439.06
1996	73.80	2.93	13.95	51.48	95.21	252.88	160.65	413.53
1999	63.75	2.07	13.44	45.62	88.88	247.74	147.94	395.69
2000	124.60	5.16	14.19	53.24	89.45	247.12	156.87	403.99
2001	120.89	6.58	14.16	53.10	93.73	247.35	160.99	408.34
2002	33.35	1.45	12.63	44.47	88.45	246.71	145.55	392.25
2004	81.79	4.44	14.42	53.07	106.86	277.58	174.35	451.93
2012	134.21	7.07	14.28	57.13	108.06	273.29	179.47	452.76
2018	117.84	10.37	14.27	59.94	113.99	289.88	188.20	478.08

Annexure C: Drought Years Soil Moisture & Runoff of Dadu

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1951	68.08	0.76	11.39	52.34	103.83	208.32	167.56	375.88
1955	55.07	0.53	11.21	50.17	100.06	203.96	161.44	365.40
1957	34.50	0.65	10.41	52.21	105.63	211.33	168.25	379.58
1963	13.94	0.30	9.14	49.47	99.90	202.85	158.51	361.36
1964	41.15	0.30	10.57	47.74	95.69	198.22	154.00	352.22
1965	44.58	0.29	10.38	47.01	93.10	194.64	150.49	345.13
1966	27.19	0.19	9.59	45.14	90.24	191.52	144.97	336.50
1968	4.92	0.79	8.31	54.36	109.86	214.87	172.53	387.40
1969	40.67	0.81	10.02	52.38	104.42	210.23	166.82	377.05
1971	31.12	0.88	9.65	53.01	106.96	213.25	169.62	382.86
1972	14.83	0.38	9.02	49.19	99.66	204.22	157.87	362.09
1973	49.63	0.44	9.96	48.79	96.43	199.34	155.19	354.53
1974	13.37	0.21	8.90	46.63	93.68	195.94	149.21	345.14
1980	18.43	0.69	9.60	53.07	107.50	214.12	170.17	384.29
1984	78.63	0.69	11.47	51.40	101.53	204.02	164.41	368.42
1987	9.56	1.00	9.28	54.40	110.22	217.22	173.91	391.12
1991	10.57	0.41	8.68	51.08	102.27	205.42	162.03	367.45
1993	18.95	0.34	9.49	49.72	100.54	202.52	159.75	362.27
1996	43.70	0.50	10.84	50.68	101.77	204.73	163.30	368.03
1998	29.84	0.39	9.93	51.03	101.68	202.09	162.64	364.73
1999	43.72	0.34	10.61	47.74	95.79	196.35	154.14	350.49
2000	31.41	0.20	9.90	45.96	92.83	192.54	148.68	341.22
2001	85.40	0.64	11.05	48.47	92.06	189.93	151.58	341.51
2002	10.09	0.14	8.82	45.66	91.34	189.80	145.82	335.63
2004	6.75	0.41	8.44	50.94	102.87	204.00	162.25	366.25
2005	40.77	0.39	11.03	48.64	97.70	199.29	157.37	356.66
2009	48.95	0.51	10.91	50.11	97.75	196.80	158.76	355.57
2012	33.08	0.48	9.46	50.74	101.50	202.27	161.70	363.97
2013	76.36	0.73	11.34	50.58	98.85	199.25	160.77	360.02
2014	53.11	0.46	11.14	48.16	95.40	195.70	154.70	350.39

Annexure C: Drought Years Soil Moisture & Runoff of Ghotki

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1950	62.08	7.50	10.51	46.83	94.87	207.35	152.20	359.56
1951	40.40	4.03	9.61	44.07	88.39	199.75	142.07	341.82
1952	48.33	2.85	10.02	42.60	85.11	195.21	137.73	332.94
1954	46.48	2.85	10.26	42.27	83.96	192.60	136.48	329.08
1957	28.55	2.77	9.64	42.05	84.40	192.13	136.08	328.21
1958	26.83	1.70	9.04	40.05	81.11	188.58	130.19	318.78
1960	42.58	2.91	9.58	42.61	84.97	191.98	137.16	329.14
1963	35.44	2.67	9.71	42.02	83.73	190.54	135.46	326.00
1965	45.03	2.35	10.00	41.25	81.32	187.01	132.56	319.57
1966	38.71	1.75	10.03	39.10	78.78	184.40	127.91	312.31
1968	4.96	2.49	7.88	43.02	85.41	189.23	136.31	325.54
1969	19.80	1.54	8.77	40.17	81.27	186.20	130.21	316.41
1971	69.44	2.75	10.29	43.25	80.84	183.77	134.37	318.14
1972	32.99	1.76	9.53	39.55	79.11	182.52	128.20	310.72
1973	40.72	1.36	9.52	38.54	76.96	180.38	125.02	305.40
1974	28.35	1.30	9.40	37.43	75.38	178.70	122.21	300.91
1979	24.81	8.94	9.68	48.45	97.47	208.96	155.60	364.56
1980	17.26	3.79	8.69	44.07	89.46	200.02	142.22	342.24
1987	20.05	4.75	9.10	44.88	90.28	199.98	144.26	344.24
1988	53.53	3.41	10.01	44.88	87.14	195.06	142.03	337.09
1991	15.80	3.14	8.78	42.93	86.62	194.71	138.33	333.04
1993	39.13	2.25	9.71	41.33	82.36	188.20	133.40	321.60
1995	50.22	9.47	10.65	49.82	99.38	208.50	159.85	368.35
1998	40.85	6.10	10.92	46.33	92.16	202.36	149.40	351.77
2000	36.27	3.27	9.08	43.41	87.39	195.49	139.88	335.36
2001	64.64	3.21	10.47	43.50	84.60	191.57	138.56	330.13
2002	5.96	1.79	7.82	40.69	82.28	188.68	130.80	319.48
2004	34.02	5.86	9.54	45.73	92.50	201.29	147.77	349.05
2005	34.50	3.62	9.84	43.06	86.59	194.88	139.49	334.37
2009	46.53	3.16	9.92	43.24	84.35	189.52	137.51	327.04
2012	72.28	3.91	10.28	45.15	88.33	194.34	143.76	338.10

Annexure C: Drought Years Soil Moisture & Runoff of Hyderabad

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	23.88	13.57	17.01	53.72	108.00	239.94	178.73	418.67
1950	87.67	27.34	17.91	60.83	118.76	246.43	197.50	443.94
1951	52.28	13.89	16.98	56.20	111.48	239.71	184.66	424.36
1957	41.95	17.63	17.67	59.62	121.76	256.41	199.05	455.46
1960	56.45	21.43	17.80	60.00	119.82	252.93	197.62	450.54
1963	23.19	14.16	16.62	57.22	116.79	246.56	190.63	437.19
1966	66.51	19.45	17.43	58.34	112.94	244.63	188.70	433.34
1968	20.17	16.12	16.94	58.22	119.19	249.69	194.35	444.04
1969	11.57	7.77	15.83	53.36	108.82	240.81	178.00	418.82
1971	66.84	22.04	17.87	59.97	118.79	248.53	196.63	445.16
1972	25.22	11.64	16.58	54.74	110.54	240.98	181.86	422.84
1973	83.72	16.05	17.54	56.96	108.73	240.97	183.23	424.20
1974	14.50	9.08	16.03	52.96	105.84	237.22	174.82	412.04
1980	54.74	21.18	17.62	60.73	120.10	248.58	198.45	447.03
1981	24.64	22.26	17.36	58.64	114.87	245.58	190.88	436.46
1982	60.75	16.75	17.79	55.61	109.31	240.93	182.71	423.64
1987	5.89	12.23	16.14	55.42	112.93	238.53	184.49	423.01
1991	4.83	12.48	15.95	55.90	114.08	238.38	185.93	424.31
1993	42.28	19.47	17.45	57.79	116.27	241.16	191.51	432.67
1995	87.47	27.57	17.77	62.45	123.04	247.50	203.26	450.76
1996	32.56	14.69	17.18	55.81	112.85	238.86	185.83	424.69
1997	82.70	17.07	18.33	56.04	109.21	237.69	183.58	421.26
1998	51.19	16.55	17.66	54.95	107.43	237.11	180.03	417.15
1999	40.39	11.11	16.88	52.45	104.19	232.60	173.51	406.11
2000	63.56	15.55	17.23	55.00	104.75	234.27	176.99	411.26
2002	14.82	9.88	16.13	52.78	106.18	232.67	175.09	407.76
2004	29.50	14.01	16.91	57.60	117.93	248.79	192.44	441.23
2005	80.56	15.86	18.01	56.35	111.35	244.59	185.70	430.30
2008	91.84	27.35	18.36	60.25	118.58	248.86	197.19	446.05
2014	80.19	21.71	18.11	58.71	114.05	241.43	190.87	432.29

Annexure C: Drought Years Soil Moisture & Runoff of Jacobabad

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1951	63.78	0.29	9.56	23.46	40.27	192.29	73.29	265.58
1952	45.50	0.17	9.25	21.41	39.90	192.27	70.56	262.83
1954	27.93	0.12	8.79	22.99	39.95	192.26	71.73	263.99
1957	31.23	0.13	9.01	22.19	40.32	192.05	71.53	263.58
1958	21.92	0.13	8.22	20.53	39.84	192.04	68.59	260.63
1960	33.36	0.16	8.77	21.20	40.18	191.83	70.16	261.99
1962	50.94	0.18	9.27	20.73	39.90	191.77	69.90	261.67
1963	27.07	0.14	8.55	21.13	39.74	191.77	69.42	261.19
1964	54.04	0.32	9.12	23.40	39.71	191.77	72.23	264.00
1965	38.46	0.16	9.02	21.73	39.67	191.77	70.42	262.19
1966	29.03	0.15	8.71	20.47	39.64	191.77	68.82	260.59
1968	2.86	0.09	7.29	21.91	41.14	191.38	70.33	261.72
1969	16.72	0.11	8.35	20.17	40.00	191.35	68.51	259.86
1971	62.09	0.51	8.85	24.71	40.15	191.34	73.71	265.05
1972	9.33	0.11	7.85	20.84	39.84	191.34	68.53	259.87
1973	23.88	0.13	8.15	20.42	39.69	191.34	68.26	259.60
1974	12.95	0.11	8.14	20.04	39.64	191.34	67.82	259.16
1980	10.67	0.11	7.79	20.53	40.48	193.09	68.80	261.89
1984	66.18	0.19	9.55	21.05	39.95	192.51	70.55	263.05
1987	17.53	0.10	8.46	20.84	40.46	191.24	69.76	261.00
1991	17.42	0.10	8.39	20.92	40.22	190.74	69.53	260.28
1993	35.19	0.12	8.94	20.39	39.79	190.74	69.12	259.85
1998	23.35	0.13	9.24	26.22	41.47	192.75	76.93	269.68
2000	23.39	0.11	8.00	20.34	40.23	192.36	68.58	260.93
2002	4.99	0.09	7.45	20.07	39.77	192.13	67.28	259.41
2004	18.17	0.11	7.94	20.83	40.62	191.31	69.39	260.70
2005	30.33	0.13	8.95	22.31	40.03	191.29	71.28	262.57
2009	22.58	0.14	8.69	21.97	39.89	191.24	70.56	261.80
2012	51.48	0.16	9.00	20.81	40.19	190.42	70.00	260.42
2014	43.52	0.13	9.69	22.49	39.91	190.39	72.09	262.48

Annexure C: Drought Years Soil Moisture & Runoff of Jamshoro

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1951	47.65	2.33	10.89	61.61	123.48	213.50	195.98	409.47
1957	22.29	4.38	10.73	64.57	131.33	227.46	206.63	434.10
1960	50.66	3.47	11.96	62.64	127.56	221.73	202.15	423.88
1963	15.61	3.54	9.86	63.16	127.60	221.35	200.62	421.98
1964	74.35	2.14	12.36	60.36	121.62	212.19	194.34	406.53
1965	79.63	2.04	11.95	60.14	120.17	208.65	192.26	400.92
1966	48.51	1.81	10.73	59.59	118.97	207.62	189.29	396.92
1968	9.34	3.90	9.51	64.86	131.37	226.64	205.74	432.38
1969	23.38	2.13	9.95	61.61	124.87	217.53	196.43	413.97
1971	51.90	3.45	11.51	62.97	127.75	222.10	202.23	424.33
1972	17.71	1.71	9.64	59.83	121.18	212.28	190.65	402.93
1973	79.92	1.84	11.59	59.94	119.61	208.54	191.14	399.68
1974	13.61	1.34	9.46	58.12	116.94	206.50	184.52	391.02
1980	40.24	4.04	11.56	63.84	130.36	226.84	205.76	432.60
1987	4.57	3.08	9.01	63.76	128.55	222.41	201.33	423.74
1991	3.38	1.96	8.73	61.03	123.41	215.74	193.16	408.91
1993	22.28	2.19	10.36	60.82	123.19	215.69	194.37	410.05
1995	58.65	4.37	11.63	65.22	131.94	227.60	208.79	436.39
1996	34.81	1.68	11.24	59.04	121.04	212.93	191.32	404.25
1998	25.78	0.66	10.79	54.77	111.90	199.25	177.46	376.71
1999	37.75	0.53	10.89	53.20	107.78	193.47	171.88	365.35
2000	39.31	0.40	10.72	51.93	104.48	189.16	167.13	356.28
2002	18.81	0.51	9.70	54.51	109.29	193.23	173.50	366.72
2004	13.18	3.11	9.66	62.98	127.64	221.78	200.28	422.06
2005	54.18	1.60	11.97	58.47	118.96	210.26	189.40	399.66
2008	81.82	3.21	12.26	62.79	125.99	218.25	201.05	419.29
2011	67.41	2.72	11.79	62.14	124.83	215.39	198.76	414.15
2012	76.34	2.37	11.29	61.71	123.32	212.52	196.31	408.84
2014	53.57	1.90	12.22	59.24	120.19	210.96	191.65	402.61

Annexure C: Drought Years Soil Moisture & Runoff of Karachi City

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1951	49.43	9.57	13.81	71.70	145.28	246.70	230.79	477.49
1957	19.46	10.35	13.18	72.72	147.61	251.57	233.52	485.09
1960	55.96	15.74	14.74	72.26	147.04	250.92	234.04	484.96
1963	17.15	10.40	12.91	73.22	148.34	252.25	234.46	486.71
1964	95.37	13.96	14.76	71.68	144.90	244.45	231.34	475.79
1965	95.83	13.83	14.75	71.61	144.90	244.90	231.26	476.16
1966	56.19	9.55	13.42	70.79	142.86	240.86	227.07	467.93
1968	9.83	10.46	12.43	72.27	146.43	249.77	231.13	480.89
1969	41.18	6.67	13.19	69.18	139.71	237.09	222.08	459.17
1971	56.77	10.76	14.28	71.70	145.80	248.38	231.78	480.17
1972	36.21	7.80	12.68	69.89	141.09	238.91	223.66	462.57
1974	14.75	6.09	12.20	69.62	140.67	238.88	222.49	461.37
1987	5.86	6.64	11.93	70.80	142.99	242.37	225.72	468.09
1989	18.39	8.48	13.13	70.96	144.17	246.27	228.26	474.53
1991	3.53	6.75	11.87	68.32	138.25	235.44	218.43	453.87
1993	14.25	7.03	12.56	68.81	139.45	237.89	220.83	458.71
1995	13.09	9.47	12.66	71.68	145.31	247.85	229.65	477.50
1998	54.19	10.67	14.16	64.95	132.21	226.12	211.32	437.44
1999	32.98	4.71	13.28	62.87	127.81	218.82	203.95	422.77
2000	43.19	5.80	13.90	61.28	124.67	214.62	199.85	414.47
2001	101.34	9.99	14.70	64.06	128.02	213.08	206.78	419.86
2002	46.52	5.45	13.52	63.37	127.12	214.37	204.01	418.39
2004	14.17	6.75	12.67	68.98	139.70	237.98	221.35	459.33
2005	59.96	7.42	14.27	66.28	134.10	228.62	214.65	443.27
2008	88.17	15.31	15.11	72.25	146.32	248.83	233.68	482.51
2011	30.25	7.76	13.72	69.87	142.26	242.60	225.86	468.46
2012	92.77	9.58	13.64	69.11	139.46	234.03	222.21	456.24
2014	65.00	10.36	15.35	67.85	138.67	237.48	221.87	459.35
2018	99.60	20.02	16.49	74.38	152.09	259.82	242.95	502.77

Annexure C: Drought Years Soil Moisture & Runoff of Kashmore

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1950	72.59	0.42	11.86	34.33	66.47	204.29	112.66	316.95
1951	63.15	0.51	11.53	34.79	64.30	203.23	110.62	313.85
1952	44.57	0.22	11.39	32.58	63.56	203.03	107.53	310.56
1954	36.01	0.20	11.24	32.66	63.36	202.80	107.26	310.06
1957	33.15	0.16	11.21	32.74	63.75	202.20	107.70	309.90
1958	12.86	0.11	9.82	31.47	62.84	201.70	104.12	305.82
1960	41.37	0.27	10.91	32.73	63.51	201.88	107.15	309.03
1962	51.02	0.25	11.45	32.31	62.95	201.46	106.71	308.17
1963	39.40	0.19	11.00	32.97	62.34	200.93	106.31	307.24
1964	74.13	0.52	11.72	35.56	62.25	200.64	109.52	310.16
1965	51.15	0.26	11.40	33.75	62.05	200.48	107.21	307.69
1966	40.03	0.17	11.27	31.60	61.76	200.23	104.64	304.86
1968	4.64	0.14	9.43	33.05	65.14	202.05	107.63	309.67
1969	15.93	0.15	10.28	31.76	63.60	201.74	105.64	307.38
1971	76.45	0.70	11.55	36.56	63.62	201.45	111.73	313.18
1972	21.04	0.14	10.35	31.91	62.90	201.02	105.16	306.17
1973	41.18	0.18	10.96	31.97	62.49	200.70	105.43	306.13
1974	27.62	0.15	10.81	31.56	62.14	200.32	104.52	304.84
1980	16.12	0.32	10.04	32.68	65.30	206.63	108.02	314.65
1987	22.54	0.27	10.75	32.89	65.02	204.41	108.67	313.08
1988	62.46	0.50	11.63	34.21	63.89	203.82	109.73	313.56
1991	22.93	0.19	10.57	32.43	64.14	202.90	107.14	310.05
1993	46.72	0.20	11.36	32.20	62.55	201.42	106.11	307.53
1998	34.74	0.36	11.94	36.53	66.33	206.68	114.80	321.48
2000	29.49	0.35	10.26	32.64	64.93	206.07	107.83	313.90
2002	8.32	0.20	9.56	32.06	63.81	205.11	105.43	310.54
2004	33.86	0.36	10.77	33.20	65.60	205.51	109.58	315.08
2005	40.94	0.28	11.26	34.01	63.93	204.19	109.20	313.40
2009	32.73	0.21	11.11	32.67	62.68	202.29	106.46	308.76
2012	69.16	0.46	11.65	33.75	64.72	203.52	110.12	313.64

Annexure C: Drought Years Soil Moisture & Runoff of Khairpur

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	44.57	2.69	9.25	50.86	101.35	199.13	161.46	360.60
1950	71.50	8.90	10.15	55.99	113.65	218.25	179.79	398.04
1951	28.83	4.28	8.35	52.65	107.17	208.34	168.17	376.51
1952	58.99	3.17	9.21	52.51	104.95	202.69	166.68	369.37
1957	25.55	5.30	8.70	52.36	106.52	207.26	167.57	374.83
1958	53.87	3.22	9.30	51.67	103.22	200.83	164.19	365.02
1960	42.36	5.40	9.18	53.02	107.66	208.75	169.87	378.62
1963	28.49	5.65	8.85	53.28	108.54	210.33	170.67	381.00
1965	49.91	4.75	9.29	52.67	106.11	205.90	168.07	373.97
1966	35.77	2.86	9.13	50.09	101.78	200.07	161.00	361.07
1968	7.76	5.08	7.21	53.75	109.26	209.83	170.22	380.05
1969	13.43	3.03	7.58	51.18	104.22	203.00	162.98	365.97
1972	27.00	2.07	8.54	49.53	100.52	196.53	158.59	355.11
1973	51.83	1.66	9.12	48.79	97.99	192.76	155.90	348.66
1974	14.17	1.29	7.92	47.23	95.78	190.22	150.92	341.14
1980	27.92	5.95	8.70	54.11	110.57	214.78	173.38	388.16
1987	14.31	4.28	7.98	52.87	107.71	208.59	168.56	377.15
1991	5.93	5.36	7.25	53.26	108.51	210.65	169.01	379.67
1993	57.99	3.64	9.49	52.38	105.47	203.63	167.34	370.97
1996	62.63	6.70	10.20	54.62	111.35	216.78	176.16	392.95
1998	41.45	6.91	9.96	54.23	111.18	216.16	175.37	391.53
2000	39.98	3.37	8.59	51.60	105.07	205.45	165.26	370.71
2001	63.49	2.73	9.51	51.72	102.93	200.40	164.16	364.55
2002	4.02	1.94	6.91	49.58	100.42	197.79	156.91	354.70
2004	28.36	10.02	8.77	55.51	113.80	220.11	178.08	398.19
2005	29.67	4.45	8.90	52.44	107.08	209.08	168.42	377.50
2014	53.69	5.51	10.21	52.99	108.20	210.62	171.40	382.02

Annexure C: Drought Years Soil Moisture & Runoff of Larkana

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1951	45.32	0.15	10.42	24.34	47.35	195.78	82.11	277.89
1952	50.34	0.19	10.25	24.94	47.11	195.78	82.31	278.09
1957	29.91	0.11	9.93	24.84	47.02	195.69	81.80	277.49
1958	43.73	0.19	10.07	24.76	47.01	195.69	81.84	277.53
1960	32.60	0.14	9.87	24.65	47.26	195.57	81.79	277.36
1963	16.74	0.09	9.32	23.90	47.05	195.50	80.27	275.77
1964	56.30	0.25	10.60	25.14	47.02	195.50	82.76	278.26
1965	30.90	0.19	9.70	24.00	47.01	195.50	80.72	276.22
1966	22.84	0.16	9.49	23.79	47.00	195.50	80.28	275.78
1968	1.13	0.06	8.16	24.77	47.89	195.25	80.82	276.07
1969	24.00	0.12	9.51	24.05	47.20	195.25	80.76	276.01
1971	45.58	0.23	9.55	25.53	47.04	195.24	82.13	277.37
1972	5.95	0.07	8.72	23.81	47.02	195.24	79.55	274.79
1973	21.91	0.10	8.99	23.95	47.01	195.24	79.94	275.18
1974	9.08	0.07	9.02	23.59	47.00	195.24	79.61	274.86
1980	13.53	0.08	9.16	23.87	47.39	195.16	80.42	275.58
1984	63.85	0.22	10.21	24.87	47.06	195.07	82.14	277.21
1987	8.93	0.06	9.03	24.18	47.51	194.72	80.71	275.44
1991	12.18	0.07	9.18	23.95	47.16	194.60	80.29	274.90
1993	27.97	0.10	9.65	23.90	47.03	194.60	80.57	275.18
1998	20.96	0.08	9.98	24.90	47.71	193.83	82.59	276.42
2000	25.23	0.08	9.20	23.92	47.14	193.83	80.26	274.09
2001	70.73	0.27	10.71	25.58	47.05	193.83	83.35	277.18
2002	4.20	0.06	8.64	23.64	47.01	193.83	79.29	273.12
2004	8.47	0.06	8.63	24.00	47.56	193.54	80.20	273.74
2005	23.74	0.07	9.82	24.08	47.17	193.54	81.07	274.61
2009	29.54	0.17	9.77	24.92	47.06	193.54	81.75	275.29
2012	37.36	0.22	9.18	24.64	47.19	193.45	81.02	274.47
2014	40.24	0.09	10.50	24.09	47.03	193.45	81.62	275.07

Annexure C: Drought Years Soil Moisture & Runoff of Matiari

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	15.57	0.16	8.82	27.30	53.93	196.23	90.04	286.27
1950	82.00	1.09	9.92	35.51	61.64	197.83	107.07	304.90
1951	49.95	0.42	9.05	30.17	57.11	196.46	96.33	292.79
1957	35.22	0.42	9.54	31.24	63.47	206.28	104.24	310.53
1960	51.58	0.56	9.63	32.70	61.62	202.29	103.96	306.25
1963	19.89	0.41	8.45	29.98	60.57	198.98	99.00	297.98
1966	59.29	0.54	9.47	31.92	56.18	195.85	97.57	293.42
1968	17.56	0.34	8.58	30.82	62.32	197.27	101.72	298.98
1969	11.39	0.27	7.88	28.18	56.81	195.94	92.88	288.82
1971	61.76	0.55	9.71	32.93	60.53	195.62	103.18	298.80
1972	22.23	0.26	8.56	28.62	56.47	194.03	93.64	287.67
1973	70.53	0.39	9.56	31.21	54.67	193.28	95.43	288.71
1974	13.29	0.21	8.12	27.68	53.95	192.76	89.74	282.50
1980	45.45	0.57	9.35	33.05	61.73	199.00	104.13	303.14
1981	33.75	0.29	9.23	33.19	57.43	196.35	99.85	296.20
1982	61.50	0.31	10.06	29.91	54.57	195.05	94.53	289.58
1987	6.89	0.32	8.06	29.28	58.73	194.97	96.07	291.04
1991	3.07	0.39	7.46	29.54	59.42	193.99	96.42	290.42
1993	46.06	0.40	9.56	31.00	59.26	192.29	99.82	292.11
1996	33.74	0.26	9.33	29.37	58.02	194.25	96.72	290.96
1998	40.22	0.17	9.69	27.97	53.51	191.67	91.17	282.85
1999	45.47	0.19	9.36	27.06	52.17	190.61	88.59	279.20
2000	52.89	0.24	9.17	28.05	51.37	189.72	88.58	278.30
2002	8.42	0.11	7.73	27.24	53.70	190.99	88.67	279.66
2004	24.87	0.74	8.70	30.88	62.84	204.98	102.41	307.39
2005	63.90	0.54	10.02	30.19	57.27	201.82	97.49	299.32
2008	82.56	0.46	10.05	32.66	59.69	197.27	102.40	299.66
2014	66.75	0.55	10.09	31.42	57.52	194.41	99.03	293.44

Annexure C: Drought Years Soil Moisture & Runoff of Mirpur Khas

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	18.49	1.18	9.78	30.15	61.64	198.38	101.57	299.95
1950	122.15	7.53	11.75	43.82	82.97	201.59	138.55	340.14
1951	63.86	2.48	10.55	37.57	68.82	197.86	116.94	314.80
1954	102.31	4.88	11.16	41.44	78.10	199.97	130.71	330.67
1957	83.96	4.05	12.36	43.39	84.72	219.52	140.47	359.98
1960	60.69	3.61	11.36	42.80	82.64	214.36	136.80	351.16
1963	48.55	2.51	10.31	37.14	74.85	213.39	122.29	335.68
1966	79.59	3.48	11.57	40.70	73.21	207.55	125.48	333.04
1968	49.41	3.33	10.84	41.92	81.42	212.64	134.18	346.82
1969	8.60	1.42	8.97	32.35	66.05	205.69	107.37	313.05
1972	61.07	2.68	11.06	37.61	69.23	201.80	117.90	319.70
1973	120.88	3.93	11.97	40.70	68.03	198.97	120.70	319.67
1974	16.82	1.47	9.44	30.95	62.42	196.44	102.80	299.25
1980	51.68	3.57	10.62	42.80	79.40	216.54	132.82	349.35
1981	19.90	2.09	10.18	34.45	66.96	209.56	111.59	321.15
1986	111.57	5.48	11.61	41.86	77.94	207.38	131.41	338.78
1987	18.18	1.84	9.95	33.61	68.27	203.29	111.83	315.12
1989	101.62	5.37	11.60	44.40	81.95	208.30	137.95	346.24
1991	14.15	2.47	9.60	39.38	81.00	209.90	129.98	339.88
1996	82.89	3.43	11.41	40.96	71.27	198.17	123.64	321.82
1999	61.84	2.27	10.92	32.68	62.41	191.81	106.00	297.82
2000	100.43	3.87	11.12	38.86	62.97	190.57	112.95	303.52
2001	101.49	4.66	11.34	39.72	67.18	190.12	118.25	308.36
2002	16.09	1.30	9.33	30.22	60.23	188.40	99.78	288.17
2004	70.42	3.72	11.70	41.57	83.35	228.35	136.63	364.98
2005	118.52	3.86	12.36	38.67	69.79	220.00	120.82	340.81
2008	117.33	5.19	12.72	45.33	83.58	223.23	141.63	364.86

Annexure C: Drought Years Soil Moisture & Runoff of Naushahro Feroze

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1951	49.56	1.07	11.33	29.09	54.35	199.73	94.77	294.49
1952	61.88	1.26	11.47	29.81	53.90	199.75	95.18	294.93
1954	47.16	1.13	11.65	28.46	54.36	199.70	94.47	294.17
1957	22.85	0.80	10.89	27.93	54.65	199.50	93.47	292.97
1960	38.63	1.25	11.25	28.94	54.85	199.46	95.04	294.50
1963	17.27	0.68	10.54	27.50	53.92	199.17	91.97	291.13
1964	69.95	0.93	12.18	29.23	53.69	199.18	95.09	294.28
1965	43.71	0.89	11.06	28.51	53.59	199.19	93.16	292.35
1966	29.22	0.67	10.70	27.76	53.51	199.11	91.96	291.07
1968	3.29	0.73	9.50	28.83	56.72	198.71	95.05	293.76
1969	23.50	0.49	10.48	27.64	54.33	198.50	92.45	290.95
1971	47.10	1.02	10.86	29.53	54.36	198.71	94.75	293.45
1972	10.32	0.54	10.03	27.16	53.77	198.56	90.96	289.52
1973	39.01	0.64	10.69	27.80	53.57	198.54	92.06	290.60
1974	12.06	0.48	10.25	26.92	53.48	198.50	90.65	289.16
1980	23.45	0.87	10.73	28.11	55.03	200.05	93.88	293.93
1984	68.38	1.24	11.69	29.09	53.91	199.97	94.69	294.66
1987	6.02	0.61	9.94	27.90	55.07	199.50	92.90	292.40
1990	34.49	1.07	11.10	28.67	55.05	199.42	94.81	294.24
1991	7.37	0.64	9.92	27.33	54.03	199.25	91.28	290.53
1993	26.55	0.71	10.79	27.77	53.85	199.27	92.41	291.67
1996	43.56	1.08	11.66	28.50	54.99	199.35	95.15	294.50
1998	21.81	1.01	10.98	28.26	54.56	199.27	93.80	293.08
2000	29.72	0.60	10.60	27.19	53.59	199.04	91.39	290.43
2002	6.80	0.48	9.91	27.18	53.48	198.98	90.57	289.55
2004	10.86	0.63	9.98	27.74	55.12	198.60	92.83	291.43
2005	34.08	0.71	11.35	27.33	54.10	198.63	92.77	291.40
2009	59.10	1.52	11.54	30.92	53.89	198.79	96.36	295.15
2012	46.58	0.86	10.49	29.20	54.02	198.43	93.70	292.13
2014	40.73	0.87	11.56	27.63	53.65	198.55	92.84	291.40

Annexure C: Drought Years Soil Moisture & Runoff of Qamber Shahdadkot

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1955	44.98	0.27	10.05	34.16	65.53	191.95	109.74	301.69
1957	45.80	0.26	9.88	36.30	67.56	191.80	113.74	305.54
1963	13.36	0.11	8.56	31.59	62.21	187.80	102.36	290.16
1964	40.52	0.18	9.75	30.95	59.71	186.35	100.40	286.75
1965	32.80	0.20	9.31	29.92	58.10	185.17	97.33	282.49
1966	22.16	0.14	8.87	29.76	56.98	184.10	95.61	279.71
1968	1.84	0.19	7.56	35.91	69.95	190.68	113.42	304.11
1969	41.80	0.32	9.53	33.28	64.30	189.16	107.12	296.28
1971	27.63	0.27	8.66	33.95	66.79	190.77	109.41	300.18
1972	7.94	0.15	8.28	32.36	62.61	188.28	103.25	291.52
1973	24.95	0.18	8.48	31.09	60.26	186.63	99.83	286.45
1974	10.45	0.11	8.35	29.83	58.84	185.49	97.01	282.50
1977	78.99	0.44	10.51	36.96	67.45	189.18	114.93	304.11
1980	11.79	0.24	8.53	34.16	67.93	193.11	110.62	303.73
1984	56.80	0.27	9.91	33.08	63.35	188.27	106.35	294.62
1987	14.76	0.34	8.99	35.58	71.06	193.96	115.63	309.59
1991	17.27	0.19	8.70	35.30	67.02	189.84	111.02	300.86
1993	23.42	0.16	9.14	32.68	65.13	187.90	106.95	294.85
1999	59.36	0.38	10.17	33.48	63.98	187.44	107.63	295.07
2000	29.05	0.13	9.02	30.58	60.63	185.33	100.22	285.55
2001	81.94	0.42	10.46	33.95	59.32	184.09	103.73	287.82
2002	7.69	0.10	8.25	30.23	58.72	183.86	97.20	281.06
2004	7.22	0.16	7.92	34.16	67.48	188.21	109.57	297.77
2005	34.56	0.19	10.04	34.91	64.08	186.94	109.03	295.97
2009	21.31	0.14	9.28	33.65	61.94	184.49	104.87	289.36
2012	22.79	0.18	8.54	32.49	64.62	186.18	105.64	291.82
2014	54.17	0.21	10.53	32.54	59.91	183.18	102.98	286.16

Annexure C: Drought Years Soil Moisture & Runoff of Sanghar

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	26.92	2.42	8.63	41.65	84.88	200.66	135.16	335.82
1950	92.74	7.09	10.46	50.02	96.89	210.40	157.36	367.76
1951	46.76	3.64	9.02	44.32	89.10	204.20	142.44	346.64
1952	89.25	4.19	9.63	46.59	88.46	201.21	144.68	345.89
1954	78.13	4.76	10.25	46.50	91.87	205.79	148.62	354.41
1957	51.89	7.30	9.98	47.99	98.01	213.69	155.98	369.66
1958	90.82	5.04	10.16	48.25	91.95	206.11	150.36	356.48
1960	52.89	6.28	9.77	47.39	95.61	210.19	152.78	362.97
1963	34.70	5.01	9.06	46.14	93.97	208.11	149.17	357.28
1966	57.64	4.07	10.04	45.00	89.36	203.11	144.40	347.51
1968	32.39	3.92	8.66	46.25	92.86	202.48	147.77	350.25
1969	12.02	2.12	7.67	42.09	85.78	196.78	135.54	332.32
1972	52.57	2.53	9.60	43.19	85.63	195.64	138.41	334.05
1973	91.69	2.49	10.29	44.69	83.85	192.55	138.83	331.38
1974	16.02	1.65	8.12	40.58	81.32	190.96	130.02	320.98
1980	39.93	5.86	9.31	47.55	95.82	212.91	152.68	365.60
1981	48.05	3.82	9.65	45.27	89.05	204.54	143.97	348.51
1986	88.38	6.48	10.04	49.15	94.15	208.06	153.34	361.40
1987	18.03	3.35	8.47	43.98	89.18	203.14	141.62	344.76
1991	5.75	7.78	7.45	47.49	97.02	213.26	151.97	365.24
1996	70.79	4.86	10.60	46.38	93.02	207.91	150.00	357.91
1998	74.89	4.21	10.97	45.01	90.24	203.63	146.22	349.85
1999	63.70	2.66	9.79	43.14	84.96	197.35	137.89	335.25
2000	63.64	2.30	9.42	41.85	81.67	193.98	132.93	326.91
2001	89.78	3.43	10.04	45.31	83.06	192.26	138.41	330.67
2002	5.61	1.58	7.16	40.03	80.31	191.49	127.50	318.99
2004	45.93	8.37	9.71	48.46	100.05	219.92	158.22	378.14
2005	64.46	3.74	10.13	44.82	90.22	208.86	145.18	354.03
2008	83.00	4.92	10.49	47.74	93.81	209.73	152.03	361.76
2014	82.74	5.43	10.83	47.31	93.79	209.49	151.92	361.41

Annexure C: Drought Years Soil Moisture & Runoff of Shaheed Benazirabad

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	26.82	1.14	9.36	24.90	46.70	193.29	80.96	274.24
1951	47.62	1.34	8.96	27.79	50.58	191.56	87.33	278.89
1952	66.44	1.48	9.42	29.21	47.98	191.25	86.61	277.86
1954	57.82	1.54	9.78	27.18	49.87	190.91	86.83	277.74
1957	20.19	1.24	8.78	26.52	52.75	190.41	88.05	278.47
1960	45.35	1.69	9.48	28.54	53.00	188.74	91.02	279.76
1963	19.77	1.23	8.70	26.05	50.56	187.03	85.31	272.34
1965	61.03	1.66	9.39	29.28	47.13	186.42	85.79	272.21
1966	41.39	1.14	9.06	26.46	45.99	186.05	81.50	267.55
1968	6.85	1.30	7.81	28.80	57.56	186.47	94.17	280.65
1969	15.11	0.71	8.03	24.74	49.60	185.30	82.37	267.67
1971	56.77	1.66	9.31	29.10	49.95	185.32	88.36	273.68
1972	14.02	0.84	8.20	24.55	47.00	184.52	79.74	264.26
1973	51.22	0.86	9.01	25.61	45.34	184.24	79.96	264.20
1974	13.53	0.65	8.25	23.46	44.60	183.96	76.32	260.27
1980	35.42	1.53	9.24	28.13	55.69	190.90	93.06	283.96
1982	52.18	1.51	9.83	27.41	50.03	189.24	87.27	276.50
1987	6.40	1.10	7.93	26.10	51.39	187.66	85.42	273.08
1990	45.99	1.63	9.27	28.99	55.47	186.62	93.73	280.34
1991	3.30	0.84	7.50	24.86	49.54	185.37	81.90	267.27
1993	35.53	1.26	9.16	26.34	48.54	185.27	84.04	269.30
1996	38.00	1.49	9.51	27.33	54.37	193.08	91.21	284.29
1998	24.18	1.33	9.16	25.97	49.97	191.47	85.10	276.56
1999	59.70	1.30	9.66	25.86	46.72	190.82	82.24	273.06
2000	37.14	0.99	8.81	24.36	45.27	190.30	78.44	268.74
2002	8.20	0.79	7.78	24.25	45.52	189.89	77.55	267.44
2004	17.95	1.36	8.37	27.56	56.27	189.96	92.20	282.16
2005	43.18	1.05	9.45	25.30	49.72	188.73	84.48	273.21
2012	67.93	1.53	9.16	28.48	51.16	186.04	88.80	274.84
2014	43.48	1.26	9.70	25.83	48.82	185.55	84.35	269.91

Annexure C: Drought Years Soil Moisture & Runoff of Shikarpur

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1951	46.89	0.20	9.06	20.75	39.61	193.61	69.42	263.04
1952	42.20	0.18	8.89	20.93	39.61	193.61	69.43	263.04
1954	26.30	0.13	8.39	21.07	39.63	193.59	69.09	262.68
1957	26.65	0.13	8.62	20.84	39.62	193.52	69.08	262.60
1958	24.39	0.14	8.19	20.09	39.60	193.52	67.89	261.41
1960	31.69	0.16	8.52	20.41	39.62	193.37	68.55	261.92
1963	23.23	0.13	8.27	20.16	39.61	193.30	68.04	261.34
1964	56.88	0.32	9.01	22.61	39.62	193.30	71.24	264.54
1965	31.46	0.18	8.62	20.33	39.61	193.30	68.56	261.86
1966	24.77	0.16	8.38	20.07	39.60	193.30	68.05	261.35
1968	1.68	0.10	6.98	20.51	39.69	193.13	67.19	260.32
1969	15.11	0.12	8.05	19.90	39.60	193.13	67.55	260.68
1971	58.63	0.37	8.55	23.03	39.66	193.13	71.24	264.37
1972	6.99	0.11	7.50	20.02	39.61	193.13	67.13	260.26
1973	19.79	0.14	7.75	20.14	39.60	193.13	67.49	260.62
1974	10.01	0.12	7.82	19.85	39.60	193.13	67.27	260.40
1977	60.87	0.25	9.16	22.26	39.62	192.33	71.04	263.37
1980	10.48	0.11	7.68	19.93	39.61	193.83	67.22	261.05
1987	13.10	0.10	8.02	20.04	39.62	192.83	67.68	260.50
1991	13.29	0.10	8.04	20.00	39.61	192.63	67.64	260.27
1993	31.51	0.11	8.52	19.92	39.60	192.63	68.05	260.67
1998	19.36	0.11	8.80	22.45	39.74	192.58	70.99	263.57
2000	22.66	0.11	7.77	19.90	39.61	192.52	67.28	259.80
2002	3.23	0.09	7.15	19.81	39.60	192.52	66.56	259.08
2004	13.79	0.10	7.57	19.94	39.62	192.09	67.13	259.21
2005	22.55	0.11	8.43	20.46	39.62	192.09	68.51	260.59
2009	24.09	0.17	8.41	20.73	39.61	192.09	68.75	260.83
2012	48.56	0.18	8.47	20.35	39.61	191.79	68.42	260.22
2014	39.02	0.12	9.32	20.64	39.61	191.79	69.57	261.37

Annexure C: Drought Years Soil Moisture & Runoff of Sujawal								
Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	89.43	1.51	15.70	72.61	141.94	268.89	230.25	499.14
1950	109.58	6.04	15.36	79.92	155.95	284.61	251.23	535.84
1951	65.12	2.61	14.75	75.05	149.92	281.69	239.73	521.41
1957	61.40	5.27	15.07	82.61	167.13	309.83	264.81	574.64
1960	72.95	5.16	15.62	82.58	166.06	306.81	264.25	571.06
1963	47.81	4.67	14.31	81.53	164.75	307.48	260.59	568.07
1966	80.16	4.61	14.53	79.83	156.27	299.01	250.63	549.64
1968	30.69	3.83	13.99	82.74	167.80	313.89	264.53	578.43
1969	35.43	2.85	13.25	77.48	156.00	304.52	246.73	551.25
1971	100.84	4.88	15.98	81.14	161.06	307.33	258.18	565.51
1972	56.28	2.29	14.26	76.08	151.62	298.80	241.95	540.75
1974	25.97	1.56	13.17	73.56	147.30	295.22	234.03	529.25
1981	69.16	2.60	15.73	78.02	156.71	301.65	250.46	552.11
1982	80.31	1.67	15.46	73.92	147.92	292.20	237.30	529.50
1986	118.97	4.22	16.14	79.60	156.49	300.03	252.23	552.26
1987	7.37	2.23	12.37	75.87	152.62	297.35	240.85	538.20
1989	105.53	7.88	15.48	81.99	162.33	304.68	259.80	564.48
1991	18.53	2.63	13.18	76.57	153.58	296.93	243.33	540.27
1993	39.74	4.16	13.96	78.09	157.75	302.01	249.80	551.81
1995	64.08	6.32	14.12	82.15	162.56	305.42	258.83	564.25
1996	64.36	2.80	14.95	76.66	152.20	295.98	243.81	539.79
1997	98.73	2.34	16.77	73.57	145.61	289.45	235.95	525.40
1998	118.23	2.88	16.06	75.59	144.70	287.34	236.35	523.70
1999	42.94	1.35	14.00	71.73	142.49	286.21	228.22	514.43
2000	106.99	1.97	15.83	72.54	139.15	282.71	227.52	510.23
2002	46.35	1.27	14.11	71.10	141.12	283.57	226.33	509.90
2004	64.93	5.64	15.38	79.49	161.59	307.10	256.46	563.56
2011	115.12	10.45	16.08	83.01	164.88	310.81	263.97	574.78
2012	115.89	5.83	15.61	80.35	158.43	303.48	254.38	557.86
2018	107.54	13.89	15.68	86.60	173.66	329.79	275.93	605.72

Annexure C: Drought Years Soil Moisture & Runoff of Sukkur

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1950	52.69	7.49	10.84	49.41	100.06	212.86	160.31	373.17
1951	22.48	3.56	9.61	46.33	93.76	205.34	149.70	355.04
1952	43.87	2.72	10.41	45.38	90.50	201.04	146.29	347.34
1954	36.24	3.38	10.48	45.29	90.74	200.87	146.51	347.37
1957	20.30	2.66	9.82	44.15	88.76	197.03	142.74	339.77
1958	30.20	1.86	9.79	42.89	86.25	193.79	138.93	332.72
1960	35.41	3.09	10.05	44.95	90.30	198.21	145.30	343.51
1963	28.21	3.43	10.01	45.55	91.28	199.89	146.83	346.72
1965	35.87	2.58	10.26	44.26	88.42	195.63	142.94	338.57
1966	27.98	1.91	10.07	42.64	85.91	192.54	138.62	331.16
1968	1.70	4.09	8.22	47.50	95.11	202.26	150.82	353.08
1969	13.29	2.28	8.99	44.70	90.50	197.97	144.20	342.17
1972	19.11	2.15	9.51	43.65	87.75	193.76	140.91	334.66
1973	28.08	1.50	9.64	42.49	85.48	190.92	137.61	328.53
1974	12.03	1.16	9.15	41.45	83.65	188.49	134.24	322.73
1980	14.87	3.41	9.26	46.30	93.76	205.06	149.33	354.38
1987	12.78	5.00	9.28	47.85	96.70	208.04	153.83	361.87
1990	41.09	5.61	10.90	48.07	96.38	206.92	155.35	362.27
1991	8.60	2.85	8.92	45.45	91.96	200.82	146.33	347.15
1993	29.82	2.22	10.06	43.91	88.30	195.31	142.27	337.59
1998	25.04	5.80	10.79	48.34	96.89	208.93	156.01	364.93
2000	30.73	3.80	9.53	46.45	93.87	204.94	149.84	354.78
2001	49.28	2.84	10.71	45.15	90.21	200.13	146.07	346.20
2002	2.52	1.72	8.12	43.49	87.81	196.20	139.43	335.62
2004	22.25	5.63	9.71	47.97	97.38	208.27	155.06	363.33
2005	17.86	3.08	9.64	45.42	91.74	201.48	146.80	348.28
2009	43.59	3.78	10.08	47.18	92.22	199.91	149.48	349.39
2014	52.66	3.80	11.55	45.39	91.39	199.99	148.33	348.33

Annexure C: Drought Years Soil Moisture & Runoff of Tando Allahyar

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	9.97	4.97	11.99	33.27	67.00	218.40	112.27	330.67
1950	92.35	15.57	13.51	41.11	72.78	220.48	127.40	347.88
1951	54.86	7.65	12.80	35.51	67.89	217.63	116.20	333.83
1954	87.96	13.95	13.34	38.19	69.89	218.28	121.42	339.70
1957	55.17	10.29	13.73	35.49	69.99	231.82	119.21	351.03
1960	55.55	10.83	13.27	37.16	69.44	226.15	119.87	346.02
1963	27.81	7.46	12.36	33.85	68.10	221.95	114.31	336.26
1966	68.85	10.94	13.39	38.14	68.87	222.16	120.40	342.56
1968	30.45	8.83	12.72	35.43	69.50	220.93	117.65	338.58
1969	8.47	4.10	11.58	33.01	66.53	217.14	111.12	328.26
1971	85.65	13.41	13.98	39.06	70.20	219.99	123.24	343.23
1972	38.01	7.00	12.81	34.81	67.78	217.06	115.40	332.46
1973	89.57	9.58	13.48	39.22	68.57	217.28	121.28	338.56
1974	13.82	4.95	11.90	33.22	66.98	215.03	112.10	327.13
1980	50.11	10.79	12.88	38.07	68.94	225.03	119.89	344.93
1981	14.60	9.31	12.57	35.86	68.38	224.18	116.81	340.99
1982	78.07	9.03	13.79	38.07	68.30	223.18	120.16	343.35
1987	10.91	6.49	12.25	33.58	67.67	217.53	113.50	331.03
1991	5.60	6.50	11.66	33.62	67.91	213.97	113.19	327.15
1993	70.43	12.30	13.59	39.04	69.55	216.15	122.18	338.32
1996	45.96	8.15	13.10	36.11	68.17	212.52	117.38	329.90
1998	70.09	10.37	13.96	36.23	68.71	213.56	118.90	332.47
1999	48.32	6.64	12.96	34.29	67.67	211.54	114.91	326.45
2000	72.30	9.65	13.09	37.62	68.35	212.79	119.07	331.86
2001	102.38	15.71	13.69	41.41	72.16	214.37	127.26	341.63
2002	9.92	5.07	11.72	33.24	67.06	210.36	112.02	322.38
2004	40.73	7.71	12.95	34.23	68.48	234.65	115.66	350.31
2005	84.82	9.36	13.92	36.27	68.16	234.25	118.34	352.59
2008	94.28	14.84	13.96	38.21	69.47	236.85	121.64	358.49
2014	90.97	12.81	13.84	38.96	69.14	230.06	121.94	352.00

Annexure C: Drought Years Soil Moisture & Runoff of Tando Muhammad Khan

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	33.15	6.58	14.56	41.20	81.64	226.96	137.40	364.36
1950	99.63	17.32	15.28	49.74	90.43	229.88	155.44	385.33
1951	59.81	8.32	14.45	43.58	84.07	226.60	142.09	368.69
1957	56.49	10.95	15.25	47.13	94.20	254.27	156.58	410.85
1960	63.65	11.49	15.24	47.89	92.86	247.30	156.00	403.29
1963	34.95	7.61	14.09	44.17	88.90	242.62	147.16	389.78
1966	74.79	11.94	14.87	46.89	86.07	241.00	147.82	388.82
1968	26.31	8.61	14.35	45.77	92.56	254.10	152.69	406.78
1969	10.71	4.20	13.19	40.93	83.14	248.83	137.26	386.09
1971	88.53	14.93	15.54	48.98	91.64	250.73	156.15	406.88
1972	35.20	7.44	14.16	42.63	84.45	246.77	141.25	388.02
1973	103.37	11.95	15.34	46.67	83.19	246.92	145.20	392.12
1974	17.50	5.18	13.48	40.62	80.81	244.29	134.91	379.21
1980	69.46	12.80	15.09	49.73	92.07	247.02	156.89	403.90
1981	21.99	9.68	14.46	45.25	86.08	243.85	145.79	389.64
1982	62.31	8.55	15.26	42.54	82.54	242.03	140.35	382.38
1987	6.70	6.15	13.41	41.99	84.79	238.16	140.19	378.35
1991	9.29	6.68	13.40	42.88	86.40	236.67	142.68	379.35
1993	47.44	11.40	14.71	44.81	88.18	237.96	147.70	385.65
1995	97.27	17.04	14.92	51.25	94.40	239.29	160.57	399.86
1996	40.19	8.28	14.63	43.35	85.22	235.28	143.20	378.48
1997	95.01	10.93	15.97	44.04	82.64	234.98	142.65	377.62
1998	80.38	12.55	15.52	45.50	82.18	235.71	143.20	378.91
1999	44.82	6.71	14.34	40.90	80.02	232.89	135.25	368.14
2000	85.79	12.08	14.95	45.95	80.69	234.55	141.59	376.14
2002	25.09	5.48	13.85	40.71	81.12	232.38	135.68	368.06
2004	45.36	7.88	14.55	44.13	89.38	248.48	148.06	396.54
2008	111.34	16.96	16.04	48.91	91.00	250.41	155.95	406.35
2014	103.76	15.09	15.81	47.32	86.00	243.35	149.13	392.49

Annexure C: Drought Years Soil Moisture & Runoff of Thar Parker

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	115.35	12.00	11.13	67.56	138.73	239.63	217.42	457.05
1951	98.64	13.83	10.78	69.66	142.66	247.11	223.10	470.21
1957	141.07	17.11	12.65	70.60	144.84	250.91	228.09	478.99
1960	81.69	16.09	11.28	69.39	143.13	250.02	223.81	473.83
1963	139.99	15.11	11.66	69.96	143.08	247.09	224.70	471.80
1966	115.21	17.03	12.11	70.43	144.73	251.20	227.28	478.48
1968	91.58	17.08	10.92	70.31	144.55	251.54	225.79	477.33
1969	37.54	6.88	9.54	65.85	135.26	234.97	210.65	445.62
1972	97.78	11.74	11.47	68.69	140.79	244.21	220.96	465.17
1974	42.29	8.06	9.64	66.51	136.52	237.29	212.67	449.96
1980	105.07	17.84	11.35	70.33	144.73	251.69	226.41	478.10
1986	98.42	14.74	10.91	70.22	143.75	247.87	224.89	472.76
1987	37.73	8.24	9.41	67.05	137.42	238.50	213.87	452.36
1989	101.99	18.08	11.13	71.04	145.63	252.73	227.80	480.53
1991	59.23	19.18	10.33	70.04	144.87	254.00	225.24	479.24
1995	158.36	31.38	12.30	72.98	150.52	262.17	235.79	497.97
1996	181.00	14.43	13.65	70.02	143.07	245.95	226.74	472.69
1999	119.44	9.04	12.32	66.57	136.84	238.20	215.73	453.93
2000	166.41	9.05	12.04	68.06	137.97	233.74	218.07	451.81
2002	39.04	7.71	9.47	66.18	135.86	236.07	211.51	447.58
2004	142.55	21.72	12.64	71.38	146.96	255.59	230.98	486.57
2008	158.58	16.65	14.23	70.07	144.01	249.86	228.31	478.17
2018	154.57	26.08	11.82	72.46	148.84	258.23	233.13	491.36

Annexure C: Drought Years Soil Moisture & Runoff of Thatta

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1951	47.40	2.21	12.16	66.37	133.41	241.78	211.94	453.72
1957	39.24	3.63	12.59	71.32	145.34	260.46	229.26	489.71
1960	64.53	3.15	13.64	70.68	142.98	256.25	227.30	483.55
1963	28.79	3.93	11.80	72.63	147.49	263.51	231.92	495.44
1966	68.26	2.77	12.24	68.45	135.26	246.77	215.95	462.72
1968	18.78	2.77	11.53	72.22	146.62	264.20	230.36	494.56
1969	32.35	1.79	11.22	67.31	135.36	251.54	213.89	465.43
1971	74.46	2.93	13.36	69.26	139.03	256.15	221.65	477.80
1972	41.17	1.84	11.41	66.23	131.29	247.13	208.93	456.06
1974	19.08	1.35	10.78	63.50	128.02	244.19	202.30	446.50
1981	66.78	1.83	13.59	67.68	136.31	250.18	217.57	467.75
1982	84.87	1.51	13.48	64.46	128.05	240.44	205.99	446.43
1987	4.79	2.00	10.19	66.47	134.13	250.33	210.79	461.12
1989	69.30	4.48	12.93	69.71	139.67	256.64	222.31	478.94
1991	8.22	1.35	10.55	63.96	128.60	242.87	203.12	445.99
1993	25.80	2.19	11.62	65.88	133.88	248.79	211.37	460.16
1995	41.25	3.29	12.01	69.28	139.97	254.84	221.25	476.09
1996	60.07	2.15	12.75	65.22	128.96	242.04	206.93	448.97
1997	78.68	1.30	14.20	62.08	122.19	234.37	198.47	432.85
1998	64.64	0.86	13.03	60.38	117.21	228.23	190.62	418.85
1999	27.01	0.44	11.47	56.28	112.68	224.42	180.43	404.85
2000	68.92	0.61	12.90	56.13	108.21	220.52	177.23	397.76
2002	39.89	0.67	11.64	57.88	113.23	223.46	182.74	406.21
2004	33.75	2.92	12.21	66.93	136.50	251.44	215.64	467.08
2008	103.08	3.24	14.36	70.89	142.16	257.09	227.41	484.50
2011	59.00	2.37	12.73	68.39	137.49	251.26	218.61	469.87
2014	98.02	2.29	14.57	65.66	130.23	243.06	210.45	453.51
2018	107.47	10.44	14.20	76.62	155.25	281.71	246.07	527.78

Annexure C: Drought Years Soil Moisture & Runoff of Umerkot

Year	Rain (mm/7month)	Runoff (mm/7month)	Soil Moisture (0-10 cm), mm	Soil Moisture (10-40 cm), mm	Soil Moisture (40-100 cm), mm	Soil Moisture (100-200 cm), mm	Soil Moisture (0-100 cm), mm	Soil Moisture (0-200 cm), mm
1948	58.48	4.14	9.44	52.96	107.14	210.45	169.55	380.00
1950	129.39	9.41	11.20	59.57	120.76	220.59	191.53	412.12
1951	65.48	4.65	9.67	55.80	111.68	213.61	177.15	390.76
1954	122.52	7.13	11.45	59.30	119.41	220.60	190.16	410.76
1957	95.05	9.61	11.58	61.34	125.48	232.33	198.40	430.73
1960	63.17	8.13	10.55	59.44	122.69	228.91	192.68	421.58
1963	65.96	6.24	9.90	58.07	119.29	224.78	187.26	412.03
1966	80.73	6.32	11.11	58.05	117.13	222.63	186.29	408.92
1968	66.67	7.22	9.91	60.05	121.77	224.60	191.74	416.33
1969	16.21	3.54	8.06	53.58	109.80	213.33	171.44	384.77
1972	87.14	3.90	10.80	56.29	111.88	211.97	178.97	390.94
1974	20.71	2.20	8.29	51.00	103.87	203.16	163.16	366.32
1980	48.17	7.33	9.77	59.65	121.80	228.31	191.23	419.54
1981	71.79	4.10	10.54	55.03	110.92	214.94	176.49	391.43
1986	83.07	7.95	10.03	60.53	122.23	225.86	192.80	418.65
1987	23.89	4.32	8.80	55.09	112.88	217.27	176.77	394.04
1989	80.96	9.71	10.30	61.11	123.82	228.94	195.23	424.17
1991	18.47	11.63	8.48	61.82	127.59	236.25	197.88	434.14
1996	112.54	6.11	11.76	58.26	115.49	218.35	185.51	403.86
1999	77.23	2.36	10.66	51.52	103.40	202.48	165.58	368.05
2000	102.11	2.06	10.38	52.98	100.80	196.52	164.16	360.68
2001	120.76	2.88	11.17	54.45	104.42	197.64	170.03	367.68
2002	12.28	2.02	7.65	49.39	100.09	198.00	157.13	355.13
2004	80.79	11.14	11.14	61.93	128.09	237.80	201.16	438.97
2005	119.39	4.49	11.77	57.22	114.24	219.41	183.23	402.64
2008	108.61	5.98	12.50	60.01	122.21	226.01	194.71	420.72

ANNEXURE-D

TERRESTRIAL WATER STORAGE ANOMALIES (TWSA)

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Badin

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		2.20	30.62	35.57	9.60	7.31	3.67	-2.85	-22.45		-27.54	-13.09	-49.72	-104.76	-88.65	-162.44		-105.04	-183.54	-159.02
2		9.31	43.79	38.32	35.45	28.39	-1.17	-14.09	-1.74	-2.18	-22.97	-16.05		-87.44	-157.96			-144.47	-103.42	-303.05
3		42.04	0.73	63.40	31.53	27.06	10.60	-12.78	24.42	-12.17	-8.55		-97.59	-69.68	-184.75	-84.5949		-101.01	-183.53	-151.31
4	25.83	37.18	15.72	37.45	15.75	30.62	-2.45	11.18	-5.18	-18.38	-18.83	-19.00	-122.66	-115.79		-94.8771		-144.99	-88.13	-257.26
5	24.58	24.54	15.33	65.09	9.49	19.99	-31.07	-2.74	0.98	-16.49		-45.99	-65.97	-126.87	-134.99	-162.318		-132.24	-171.53	-215.59
6			0.66	49.39	-4.71	17.03	-18.64	-0.24	-21.66		-30.83	-50.84	-77.86		-201.89	-57.86	-167.10	-174.43	-173.66	-150.76
7		14.07	13.40	-5.60	-5.54	7.92	-14.78	-11.59	-17.18	-23.22	-48.43	-63.63		-112.38	-133.42		-143.20	-206.14	-179.55	-249.27
8	2.97	2.81	-2.93	9.23	-4.81	1.69	-32.74	-31.18	-31.60	-36.59	-48.29		-94.59	-140.66	-144.33		-179.36		-153.51	-206.58
9	-19.77	-2.62	-15.58	7.77	-18.70	-12.69	-34.43	-26.43	-44.11	-56.47	-79.67		-117.59	-111.13			-171.64		-151.11	-164.48
10	-14.67	-24.39	-22.27	11.29	-39.14	-41.20	-56.51	-55.20	-44.96	-64.72		-97.65	-168.35				-136.99	-192.12	-184.28	-234.14
11	0.09	-13.74	-14.82	4.07	-16.18	-33.85	-43.20	-42.63	-47.24	-56.50	-64.27	-96.44	-89.49		-100.63		-189.37	-144.16	-134.01	-143.47
12	-13.89	13.52	5.36	7.08	11.35	-10.12	-32.44	-17.64	-32.46	-27.34	-73.59	-94.89		-132.24	-132.26		-159.54	-179.82	-263.75	-192.54

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Dadu

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-4.60	1.28	10.92	0.42	3.90	9.30	-2.30	-30.07		-33.64	-22.52	-58.24	-161.88	-91.39	-101.68		-114.28	-30.52	-132.13
2		-2.60	16.92	43.92	21.96	27.19	8.62	-8.99	-13.68	12.57	-8.18	-26.58		-90.82	-179.69			-119.30	-76.48	-143.06
3		29.75	-2.72	80.10	26.38	28.66	17.80	1.31	18.02	2.86	1.21		-23.20	-60.30	-58.66	-63.60		-116.87	-72.05	-81.88
4	31.01	24.27	3.23	79.14	19.73	38.22	13.40	33.69	0.19	7.79	-10.00	-8.38	-15.39	-48.14		-80.72		-102.10	-56.09	-23.69
5	19.41	22.55	3.98	110.32	7.02	28.11	-14.52	6.80	4.99	-1.82		-21.79	-6.88	-63.69	-82.99	-50.34		-114.95	-52.75	-154.21
6			-23.03	57.79	-1.41	18.38	-12.10	1.26	-25.79		-48.39	-48.38	-24.69		-73.94	-41.21	-113.19	-145.88	-91.00	-61.88
7		-0.65	-8.71	-0.03	-11.98	4.52	-17.39	-18.62	-27.80	-25.37	-36.49	-43.63		-110.08	-74.26		-141.64	-192.22	-90.85	-165.13
8	-7.24	-2.53	-19.34	8.42	-11.70	-2.23	-20.30	-19.64	-27.11	-26.97	-51.79		-78.25	-55.49	-63.40		-126.84		-86.98	-115.54
9	-11.74	-1.58	-12.86	9.47	-15.80	-17.35	-33.89	-16.08	-46.11	-42.59	-47.49		-97.93	-92.35			-128.17		-150.81	18.73
10	-13.28	-31.00	-28.28	8.29	-34.97	-34.90	-47.56	-53.06	-33.73	-46.97		-84.85	-87.86				-125.84	-197.59	-116.55	-20.18
11	2.09	-18.79	-22.07	-2.00	-14.73	-26.78	-42.80	-49.21	-45.14	-44.94	-62.54	-73.40	-51.23		-98.25		-170.16	-126.11	-180.25	-128.89
12	-26.22	-9.87	-19.69	-2.12	11.88	-25.40	-33.31	-34.50	-34.87	-42.48	-50.44	-126.01		-90.15	-107.91		-167.30	-90.17	-164.87	-289.79

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Ghotki

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-8.52	7.90	28.13	-5.19	1.00	2.89	-11.32	-26.50		-17.04	-18.21	-59.29	-147.06	-104.88	-99.33		-21.46	27.03	-79.16
2		8.90	37.75	115.36	39.43	25.49	11.28	-3.42	3.51	16.68	13.57	2.17		-85.81	-141.35			28.12	-24.21	-45.77
3		46.31	18.13	78.00	49.92	45.83	27.79	9.67	45.64	14.71	25.65		1.18	-1.37	-30.57	-20.75		-11.18	34.64	-42.53
4	30.14	49.37	22.24	87.24	30.53	52.48	18.50	48.30	21.81	14.27	12.45	15.87	9.12	-7.25		-33.41		-37.61	39.45	27.99
5	24.63	39.28	20.23	103.38	10.15	27.10	-14.83	15.59	19.44	-0.94		-5.41	4.33	-19.76	-99.75	-62.47		-83.89	15.37	-136.72
6			-24.30	44.63	-9.78	12.01	-18.70	6.15	-21.65		-36.38	-47.91	-26.74		-29.29	-25.08	-91.04	-89.47	-46.36	-30.52
7		-4.16	-4.25	-12.85	-19.35	-5.56	-25.96	-21.55	-28.45	-33.53	-30.52	-42.84		-97.80	-105.95		-114.27	-112.43	-36.76	-122.83
8	-13.81	-6.52	-11.66	3.80	-17.99	-6.62	-29.93	-16.73	-29.87	-34.13	-45.54		-84.49	-44.07	-14.48		-62.04		-54.32	-133.22
9	-21.91	-8.29	-7.85	0.13	-22.71	-25.44	-43.05	-14.58	-42.81	-48.61	-43.43		-59.59	-68.59			-78.59		-106.10	28.76
10	-27.35	-38.47	-28.86	-5.70	-44.84	-46.05	-58.85	-56.72	-33.99	-54.44		-79.45	-103.20				-80.35	-117.43	-79.07	-24.11
11	-16.29	-27.13	-26.08	-4.64	-30.09	-45.65	-60.28	-63.69	-53.53	-57.25	-64.60	-83.92	-55.89		-129.90		-124.55	-70.41	-135.32	-147.98
12	-33.97	-14.42	-19.02	-16.14	1.86	-33.67	-49.80	-39.21	-40.09	-31.86	-54.92	-117.94		-52.54	-85.68		-44.27	-14.57	-59.83	-264.42

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Hyderabad

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-0.01	23.30	31.69	7.17	5.97	5.86	-1.79	-25.04		-27.10	-11.81	-54.72	-123.55	-90.73	-144.39		-113.91	-146.41	-153.52
2		8.17	42.88	44.06	34.31	30.63	-1.28	-12.64	-3.84	3.38	-17.37	-15.31		-85.63	-183.26			-163.23	-91.67	-300.05
3		40.40	0.30	65.54	29.89	25.84	13.65	-10.15	26.10	-9.19	-3.47		-79.00	-63.34	-144.94	-101.01		-111.45	-170.63	-126.05
4	27.11	36.95	11.97	44.21	16.11	33.00	-0.38	18.11	-4.48	-12.73	-16.25	-18.15	-107.44	-105.73		-96.89		-135.95	-79.68	-220.63
5	22.41	24.70	13.90	78.56	8.66	21.31	-30.10	-0.62	2.33	-11.82		-47.88	-55.57	-118.17	-122.84	-120.87		-130.42	-135.34	-232.60
6			-5.97	50.34	-4.16	15.88	-16.77	1.99	-23.31		-35.73	-50.92	-65.77		-190.99	-58.66	-151.09	-167.49	-165.87	-114.02
7		10.53	9.06	-6.17	-6.01	6.10	-15.81	-13.93	-19.66	-24.21	-43.06	-59.61		-115.17	-119.92		-140.22	-219.77	-161.65	-245.17
8	0.43	2.25	-4.58	11.24	-5.20	0.08	-29.92	-27.25	-30.50	-33.29	-49.87		-96.01	-112.70	-123.39		-171.01		-130.92	-180.28
9	-18.37	-2.47	-13.41	8.24	-18.92	-14.23	-35.13	-22.11	-44.01	-53.86	-73.85		-112.19	-94.43			-156.80		-152.92	-87.08
10	-14.25	-26.83	-22.25	10.48	-39.04	-41.35	-56.65	-54.97	-40.70	-61.00		-102.39	-148.94				-126.93	-212.79	-150.21	-138.44
11	-0.20	-15.32	-15.82	2.43	-16.56	-32.40	-43.51	-44.87	-47.05	-54.09	-64.33	-100.92	-77.06		-92.83		-175.81	-133.34	-147.62	-131.77
12	-17.56	8.05	-1.43	4.62	12.02	-15.15	-34.91	-23.96	-31.30	-28.40	-68.76	-109.11		-125.67	-124.99		-168.59	-165.92	-264.06	-206.01

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Jacobabad

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-8.69	0.46	5.99	-6.56	1.97	6.84	-10.99	-34.86		-24.73	-28.04	-62.64	-144.37	-104.72	-125.52		-19.31	27.59	-85.85
2		4.54	26.04	90.09	30.98	31.58	12.30	-2.84	-3.85	16.81	5.57	-5.11		-129.25	-111.90			15.54	-30.70	-19.26
3		40.17	10.35	84.95	45.20	50.07	28.77	11.50	39.18	18.93	20.61		3.94	-14.48	-16.41	-54.04		-34.62	42.10	-72.74
4	34.48	40.85	14.62	101.38	28.46	55.44	22.91	53.99	18.28	19.81	12.34	15.38	18.93	-2.88		-39.01		-52.64	33.76	22.61
5	24.73	38.89	12.60	119.98	9.51	34.91	-9.27	17.21	18.77	1.19		-0.28	13.90	-7.42	-105.28	-69.55		-107.20	13.10	-126.17
6			-31.39	57.25	-10.63	18.16	-16.96	10.02	-23.70		-49.31	-46.88	-18.04		-12.66	-18.73	-102.35	-107.34	-40.54	-57.70
7		-7.81	-14.34	-5.59	-22.63	-4.44	-26.45	-23.86	-32.62	-35.88	-32.13	-42.30		-93.17	-106.09		-124.40	-125.29	-51.08	-119.33
8	-15.04	-10.05	-22.24	1.19	-22.31	-5.49	-26.97	-15.66	-28.08	-37.10	-53.87		-76.01	-60.77	4.44		-66.30		-92.91	-172.03
9	-17.64	-6.47	-10.73	1.62	-20.90	-23.85	-41.22	-13.27	-42.15	-45.27	-38.49		-64.29	-101.95			-105.79		-126.07	-36.54
10	-22.14	-36.32	-32.12	-4.90	-41.86	-39.72	-53.79	-55.02	-32.17	-49.77		-82.70	-100.89				-118.00	-130.40	-110.44	-100.17
11	-11.87	-24.71	-29.59	-5.27	-26.50	-39.47	-56.12	-63.93	-49.43	-51.93	-63.86	-68.47	-67.27		-146.88		-159.96	-103.51	-164.02	-187.16
12	-32.81	-19.12	-26.25	-15.80	6.32	-35.45	-47.14	-41.14	-40.27	-40.49	-51.50	-118.10		-57.05	-86.77		-45.40	-22.13	-30.31	-236.39

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Jamshoro

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	9.00	0.07	15.79	24.48	6.03	4.34	5.59	-1.66	-27.19		-33.03	-15.00	-53.99	-138.37	-86.61	-125.33		-123.84	-106.42	-136.25
2		4.45	34.78	44.35	31.05	31.25	-0.29	-11.06	-8.88	8.05	-18.63	-22.61		-84.83	-184.62			-173.35	-89.08	-242.60
3		36.82	-2.77	69.98	28.15	25.15	14.16	-6.61	22.65	-5.48	-3.42		-57.84	-64.48	-106.09	-98.67		-125.94	-155.13	-103.86
4	32.27	31.59	6.83	53.85	18.10	35.93	3.45	23.65	-6.83	-6.32	-16.18	-19.78	-72.53	-93.37		-95.02		-130.76	-89.06	-150.00
5	22.70	21.52	9.12	86.16	8.87	24.12	-24.92	1.18	1.54	-7.26		-42.29	-35.58	-105.58	-102.19	-74.78		-123.01	-112.47	-193.97
6			-11.15	54.15	-1.11	17.53	-14.50	2.77	-24.81		-42.00	-49.72	-45.29		-139.92	-55.11	-129.21	-158.50	-138.52	-92.42
7		7.78	2.27	-3.45	-6.07	6.66	-14.85	-15.88	-22.12	-22.86	-39.97	-52.00		-103.32	-81.34		-136.05	-217.66	-136.51	-215.21
8	-1.36	1.14	-10.21	11.44	-5.86	-1.11	-26.27	-24.98	-29.89	-30.16	-52.30		-84.76	-79.52	-92.86		-157.70		-109.95	-136.62
9	-15.39	-2.04	-13.33	11.08	-18.05	-15.46	-34.70	-20.54	-46.97	-50.98	-65.65		-104.63	-84.90			-140.84		-150.19	-39.28
10	-11.91	-28.49	-24.30	10.25	-37.95	-39.89	-55.55	-57.12	-41.14	-58.39		-97.98	-113.56				-122.45	-212.17	-133.75	-79.06
11	2.52	-16.40	-18.19	0.39	-14.99	-30.16	-43.12	-46.21	-47.30	-51.19	-65.55	-88.37	-59.54		-90.41		-162.69	-123.87	-152.99	-114.93
12	-19.77	2.92	-7.15	5.81	13.92	-19.96	-34.88	-28.33	-33.61	-36.54	-63.52	-112.37		-111.02	-125.58		-179.65	-144.30	-231.41	-212.79

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Karachi

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		4.61	21.31	26.65	10.81	3.87	1.32	-3.10	-26.55		-41.80	-16.09	-43.66	-118.24	-73.82	-133.74		-127.05	-140.97	-123.20
2		4.57	35.65	35.56	31.40	30.72	-3.29	-14.60	-11.18	1.12	-36.38	-30.90		-82.35	-152.84			-195.68	-101.64	-246.57
3		35.98	-9.62	67.10	26.40	21.04	8.44	-11.91	16.38	-11.88	-13.44		-76.12	-76.01	-131.60	-92.39		-136.16	-204.26	-120.98
4	35.43	28.52	5.65	44.56	17.47	32.68	-1.78	12.15	-18.01	-15.44	-25.04	-32.19	-95.66	-122.32		-97.37		-150.00	-127.73	-198.43
5	24.71	14.75	5.48	68.39	9.45	21.92	-28.31	-4.17	-6.26	-11.75		-50.45	-46.36	-126.33	-69.78	-63.67		-120.56	-156.41	-170.12
6			-4.96	55.40	0.41	18.54	-17.24	0.13	-26.70		-41.99	-47.69	-48.49		-123.69	-56.86	-130.15	-160.71	-145.93	-119.07
7		12.12	3.81	-0.63	-1.05	11.44	-12.02	-14.01	-19.21	-19.38	-42.66	-52.19		-72.44	-43.34		-129.90	-215.23	-153.60	-221.15
8	4.33	3.44	-9.24	13.58	-1.23	2.16	-27.30	-28.38	-30.60	-31.07	-52.04		-65.81	-74.53	-93.07		-162.71		-121.72	-141.86
9	-13.03	0.66	-14.40	17.55	-15.89	-10.99	-30.57	-25.23	-47.44	-52.34	-70.16		-97.17	-73.17			-143.03		-142.85	-111.15
10	-5.99	-23.66	-23.06	15.78	-35.29	-38.48	-56.12	-60.27	-48.40	-62.63		-94.10	-103.56				-127.08	-197.85	-156.53	-136.91
11	8.46	-12.39	-18.52	5.14	-11.48	-26.87	-40.84	-42.48	-49.09	-52.01	-69.32	-83.62	-51.77		-86.68		-156.63	-122.72	-122.66	-104.68
12	-14.75	11.07	-1.00	16.99	17.80	-15.91	-33.42	-23.10	-38.98	-44.91	-73.35	-90.45		-111.77	-142.20		-183.79	-167.09	-236.62	-153.55

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Kashmore

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-9.24	2.24	9.52	-7.27	0.95	4.42	-13.18	-33.72		-21.70	-25.76	-62.84	-140.59	-110.66	-126.12		-4.90	34.14	-71.12
2		7.55	31.72	110.25	36.30	31.58	12.89	-1.22	0.00	18.39	9.75	0.24		-126.25	-105.88			34.96	-22.59	-4.60
3		45.22	16.21	82.81	51.64	53.73	31.41	13.91	46.54	21.73	27.31		8.32	-1.54	-11.17	-46.97		-15.09	55.24	-61.31
4	35.92	47.54	20.17	100.30	32.44	60.19	24.68	58.00	23.92	21.48	18.14	20.31	22.89	3.04		-29.96		-41.31	47.97	28.80
5	27.82	43.92	17.91	114.77	11.83	35.56	-9.06	20.44	23.16	2.50		2.51	16.31	-1.24	-127.25	-80.69		-99.25	22.43	-121.02
6			-30.18	54.34	-11.14	17.16	-17.86	12.46	-21.78		-45.07	-46.23	-17.34		-9.31	-17.87	-93.65	-94.44	-34.46	-50.71
7		-7.70	-12.74	-9.36	-23.02	-6.17	-27.91	-24.28	-31.98	-37.19	-30.63	-42.28		-91.41	-113.31		-116.91	-111.92	-41.49	-97.02
8	-16.30	-10.71	-19.86	0.52	-23.17	-6.98	-29.86	-15.27	-28.98	-39.05	-52.67		-76.55	-60.73	8.19		-56.13		-82.39	-166.72
9	-20.92	-8.83	-9.71	-0.40	-23.34	-26.96	-44.48	-14.01	-42.77	-48.35	-40.03		-58.21	-95.74			-90.15		-114.77	-28.45
10	-25.88	-39.34	-32.55	-8.52	-45.46	-44.30	-58.67	-58.02	-33.92	-53.90		-83.98	-104.21				-103.40	-115.85	-99.24	-92.40
11	-16.77	-27.29	-31.27	-6.58	-30.92	-44.63	-61.18	-67.82	-52.31	-55.99	-65.89	-72.22	-66.94		-156.02		-142.70	-86.25	-151.88	-184.61
12	-34.58	-20.27	-25.85	-18.37	3.76	-38.11	-51.98	-42.42	-42.18	-38.90	-55.23	-114.73		-50.64	-86.24		-25.68	-11.88	-3.73	-217.87

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Khairpur

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	9.00	-5.55	11.79	27.31	-1.17	3.23	5.88	-5.87	-26.23		-20.47	-15.69	-64.06	-158.99	-108.39	-109.99		-72.00	-25.47	-122.15
2		7.03	36.64	80.66	35.72	28.73	6.20	-6.42	-0.30	14.24	5.47	-5.77		-87.31	-194.46			-46.58	-55.34	-153.68
3		40.45	9.99	75.60	39.30	35.16	21.83	2.31	34.26	5.00	12.01		-21.83	-28.53	-62.65	-62.88		-59.42	-34.57	-73.76
4	28.37	42.42	15.34	74.86	23.21	42.93	11.81	36.73	10.20	5.47	-0.81	2.06	-22.47	-38.52		-65.98		-74.37	-1.29	-45.12
5	21.12	31.24	15.60	103.68	7.49	24.25	-19.34	8.16	11.82	-4.74		-21.05	-13.79	-56.27	-127.49	-95.41		-108.00	-26.61	-190.63
6			-20.37	47.88	-7.48	12.88	-17.32	2.41	-23.42		-41.53	-53.75	-39.21		-101.96	-41.49	-120.75	-127.08	-92.55	-58.11
7		-0.32	-0.39	-10.49	-15.88	-1.91	-21.92	-20.04	-27.04	-30.12	-35.71	-48.55		-126.96	-133.02		-133.15	-165.16	-78.69	-180.42
8	-9.11	-3.04	-10.11	7.30	-13.56	-4.90	-27.67	-20.93	-29.92	-31.82	-48.25		-104.28	-70.06	-49.97		-110.32		-79.89	-140.32
9	-19.29	-5.76	-9.66	2.28	-20.34	-20.62	-39.09	-16.28	-43.37	-48.55	-51.82		-84.99	-85.29			-114.44		-136.09	25.56
10	-20.82	-33.32	-25.27	1.18	-40.54	-42.16	-54.81	-53.88	-33.49	-53.50		-89.82	-122.87				-101.40	-170.74	-99.73	-29.35
11	-7.34	-22.13	-20.23	-1.31	-23.46	-38.99	-51.48	-55.29	-49.48	-54.41	-63.52	-92.30	-62.22		-109.77		-155.64	-102.16	-162.86	-139.15
12	-27.85	-6.70	-13.94	-8.80	6.34	-26.75	-41.62	-34.36	-34.71	-30.86	-56.35	-134.65		-80.51	-98.74		-109.85	-68.62	-151.65	-296.85

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Larkana

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-6.44	6.12	15.42	-3.09	2.69	7.98	-6.29	-32.11		-24.46	-21.74	-24.46	-21.74	-107.11	-114.57		-70.32	-0.20	-125.63
2		4.97	29.50	77.66	33.20	32.82	7.70	-5.17	-4.41	16.97	5.51	-10.47	5.51	-10.47	-188.27			-40.35	-57.53	-106.90
3		38.79	8.43	79.85	39.15	37.92	23.52	4.86	33.29	9.18	12.66		12.66		-51.39	-81.01		-70.22	-8.88	-79.45
4	32.16	38.53	12.35	87.45	24.07	46.95	15.91	43.30	10.19	10.56	0.94	3.99	0.94	3.99		-65.20		-75.63	3.29	-2.44
5	21.73	32.17	12.15	114.73	7.48	28.59	-15.74	9.63	12.78	-2.99		-15.59		-15.59	-146.45	-85.24		-117.28	-14.55	-174.96
6			-26.28	52.77	-8.25	15.26	-16.78	4.82	-25.04		-51.44	-56.29	-51.44	-56.29	-68.52	-38.47	-123.04	-131.04	-77.81	-64.28
7		-3.31	-6.84	-8.75	-18.52	-2.82	-23.07	-22.40	-30.91	-32.39	-35.29	-45.80	-35.29	-45.80	-127.80		-142.21	-163.16	-72.78	-168.90
8	-10.53	-4.56	-15.32	5.93	-16.15	-5.93	-25.73	-19.42	-29.71	-32.93	-53.67		-53.67		-16.52		-103.29		-81.16	-142.15
9	-16.84	-4.60	-9.59	2.71	-19.20	-21.13	-39.04	-13.55	-43.72	-45.54	-45.56		-45.56				-119.40		-146.49	15.07
10	-18.94	-33.21	-26.87	-0.82	-39.73	-39.41	-52.69	-53.62	-32.40	-51.00		-90.75		-90.75			-114.79	-169.70	-110.60	-32.49
11	-5.21	-22.19	-22.23	-2.79	-22.59	-37.42	-51.51	-57.89	-49.62	-52.70	-64.19	-81.14	-64.19	-81.14	-123.39		-174.09	-114.34	-182.55	-153.40
12	-29.23	-11.85	-19.48	-10.73	7.73	-30.41	-42.59	-38.79	-36.60	-37.36	-53.37	-139.95	-53.37	-139.95	-93.94		-107.73	-57.11	-120.38	-323.78

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Matiari

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1	9.00	-1.04	18.74	27.95	5.56	5.22	6.37	-2.02	-26.50		-28.04	-13.61	-57.09	-134.84	-92.58	-134.39		-116.12	-119.78	-149.06
2		6.62	39.09	46.45	32.95	31.00	-0.11	-11.59	-5.68	6.42	-14.21	-16.90		-86.35	-190.91			-157.14	-88.05	-270.36
3		38.92	0.44	68.35	29.70	26.62	14.69	-7.80	25.55	-6.41	-1.63		-65.96	-61.13	-122.69	-100.53		-113.50	-149.86	-114.13
4	28.64	35.29	10.41	50.76	17.25	34.89	2.34	22.34	-3.18	-8.43	-14.58	-16.03	-85.44	-93.16		-94.66		-128.53	-73.47	-177.39
5	22.06	24.76	12.66	85.85	8.65	22.80	-27.24	1.02	3.46	-9.48		-43.33	-44.41	-107.24	-122.05	-105.26		-127.84	-114.87	-219.85
6			-9.58	51.89	-3.40	16.16	-15.62	2.63	-23.80		-38.85	-51.28	-55.98		-170.99	-56.42	-142.17	-162.65	-151.11	-100.99
7		8.44	5.92	-5.50	-7.00	5.40	-16.17	-15.15	-21.45	-24.52	-41.28	-56.17		-116.96	-112.97		-139.91	-216.46	-145.88	-230.09
8	-1.17	1.43	-6.98	11.11	-6.34	-0.96	-28.20	-25.57	-30.09	-32.00	-50.91		-95.86	-99.03	-107.61		-163.09		-119.50	-160.84
9	-17.30	-2.51	-12.80	8.31	-18.56	-15.44	-35.55	-20.30	-44.90	-51.97	-68.78		-109.55	-93.21			-149.45		-153.21	-51.11
10	-14.32	-28.15	-23.23	9.33	-38.85	-40.71	-55.82	-55.08	-39.38	-58.86		-100.72	-136.07				-124.26	-213.33	-139.43	-103.12
11	-0.09	-16.50	-16.97	0.96	-16.65	-32.26	-44.22	-46.46	-47.41	-53.01	-64.58	-96.55	-71.55		-93.65		-172.47	-130.10	-156.77	-128.25
12	-19.53	4.01	-5.15	2.68	11.67	-18.20	-35.56	-27.09	-32.12	-31.06	-65.27	-115.87		-118.30	-121.22		-170.03	-150.49	-245.27	-225.86

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Mirpurkhas

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		0.13	25.79	35.39	7.27	6.38	4.43	-2.59	-21.70		-24.50	-10.85	-53.21	-115.20	-96.01	-150.04		-102.12	-155.69	-153.28
2		8.65	44.28	45.85	35.35	28.05	-0.22	-12.43	-1.31	1.79	-15.95	-12.65		-84.32	-175.77			-137.17	-90.15	-301.66
3		41.05	2.49	65.55	31.70	26.90	13.27	-9.61	26.53	-9.25	-3.30		-81.34	-60.25	-156.54	-81.82		-93.83	-162.94	-128.57
4	25.34	39.57	15.02	42.54	16.45	32.21	-0.21	16.04	-1.71	-13.42	-15.21	-15.33	-110.83	-102.98		-92.81		-128.70	-69.78	-227.72
5	22.83	25.74	16.13	74.72	9.00	20.15	-28.91	0.19	3.59	-12.54		-42.91	-57.65	-115.95	-132.44	-163.53		-124.57	-136.96	-227.43
6			-3.40	48.97	-4.29	15.44	-16.94	0.22	-21.52		-30.83	-50.03	-74.77		-203.11	-56.16	-154.56	-164.25	-162.94	-118.22
7		11.12	11.74	-7.04	-6.69	6.04	-15.76	-12.87	-18.36	-23.83	-45.01	-61.43		-122.03	-142.58		-138.28	-208.64	-159.43	-242.72
8	0.14	1.74	-3.51	9.64	-6.07	0.14	-31.38	-28.32	-31.03	-34.07	-47.24		-98.67	-131.29	-141.45		-170.58		-135.28	-193.11
9	-20.12	-3.90	-14.44	6.24	-19.72	-14.51	-35.57	-24.35	-44.06	-55.65	-76.09		-114.78	-105.31			-159.36		-147.96	-108.94
10	-16.43	-27.24	-22.76	10.06	-39.69	-42.42	-56.62	-54.86	-41.51	-61.84		-99.04	-163.73				-125.43	-199.53	-156.06	-169.38
11	-2.38	-15.94	-15.62	2.55	-17.87	-34.40	-44.37	-44.62	-47.09	-55.43	-63.62	-102.28	-82.48		-95.73		-175.95	-131.68	-140.42	-137.94
12	-17.28	9.30	0.79	3.59	10.22	-13.48	-34.17	-21.13	-31.21	-26.06	-69.97	-107.57		-125.30	-127.79		-156.30	-161.92	-261.98	-206.69

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Naushahro Feroze

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-4.22	8.44	18.78	0.53	3.38	7.58	-3.75	-30.32		-28.09	-18.72	-64.21	-164.20	-99.90	-114.45		-103.79	-44.41	-135.31
2		4.01	30.84	60.04	31.23	32.09	4.04	-8.04	-7.71	14.00	-3.43	-16.88		-93.89	-200.23			-110.09	-73.06	-176.30
3		36.89	3.29	75.93	32.61	31.42	19.02	-0.45	27.40	2.48	5.59		-30.73	-48.59	-69.25	-93.39		-101.81	-75.17	-86.67
4	31.85	34.17	8.98	71.73	21.04	41.43	10.48	34.97	3.01	3.63	-7.17	-6.53	-27.44	-54.43		-81.87		-100.99	-39.60	-61.42
5	21.48	27.33	10.85	105.19	8.24	26.71	-19.60	6.06	8.08	-4.21		-28.00	-14.72	-71.20	-129.13	-77.76		-120.88	-54.15	-187.88
6			-19.97	54.25	-4.00	16.23	-14.46	4.22	-24.87		-47.21	-53.43	-32.84		-110.16	-47.46	-123.92	-145.67	-107.00	-71.39
7		1.73	-2.53	-5.70	-12.16	1.73	-18.93	-19.20	-26.99	-27.56	-36.90	-48.12		-123.70	-108.66		-140.27	-194.30	-100.50	-189.59
8	-6.43	-1.66	-12.97	9.22	-11.12	-4.00	-25.08	-21.27	-29.42	-30.59	-53.22		-98.80	-69.35	-56.20		-132.60		-91.49	-128.69
9	-15.73	-3.27	-10.93	6.54	-18.28	-18.95	-37.27	-15.65	-45.69	-47.31	-54.28		-96.91	-92.91			-129.64		-151.36	18.91
10	-15.95	-31.59	-25.76	4.43	-38.89	-39.43	-53.67	-54.74	-35.28	-53.39		-95.18	-111.50				-117.55	-199.51	-115.45	-32.49
11	-1.64	-19.96	-20.26	-2.25	-18.75	-33.80	-47.59	-52.40	-48.63	-51.47	-64.77	-85.59	-62.12		-104.67		-168.55	-120.53	-177.56	-131.94
12	-25.39	-6.66	-14.87	-4.39	9.89	-26.34	-38.78	-35.16	-34.71	-36.71	-56.64	-132.92		-94.42	-107.10		-151.19	-98.80	-178.60	-284.96

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Qambar Shahdadkot

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-6.57	-1.82	5.23	-3.06	3.78	10.49	-4.98	-34.08		-31.51	-27.69	-60.92	-160.87	-92.90	-109.41		-79.91	-1.21	-123.92
2		-1.79	15.64	50.22	21.78	29.26	10.61	-7.30	-12.48	13.65	-3.42	-20.86		-110.70	-154.15			-63.68	-60.54	-87.89
3		30.61	-0.33	84.94	30.45	36.19	21.19	4.85	22.25	8.84	5.77		-11.69	-48.83	-42.08	-61.69		-92.13	-19.74	-83.85
4	31.63	26.78	5.02	93.10	21.37	42.92	17.29	40.95	5.51	13.30	-3.22	0.73	2.75	-27.12		-66.70		-84.35	-20.47	7.45
5	19.66	27.14	4.37	121.47	6.74	31.34	-11.47	9.81	8.88	-0.92		-11.75	3.54	-38.38	-78.31	-51.00		-116.44	-23.33	-141.72
6			-28.35	59.98	-5.19	19.04	-13.49	3.84	-26.11		-52.11	-48.30	-20.27		-43.92	-30.55	-114.21	-137.19	-68.53	-62.00
7		-4.53	-12.88	0.50	-16.87	1.42	-20.59	-20.85	-30.91	-29.37	-35.15	-42.31		-106.50	-84.41		-140.66	-168.48	-75.91	-155.28
8	-10.39	-5.69	-22.89	5.29	-16.35	-2.92	-20.74	-17.75	-26.78	-30.05	-53.59		-78.42	-55.58	-32.95		-104.22		-93.92	-143.27
9	-12.01	-2.11	-12.69	6.74	-16.16	-18.41	-35.06	-13.60	-43.69	-40.84	-40.67		-87.33	-102.75			-128.94		-148.85	-7.44
10	-15.26	-31.57	-30.40	4.13	-35.62	-33.59	-46.59	-51.24	-31.28	-44.66		-81.83	-90.40				-133.46	-175.94	-121.81	-55.21
11	-1.17	-20.33	-24.82	-3.17	-17.30	-29.15	-45.81	-53.89	-45.57	-45.22	-61.48	-67.78	-59.22		-115.40		-180.75	-129.62	-185.43	-158.51
12	-28.59	-14.78	-24.07	-7.94	10.37	-28.86	-36.55	-37.58	-36.36	-43.00	-47.27	-126.54		-79.00	-95.72		-124.45	-61.39	-116.73	-295.19

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Sanghar

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-3.43	18.63	36.62	2.37	4.44	4.14	-4.41	-20.64		-19.05	-10.21	-57.83	-134.47	-107.42	-120.08		-81.62	-80.83	-129.70
2		8.13	42.78	69.62	36.49	25.71	3.52	-8.82	1.49	9.00	-0.78	-5.25		-76.02	-194.12			-76.98	-63.21	-232.22
3		40.83	8.33	70.72	36.35	30.41	18.12	-2.52	31.66	-1.86	6.87		-44.22	-36.21	-97.38	-55.80		-62.21	-89.10	-84.32
4	25.02	44.01	16.81	57.51	20.35	36.98	5.95	26.26	6.90	-2.86	-6.25	-4.15	-63.94	-64.20		-75.70		-87.63	-23.42	-126.36
5	21.02	28.73	17.85	89.70	8.05	20.42	-23.44	5.40	9.02	-7.34		-29.44	-34.40	-81.92	-120.65	-139.38		-105.01	-64.12	-211.53
6			-11.44	46.06	-5.33	12.29	-16.65	0.00	-21.45		-31.80	-50.30	-60.24		-159.91	-47.38	-128.34	-135.01	-121.30	-67.75
7		4.81	7.39	-10.22	-11.35	1.31	-18.96	-16.17	-21.80	-26.30	-38.78	-54.16		-128.01	-146.12		-128.00	-181.17	-104.88	-206.15
8	-5.66	-0.93	-5.32	8.66	-9.91	-2.87	-29.68	-23.87	-30.31	-31.21	-44.37		-102.62	-96.99	-105.94		-134.27		-95.28	-156.18
9	-21.02	-6.28	-11.63	2.84	-20.99	-18.50	-37.93	-20.73	-43.60	-52.73	-63.27		-97.92	-89.06			-125.92		-133.08	-7.57
10	-20.84	-31.94	-24.03	5.44	-40.71	-44.04	-56.23	-54.28	-36.35	-57.06		-92.01	-143.25				-100.27	-181.67	-108.60	-66.97
11	-7.42	-20.47	-17.78	0.26	-22.30	-38.32	-48.97	-50.22	-48.36	-55.36	-62.84	-102.90	-66.45		-95.95		-149.49	-102.93	-144.85	-129.65
12	-23.95	0.94	-6.46	-4.07	6.52	-20.43	-38.26	-27.44	-32.09	-25.45	-61.82	-125.53		-97.54	-112.36		-126.46	-103.02	-208.47	-252.84

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Shaheed Benazirabad

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-3.12	9.61	20.46	2.35	3.72	7.39	-2.47	-29.43		-29.91	-17.21	-61.82	-157.43	-96.29	-114.39		-120.53	-66.52	-140.15
2		3.53	31.51	51.23	30.24	31.73	2.21	-9.48	-9.36	12.52	-7.90	-20.09		-87.78	-206.21			-144.95	-80.82	-210.99
3		35.94	0.72	73.97	29.34	28.16	16.77	-3.11	24.46	-0.87	2.05		-39.89	-56.72	-78.18	-99.58		-117.61	-108.31	-90.28
4	31.70	31.99	7.29	63.87	19.52	38.67	7.77	30.80	-0.58	0.16	-11.22	-11.78	-41.45	-68.02		-90.21		-113.68	-61.04	-90.92
5	21.36	24.90	10.19	100.42	8.62	25.77	-21.54	4.28	5.72	-4.82		-34.21	-22.10	-85.37	-120.47	-74.03		-122.69	-73.94	-194.34
6			-16.81	54.99	-1.88	16.71	-13.31	3.92	-24.79		-45.10	-52.00	-36.40		-130.97	-51.96	-124.35	-152.98	-121.60	-74.94
7		4.25	-0.38	-4.17	-8.98	4.00	-16.87	-17.59	-25.03	-25.14	-37.70	-49.27		-120.53	-99.08		-139.30	-209.86	-114.36	-199.94
8	-4.38	-0.20	-11.79	10.86	-8.61	-3.04	-24.76	-22.20	-29.27	-29.42	-52.99		-95.56	-71.70	-76.04		-147.25		-96.65	-121.96
9	-15.17	-2.61	-11.60	8.46	-17.82	-17.87	-36.38	-16.70	-46.68	-48.19	-58.64		-104.29	-90.78			-134.75		-153.79	20.84
10	-14.46	-30.78	-25.20	7.05	-38.47	-39.45	-54.16	-55.30	-36.72	-54.58		-97.40	-110.35				-118.94	-214.41	-117.88	-32.48
11	0.14	-18.85	-19.28	-1.97	-16.82	-31.99	-45.64	-49.65	-48.14	-50.86	-65.07	-87.82	-60.54		-95.30		-165.78	-123.63	-175.06	-121.21
12	-23.47	-4.07	-12.57	-1.22	10.97	-24.31	-36.87	-33.34	-33.77	-36.39	-58.28	-129.40		-103.58	-113.68		-172.91	-119.64	-207.71	-265.56

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Shikarpur

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-7.37	4.83	13.45	-4.48	2.11	6.79	-8.59	-32.65		-23.54	-23.08	-66.93	-165.35	-108.29	-118.42		-48.51	11.25	-107.46
2		5.83	30.24	88.52	34.23	32.40	9.43	-3.86	-2.94	17.45	6.92	-6.90		-112.83	-160.80			-15.25	-45.89	-72.80
3		40.93	11.02	80.84	43.31	43.19	26.15	7.88	37.71	13.36	17.55		-5.49	-22.07	-37.98	-69.66		-51.84	12.50	-73.40
4	33.42	41.53	14.95	91.73	26.86	51.36	18.83	48.20	14.77	14.20	6.67	9.43	8.03	-17.16		-53.45		-64.19	18.18	7.97
5	23.76	36.09	14.07	114.75	8.93	30.91	-13.51	13.23	16.24	-1.16		-9.55	5.48	-28.99	-140.05	-83.72		-111.27	-2.22	-156.98
6			-27.58	53.29	-9.22	15.89	-17.14	7.37	-23.95		-49.31	-52.94	-22.93		-48.79	-31.60	-113.25	-118.84	-63.36	-59.75
7		-4.77	-8.81	-8.95	-20.02	-3.94	-24.68	-23.03	-31.27	-33.99	-33.74	-44.63		-117.17	-122.97		-133.78	-146.08	-62.35	-144.94
8	-12.45	-6.61	-16.83	4.13	-18.49	-6.28	-27.11	-18.03	-29.47	-34.97	-53.33		-95.71	-63.34	-8.29		-87.57		-81.57	-150.34
9	-18.20	-6.01	-9.63	1.67	-20.58	-23.07	-40.85	-13.71	-43.40	-46.47	-43.71		-74.18	-96.70			-109.65		-135.92	0.56
10	-21.25	-35.26	-28.77	-3.39	-41.64	-41.04	-54.68	-55.09	-32.91	-51.97		-88.49	-110.61				-110.99	-151.75	-106.81	-52.46
11	-9.06	-23.89	-25.25	-4.05	-25.37	-39.82	-54.73	-61.20	-50.52	-53.80	-64.75	-78.16	-65.83		-134.27		-163.62	-104.97	-172.33	-163.80
12	-31.01	-14.66	-21.60	-13.27	6.41	-32.98	-45.72	-40.00	-38.46	-37.88	-53.99	-131.55		-67.62	-91.38		-80.38	-42.03	-81.50	-288.47

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Sujawal

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		5.88	33.54	33.43	12.79	6.75	1.87	-4.20	-29.37		-38.07	-19.97	-41.44	-96.77	-65.19	-159.23		-113.86	-190.10	-142.07
2		10.24	41.40	30.99	35.01	31.49	-3.57	-17.09	-6.72	-6.05	-37.00	-25.50		-88.12	-130.05			-168.47	-114.24	-265.80
3		44.28	-6.24	61.85	30.38	26.02	6.02	-19.07	19.94	-17.39	-16.90		-109.07	-80.82	-194.24	-100.00		-124.24	-216.49	-161.27
4	31.95	32.12	14.08	33.88	16.55	30.80	-6.30	5.75	-16.40	-24.92	-25.76	-28.83	-125.46	-135.97		-95.63		-165.24	-128.52	-264.94
5	28.14	18.99	10.12	54.83	10.70	20.60	-36.04	-9.37	-6.71	-21.36		-54.91	-68.55	-142.12	-89.22	-80.48		-135.20	-204.62	-176.52
6			4.69	52.40	-4.00	18.68	-22.43	1.83	-25.99		-38.93	-51.17	-63.30		-148.23	-60.33	-162.34	-173.78	-174.58	-174.48
7		18.04	11.47	-0.89	-1.01	11.50	-12.71	-11.32	-16.98	-21.37	-46.65	-59.24		-68.24	-57.66		-138.98	-198.06	-192.63	-244.73
8	9.08	5.52	-3.43	12.27	0.10	4.75	-32.19	-33.42	-31.45	-37.85	-51.35		-72.75	-95.62	-102.55		-174.13		-156.18	-186.98
9	-15.42	2.29	-15.25	14.94	-15.05	-8.83	-30.56	-26.44	-43.64	-53.41	-75.06		-102.60	-83.33			-164.82		-146.23	-197.75
10	-8.78	-19.47	-22.46	14.03	-37.40	-38.29	-57.19	-57.51	-52.63	-69.22		-92.49	-130.16				-142.98	-179.76	-203.91	-255.80
11	6.24	-10.45	-16.89	6.14	-13.17	-32.26	-42.91	-42.21	-51.63	-58.09	-68.72	-84.62	-74.29		-100.30		-184.27	-143.49	-114.50	-128.48
12	-9.57	17.92	9.44	14.85	15.01	-9.36	-33.43	-18.50	-39.90	-37.33	-77.68	-74.49		-128.65	-134.61		-164.95	-190.86	-246.77	-153.38

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Sukkur

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-7.25	6.48	19.19	-3.99	2.06	6.15	-8.28	-30.40		-21.93	-20.82	-65.53	-165.89	-106.59	-110.29		-51.11	10.39	-107.77
2		6.37	32.27	91.52	35.37	30.40	9.13	-4.40	-1.63	16.95	8.33	-5.83		-100.67	-168.77			-14.31	-44.95	-81.77
3		41.55	11.96	79.42	43.28	41.31	25.31	6.89	37.97	11.63	17.62		-6.92	-20.73	-42.54	-59.82		-48.29	8.54	-66.61
4	31.71	42.50	15.95	88.07	26.60	49.44	17.21	45.70	14.67	12.34	5.56	8.68	4.53	-19.21		-53.09		-61.57	17.30	9.02
5	22.99	35.08	15.05	111.08	8.58	28.48	-15.09	12.13	15.48	-2.04		-11.35	2.30	-33.21	-130.41	-77.67		-105.58	-2.95	-159.78
6			-25.86	50.24	-8.90	14.32	-17.45	5.66	-23.78		-46.26	-53.06	-25.60		-52.74	-33.06	-111.18	-115.72	-65.38	-52.70
7		-3.82	-6.32	-10.10	-19.02	-3.88	-24.26	-22.23	-30.18	-33.01	-33.51	-44.66		-117.61	-120.00		-131.87	-144.11	-59.53	-150.24
8	-11.89	-5.52	-14.39	4.96	-17.11	-6.21	-27.30	-18.33	-29.72	-33.64	-51.00		-97.06	-57.82	-14.54		-87.51		-72.60	-140.59
9	-18.69	-6.02	-9.03	1.72	-20.55	-22.83	-40.62	-13.91	-43.38	-46.67	-44.58		-73.62	-87.92			-104.72		-131.81	17.14
10	-22.02	-35.23	-27.82	-2.80	-41.68	-41.80	-54.99	-54.85	-32.99	-52.26		-86.75	-109.89				-103.11	-150.02	-99.86	-33.00
11	-9.39	-24.05	-23.95	-3.59	-25.45	-40.45	-54.84	-60.29	-51.02	-54.34	-64.41	-81.56	-62.35		-127.23		-156.48	-98.71	-165.73	-153.33
12	-31.04	-13.13	-19.68	-12.88	5.63	-31.87	-45.41	-39.12	-38.02	-35.68	-53.97	-131.53		-67.17	-90.87		-82.94	-41.01	-94.67	-299.03

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Tando Allahyar

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-0.01	23.30	31.69	7.17	5.97	5.86	-1.79	-25.04		-27.10	-11.81	-54.72	-123.55	-90.73	-144.39		-113.91	-146.41	-153.52
2		8.17	42.88	44.06	34.31	30.63	-1.28	-12.64	-3.84	3.38	-17.37	-15.31		-85.63	-183.26			-163.23	-91.67	-300.05
3		40.40	0.30	65.54	29.89	25.84	13.65	-10.15	26.10	-9.19	-3.47		-79.00	-63.34	-144.94	-101.01		-111.45	-170.63	-126.05
4	27.11	36.95	11.97	44.21	16.11	33.00	-0.38	18.11	-4.48	-12.73	-16.25	-18.15	-107.44	-105.73		-96.89		-135.95	-79.68	-220.63
5	22.41	24.70	13.90	78.56	8.66	21.31	-30.10	-0.62	2.33	-11.82		-47.88	-55.57	-118.17	-122.84	-120.87		-130.42	-135.34	-232.60
6			-5.97	50.34	-4.16	15.88	-16.77	1.99	-23.31		-35.73	-50.92	-65.77		-190.99	-58.66	-151.09	-167.49	-165.87	-114.02
7		10.53	9.06	-6.17	-6.01	6.10	-15.81	-13.93	-19.66	-24.21	-43.06	-59.61		-115.17	-119.92		-140.22	-219.77	-161.65	-245.17
8	0.43	2.25	-4.58	11.24	-5.20	0.08	-29.92	-27.25	-30.50	-33.29	-49.87		-96.01	-112.70	-123.39		-171.01		-130.92	-180.28
9	-18.37	-2.47	-13.41	8.24	-18.92	-14.23	-35.13	-22.11	-44.01	-53.86	-73.85		-112.19	-94.43			-156.80		-152.92	-87.08
10	-14.25	-26.83	-22.25	10.48	-39.04	-41.35	-56.65	-54.97	-40.70	-61.00		-102.39	-148.94				-126.93	-212.79	-150.21	-138.44
11	-0.20	-15.32	-15.82	2.43	-16.56	-32.40	-43.51	-44.87	-47.05	-54.09	-64.33	-100.92	-77.06		-92.83		-175.81	-133.34	-147.62	-131.77
12	-17.56	8.05	-1.43	4.62	12.02	-15.15	-34.91	-23.96	-31.30	-28.40	-68.76	-109.11		-125.67	-124.99		-168.59	-165.92	-264.06	-206.01

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Tando Muhammad Khan

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-0.01	23.30	31.69	7.17	5.97	5.86	-1.79	-25.04		-27.10	-11.81	-54.72	-123.55	-90.73	-144.39		-113.91	-146.41	-153.52
2		8.17	42.88	44.06	34.31	30.63	-1.28	-12.64	-3.84	3.38	-17.37	-15.31		-85.63	-183.26			-163.23	-91.67	-300.05
3		40.40	0.30	65.54	29.89	25.84	13.65	-10.15	26.10	-9.19	-3.47		-79.00	-63.34	-144.94	-101.01		-111.45	-170.63	-126.05
4	27.11	36.95	11.97	44.21	16.11	33.00	-0.38	18.11	-4.48	-12.73	-16.25	-18.15	-107.44	-105.73		-96.89		-135.95	-79.68	-220.63
5	22.41	24.70	13.90	78.56	8.66	21.31	-30.10	-0.62	2.33	-11.82		-47.88	-55.57	-118.17	-122.84	-120.87		-130.42	-135.34	-232.60
6			-5.97	50.34	-4.16	15.88	-16.77	1.99	-23.31		-35.73	-50.92	-65.77		-190.99	-58.66	-151.09	-167.49	-165.87	-114.02
7		10.53	9.06	-6.17	-6.01	6.10	-15.81	-13.93	-19.66	-24.21	-43.06	-59.61		-115.17	-119.92		-140.22	-219.77	-161.65	-245.17
8	0.43	2.25	-4.58	11.24	-5.20	0.08	-29.92	-27.25	-30.50	-33.29	-49.87		-96.01	-112.70	-123.39		-171.01		-130.92	-180.28
9	-18.37	-2.47	-13.41	8.24	-18.92	-14.23	-35.13	-22.11	-44.01	-53.86	-73.85		-112.19	-94.43			-156.80		-152.92	-87.08
10	-14.25	-26.83	-22.25	10.48	-39.04	-41.35	-56.65	-54.97	-40.70	-61.00		-102.39	-148.94				-126.93	-212.79	-150.21	-138.44
11	-0.20	-15.32	-15.82	2.43	-16.56	-32.40	-43.51	-44.87	-47.05	-54.09	-64.33	-100.92	-77.06		-92.83		-175.81	-133.34	-147.62	-131.77
12	-17.56	8.05	-1.43	4.62	12.02	-15.15	-34.91	-23.96	-31.30	-28.40	-68.76	-109.11		-125.67	-124.99		-168.59	-165.92	-264.06	-206.01

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Tharparkar

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-1.38	26.80	42.09	5.51	5.84	0.34	-5.63	-11.91		-15.82	-6.14	-45.31	-96.42	-107.62	-150.27		-56.46	-147.78	-125.51
2		7.25	44.67	51.69	36.05	19.30	3.35	-11.64	3.24	-0.63	-8.88	-4.63		-81.40	-152.09			-54.54	-62.46	-275.67
3		38.61	7.49	67.16	34.73	27.79	13.13	-5.77	26.22	-7.49	0.54		-66.45	-43.19	-154.72	-19.29		-34.95	-116.62	-94.93
4	19.13	44.23	22.40	39.73	17.73	31.59	1.64	12.03	8.24	-11.01	-9.42	-4.74	-96.74	-80.95		-74.25		-84.39	-28.65	-195.59
5	21.72	27.43	21.51	67.41	9.95	17.20	-21.98	5.00	8.52	-10.58		-22.39	-47.38	-97.05	-140.24	-248.19		-83.85	-103.24	-183.70
6			1.29	44.95	-2.40	13.29	-15.56	-5.10	-15.85		-16.84	-43.06	-91.85		-202.75	-44.33	-137.94	-129.02	-124.37	-86.78
7		10.51	18.16	-9.65	-8.18	6.13	-15.36	-10.46	-14.20	-21.42	-44.37	-59.50		-132.11	-171.79		-115.39	-162.69	-120.70	-209.88
8	-2.50	-0.84	-2.08	5.44	-9.01	-0.15	-33.08	-27.89	-30.68	-32.62	-38.46		-96.97	-155.86	-185.96		-151.17		-117.98	-191.36
9	-24.14	-8.37	-15.90	1.64	-21.56	-15.06	-35.84	-28.93	-42.98	-59.45	-75.22		-111.48	-131.90			-143.79		-113.14	-120.11
10	-23.14	-29.87	-24.80	10.64	-40.35	-45.30	-54.61	-53.68	-39.95	-60.59		-83.16	-178.59				-101.39	-149.82	-138.96	-196.57
11	-10.78	-18.63	-16.13	1.12	-21.84	-38.33	-45.75	-43.15	-45.13	-55.88	-58.73	-97.95	-80.45		-94.87		-147.46	-99.33	-105.10	-125.26
12	-19.72	8.18	3.84	-0.40	4.86	-10.55	-32.50	-14.88	-29.77	-18.77	-68.34	-102.58		-111.02	-134.55		-111.23	-116.98	-231.15	-188.92

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Thatta

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		4.82	26.02	29.59	11.39	4.94	1.48	-3.83	-27.52		-39.74	-17.40	-43.65	-110.33	-72.44	-144.27		-120.44	-159.72	-132.11
2		6.96	38.44	34.54	33.07	30.91	-3.34	-15.77	-9.12	-1.91	-35.94	-28.11		-84.80	-146.26			-180.91	-105.88	-257.03
3		39.11	-7.90	65.09	28.11	23.04	7.49	-14.76	17.91	-14.09	-14.50		-89.06	-76.96	-156.31	-94.86		-128.78	-206.26	-137.40
4	33.53	30.46	9.38	40.41	17.04	31.76	-3.61	9.31	-16.89	-19.36	-25.17	-30.37	-107.72	-126.74		-96.33		-154.38	-124.33	-225.93
5	25.72	16.75	7.74	63.66	9.84	21.08	-31.47	-6.14	-6.20	-15.75		-52.09	-55.66	-131.74	-80.55	-76.41		-126.47	-173.03	-176.84
6			-1.35	54.02	-1.63	18.21	-19.43	0.51	-26.39		-40.50	-49.35	-55.60		-137.54	-58.17	-143.96	-165.75	-157.61	-140.62
7		14.30	7.20	-1.07	-1.12	11.30	-12.56	-12.92	-18.34	-20.42	-44.36	-55.36		-73.63	-54.98		-133.74	-207.90	-168.24	-231.82
8	6.21	4.29	-6.50	13.21	-0.77	3.18	-29.39	-30.24	-30.94	-33.85	-51.49		-70.51	-85.42	-98.16		-167.22		-135.45	-162.31
9	-14.06	1.29	-14.44	16.29	-15.48	-10.08	-30.56	-25.59	-45.61	-52.77	-72.26		-99.48	-78.32			-152.14		-144.47	-143.50
10	-7.26	-21.93	-22.54	15.14	-36.02	-38.43	-56.43	-58.89	-49.56	-64.94		-93.82	-117.15				-132.94	-190.85	-174.38	-183.62
11	7.35	-11.64	-17.82	5.85	-12.35	-29.12	-41.91	-42.49	-50.27	-54.59	-69.21	-85.63	-61.88		-92.34		-168.29	-131.22	-120.48	-115.99
12	-12.88	13.65	3.02	15.74	16.30	-13.35	-33.71	-21.29	-39.49	-41.77	-75.69	-85.88		-118.54	-138.76		-174.42	-176.07	-241.36	-157.38

Annexure D: Terrestial Water Storage Anomalies (TWSA) of Umerkot

Unit: mm

Month/ Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
1		-2.29	23.68	42.85	4.20	5.54	2.08	-4.26	-14.64		-15.97	-6.46	-53.86	-112.71	-114.91	-140.24		-72.67	-129.50	-138.45
2		8.80	47.67	61.20	37.42	22.45	3.21	-9.79	3.90	4.21	-4.00	-3.09		-76.10	-183.13			-71.77	-66.22	-293.53
3		41.31	8.76	68.95	35.77	28.76	15.93	-4.44	30.06	-5.58	4.21		-61.03	-39.57	-135.67	-37.63		-47.41	-117.85	-96.92
4	22.05	48.40	20.24	46.81	18.64	33.28	3.11	18.54	7.78	-7.93	-8.24	-5.00	-98.43	-79.41		-80.22		-88.95	-25.53	-193.91
5	21.60	28.80	21.27	80.37	9.23	17.97	-23.71	5.49	9.07	-8.47		-28.58	-48.45	-95.67	-138.15	-241.19		-98.71	-88.40	-226.74
6			-3.70	45.89	-3.68	12.08	-15.29	-2.44	-18.32		-21.83	-46.68	-85.98		-219.08	-48.16	-139.23	-138.99	-137.81	-76.66
7		8.27	14.38	-10.35	-9.11	3.51	-16.83	-12.65	-17.48	-23.59	-42.97	-60.58		-143.29	-190.65		-124.26	-185.97	-122.50	-224.60
8	-3.95	-0.59	-2.26	7.54	-9.02	-1.66	-32.15	-26.26	-31.18	-31.71	-40.26		-106.35	-145.45	-166.63		-152.96		-113.85	-193.48
9	-23.57	-8.15	-14.66	0.85	-22.37	-17.36	-37.57	-25.79	-44.00	-57.47	-73.73		-111.96	-112.64			-141.96		-130.06	-69.22
10	-22.97	-31.92	-24.84	7.66	-41.66	-46.24	-56.88	-54.60	-39.19	-59.83		-92.65	-179.35				-103.34	-179.59	-124.76	-131.06
11	-10.05	-20.34	-17.07	0.68	-23.02	-39.48	-48.26	-47.44	-47.99	-56.97	-62.00	-112.62	-78.59		-93.61		-151.48	-105.94	-130.55	-138.37
12	-21.51	5.85	-1.17	-2.86	5.13	-15.40	-35.77	-21.11	-30.68	-21.07	-67.39	-121.19		-111.46	-126.85		-124.37	-124.34	-249.95	-223.20

ANNEXURE-E

MEAN MONTHLY LEAF AREA INDEX (LAI)

Annexure E: Mean Monthly Leaf Area Index (LAI) of Badin

Unit: m^2/m^2

Month / Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.29	0.30	0.34	0.30	0.36	0.32	0.33	0.34	0.37	0.24	0.33	0.31	0.34	0.35	0.36	0.34	0.30	0.39	0.39	0.41
February		0.29	0.33	0.33	0.35	0.39	0.35	0.35	0.37	0.40	0.28	0.35	0.35	0.40	0.39	0.40	0.36	0.33	0.46	0.46	0.45
March		0.27	0.34	0.33	0.37	0.40	0.35	0.34	0.35	0.43	0.30	0.36	0.36	0.37	0.36	0.35	0.34	0.34	0.44	0.42	0.41
April		0.25	0.28	0.29	0.31	0.37	0.29	0.30	0.28	0.36	0.28	0.35	0.33	0.30	0.29	0.27	0.27	0.29	0.35	0.31	0.33
May		0.24	0.24	0.27	0.25	0.32	0.23	0.25	0.23	0.30	0.25	0.32	0.28	0.27	0.26	0.25	0.23	0.25	0.31	0.27	0.27
June		0.25	0.23	0.28	0.24	0.34	0.21	0.25	0.24	0.26	0.22	0.28	0.27	0.31	0.27	0.24	0.21	0.25	0.30	0.24	0.24
July	0.22	0.28	0.23	0.29	0.26	0.38	0.21	0.27	0.25	0.30	0.21	0.26	0.28	0.30	0.31	0.26	0.21	0.25	0.44	0.25	
August	0.30	0.35	0.29	0.40	0.33	0.55	0.36	0.40	0.37	0.38	0.27	0.42	0.40	0.42	0.48	0.48	0.25	0.35	0.78	0.35	
September	0.57	0.54	0.45	0.69	0.61	0.80	0.74	0.84	0.79	0.40	0.53	0.84	0.81	0.74	0.79	0.98	0.56	0.92	1.06	0.94	
October	0.64	0.58	0.55	0.70	0.80	0.74	0.84	0.90	0.97	0.47	0.87	0.99	0.85	0.72	0.66	0.94	0.87	1.10	0.88	1.15	
November	0.50	0.44	0.45	0.50	0.58	0.51	0.55	0.57	0.70	0.36	0.64	0.62	0.55	0.44	0.41	0.55	0.65	0.71	0.45	0.67	
December	0.33	0.32	0.35	0.33	0.40	0.36	0.37	0.35	0.45	0.25	0.41	0.34	0.34	0.30	0.33	0.33	0.34	0.39	0.36	0.38	

Annexure E: Mean Monthly Leaf Area Index of Dadu

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.359	0.348	0.390	0.354	0.406	0.394	0.347	0.444	0.353	0.430	0.414	0.446	0.429	0.512	0.545	0.560	0.551	0.481	0.596	0.668
February		0.508	0.601	0.485	0.518	0.656	0.578	0.586	0.619	0.639	0.619	0.652	0.686	0.678	0.728	0.798	0.775	0.916	0.836	0.850	0.957
March		0.474	0.559	0.574	0.533	0.625	0.575	0.511	0.530	0.673	0.585	0.668	0.649	0.629	0.625	0.607	0.636	0.752	0.788	0.692	0.687
April		0.286	0.294	0.350	0.292	0.356	0.330	0.322	0.278	0.378	0.342	0.377	0.381	0.335	0.289	0.304	0.287	0.343	0.381	0.322	0.324
May		0.204	0.206	0.239	0.207	0.241	0.222	0.244	0.209	0.251	0.242	0.255	0.253	0.224	0.210	0.215	0.201	0.227	0.248	0.233	0.237
June		0.181	0.187	0.198	0.181	0.199	0.191	0.211	0.189	0.202	0.205	0.212	0.208	0.192	0.187	0.189	0.181	0.205	0.204	0.211	0.197
July	0.178	0.211	0.177	0.197	0.174	0.220	0.190	0.222	0.199	0.213	0.205	0.211	0.198	0.197	0.210	0.206	0.181	0.227	0.200	0.224	
August	0.293	0.396	0.280	0.338	0.315	0.400	0.380	0.362	0.342	0.353	0.297	0.353	0.333	0.381	0.416	0.390	0.244	0.385	0.342	0.313	
September	0.491	0.609	0.488	0.600	0.614	0.617	0.630	0.632	0.480	0.626	0.497	0.662	0.618	0.669	0.693	0.782	0.463	0.727	0.709	0.557	
October	0.519	0.561	0.575	0.606	0.659	0.585	0.653	0.646	0.405	0.735	0.749	0.696	0.628	0.646	0.672	0.770	0.595	0.766	0.749	0.734	
November	0.338	0.365	0.357	0.353	0.396	0.384	0.365	0.354	0.277	0.460	0.480	0.419	0.393	0.368	0.358	0.399	0.416	0.416	0.467	0.478	
December	0.243	0.254	0.270	0.246	0.278	0.289	0.249	0.260	0.221	0.326	0.331	0.292	0.274	0.280	0.314	0.303	0.311	0.379	0.348	0.368	

Annexure E: Mean Monthly Leaf Area Index of Ghotki

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.318	0.356	0.367	0.311	0.387	0.348	0.472	0.445	0.431	0.428	0.413	0.481	0.475	0.605	0.597	0.549	0.634	0.668	0.762	0.955
February		0.499	0.691	0.567	0.631	0.714	0.580	0.898	0.808	0.796	0.686	0.780	0.910	0.887	0.924	0.985	0.798	1.068	1.194	1.035	1.236
March		0.653	0.802	0.867	0.809	0.863	0.734	0.738	0.819	1.022	0.719	0.887	0.937	0.929	0.889	0.819	0.763	1.058	1.035	0.838	0.869
April		0.445	0.425	0.585	0.460	0.523	0.475	0.397	0.404	0.558	0.429	0.479	0.527	0.485	0.421	0.385	0.384	0.508	0.471	0.398	0.417
May		0.262	0.234	0.308	0.280	0.326	0.274	0.279	0.264	0.323	0.289	0.314	0.312	0.309	0.313	0.300	0.275	0.310	0.321	0.324	0.328
June		0.222	0.223	0.245	0.243	0.281	0.233	0.269	0.271	0.282	0.282	0.306	0.278	0.319	0.368	0.377	0.319	0.360	0.392	0.417	0.329
July	0.377	0.377	0.329	0.325	0.306	0.369	0.291	0.374	0.368	0.389	0.354	0.370	0.343	0.469	0.598	0.607	0.503	0.665	0.681	0.616	
August	0.634	0.727	0.629	0.644	0.669	0.657	0.647	0.669	0.633	0.780	0.663	0.699	0.725	0.783	1.025	0.929	0.775	1.077	1.117	0.880	
September	0.964	1.121	0.984	1.160	1.090	1.132	1.082	1.175	0.985	1.280	1.109	1.279	1.268	0.975	1.281	1.272	1.013	1.398	1.347	1.125	
October	0.926	1.130	1.070	1.149	1.095	1.101	1.015	1.069	0.973	1.143	1.071	1.198	1.139	0.823	1.015	1.116	0.885	1.016	0.976	1.007	
November	0.641	0.775	0.736	0.703	0.689	0.668	0.514	0.562	0.604	0.657	0.551	0.637	0.552	0.539	0.590	0.665	0.564	0.630	0.510	0.585	
December	0.390	0.376	0.433	0.344	0.397	0.346	0.316	0.305	0.357	0.370	0.346	0.355	0.296	0.357	0.427	0.415	0.439	0.420	0.481	0.504	

Annexure E: Mean Monthly Leaf Area Index of Hyderabad

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.437	0.422	0.496	0.463	0.554	0.515	0.531	0.559	0.505	0.439	0.505	0.506	0.525	0.541	0.582	0.554	0.571	0.610	0.592	0.678
February		0.487	0.558	0.549	0.563	0.633	0.589	0.636	0.659	0.615	0.536	0.594	0.581	0.632	0.616	0.664	0.589	0.657	0.695	0.652	0.703
March		0.437	0.506	0.477	0.510	0.562	0.531	0.496	0.508	0.552	0.470	0.508	0.511	0.488	0.479	0.515	0.487	0.547	0.575	0.542	0.538
April		0.369	0.383	0.361	0.407	0.467	0.400	0.367	0.348	0.373	0.366	0.393	0.386	0.342	0.346	0.375	0.371	0.410	0.438	0.415	0.429
May		0.357	0.360	0.376	0.385	0.453	0.347	0.354	0.349	0.359	0.384	0.422	0.403	0.367	0.377	0.373	0.343	0.416	0.459	0.450	0.428
June		0.401	0.368	0.454	0.428	0.508	0.366	0.462	0.481	0.424	0.407	0.499	0.463	0.518	0.449	0.465	0.403	0.496	0.531	0.518	0.461
July	0.406	0.501	0.408	0.482	0.476	0.600	0.403	0.558	0.608	0.508	0.476	0.534	0.506	0.520	0.554	0.521	0.477	0.501	0.634	0.557	
August	0.425	0.660	0.499	0.579	0.640	0.664	0.566	0.616	0.734	0.617	0.520	0.625	0.597	0.624	0.606	0.633	0.490	0.640	0.731	0.647	
September	0.539	0.744	0.579	0.634	0.786	0.749	0.664	0.790	0.779	0.711	0.631	0.768	0.711	0.647	0.718	0.811	0.578	0.915	0.869	0.789	
October	0.528	0.631	0.601	0.613	0.744	0.637	0.605	0.739	0.707	0.813	0.736	0.733	0.625	0.573	0.629	0.715	0.573	0.781	0.730	0.750	
November	0.488	0.518	0.522	0.504	0.548	0.510	0.467	0.512	0.570	0.611	0.550	0.560	0.482	0.459	0.466	0.508	0.472	0.541	0.485	0.541	
December	0.408	0.392	0.426	0.401	0.470	0.463	0.402	0.390	0.465	0.415	0.447	0.462	0.421	0.409	0.456	0.441	0.473	0.480	0.503	0.503	

Annexure E: Mean Monthly Leaf Area Index of Jacobabad

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.272	0.274	0.312	0.222	0.275	0.265	0.173	0.285	0.223	0.252	0.211	0.318	0.307	0.350	0.428	0.404	0.384	0.290	0.378	0.431
February		0.413	0.499	0.430	0.368	0.493	0.397	0.347	0.456	0.403	0.376	0.387	0.536	0.556	0.550	0.733	0.680	0.768	0.575	0.630	0.764
March		0.551	0.597	0.621	0.535	0.652	0.507	0.412	0.532	0.596	0.478	0.570	0.648	0.724	0.650	0.719	0.773	0.902	0.764	0.699	0.825
April		0.415	0.344	0.422	0.376	0.419	0.339	0.315	0.328	0.410	0.376	0.451	0.483	0.460	0.386	0.380	0.384	0.537	0.468	0.384	0.465
May		0.256	0.217	0.253	0.234	0.248	0.219	0.237	0.226	0.269	0.252	0.295	0.283	0.262	0.233	0.237	0.221	0.278	0.248	0.238	0.286
June		0.201	0.195	0.200	0.189	0.197	0.185	0.200	0.191	0.196	0.205	0.218	0.205	0.197	0.192	0.191	0.188	0.197	0.196	0.193	0.202
July	0.209	0.220	0.232	0.222	0.210	0.243	0.204	0.226	0.189	0.196	0.198	0.216	0.213	0.200	0.251	0.230	0.172	0.182	0.216	0.178	
August	0.465	0.508	0.566	0.571	0.567	0.644	0.570	0.504	0.249	0.414	0.418	0.473	0.582	0.574	0.771	0.672	0.400	0.547	0.615	0.421	
September	1.011	0.963	1.025	1.173	1.164	1.129	1.025	1.164	0.361	1.007	0.804	1.101	1.211	1.244	1.313	1.411	1.076	1.400	1.235	1.225	
October	1.162	0.930	1.049	1.193	1.222	0.998	1.123	1.229	0.426	1.199	0.888	1.184	1.157	1.164	1.168	1.303	1.236	1.318	1.264	1.441	
November	0.640	0.532	0.462	0.569	0.583	0.502	0.503	0.580	0.285	0.670	0.445	0.624	0.565	0.556	0.468	0.548	0.630	0.618	0.498	0.683	
December	0.260	0.256	0.258	0.242	0.257	0.251	0.218	0.248	0.192	0.291	0.237	0.303	0.265	0.261	0.294	0.275	0.288	0.261	0.295	0.285	

Annexure E: Mean Monthly Leaf Area Index of Jamshoro

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.204	0.247	0.229	0.235	0.301	0.286	0.288	0.287	0.321	0.365	0.325	0.347	0.317	0.385	0.371	0.385	0.313	0.405	0.439	0.470
February		0.265	0.349	0.270	0.321	0.418	0.384	0.420	0.377	0.487	0.484	0.450	0.480	0.436	0.480	0.463	0.474	0.443	0.547	0.536	0.553
March		0.249	0.331	0.287	0.306	0.371	0.368	0.346	0.313	0.436	0.433	0.401	0.427	0.345	0.357	0.347	0.362	0.365	0.405	0.407	0.376
April		0.195	0.225	0.216	0.202	0.254	0.244	0.226	0.199	0.263	0.268	0.246	0.261	0.205	0.195	0.214	0.213	0.212	0.232	0.236	0.230
May		0.167	0.191	0.188	0.171	0.218	0.203	0.195	0.180	0.217	0.221	0.211	0.210	0.180	0.178	0.189	0.184	0.180	0.203	0.213	0.202
June		0.155	0.184	0.177	0.161	0.197	0.188	0.186	0.181	0.195	0.205	0.197	0.195	0.186	0.174	0.182	0.175	0.171	0.198	0.207	0.194
July	0.151	0.159	0.174	0.161	0.149	0.216	0.178	0.191	0.200	0.189	0.198	0.187	0.181	0.174	0.176	0.185	0.174	0.174	0.204	0.215	
August	0.163	0.225	0.195	0.169	0.195	0.261	0.216	0.228	0.267	0.207	0.199	0.192	0.196	0.189	0.200	0.218	0.182	0.210	0.238	0.245	
September	0.206	0.294	0.229	0.208	0.326	0.361	0.267	0.275	0.299	0.285	0.219	0.237	0.225	0.205	0.250	0.278	0.205	0.344	0.352	0.276	
October	0.219	0.278	0.256	0.247	0.329	0.326	0.275	0.273	0.241	0.422	0.276	0.256	0.220	0.214	0.254	0.270	0.218	0.333	0.344	0.294	
November	0.204	0.256	0.252	0.230	0.268	0.277	0.246	0.224	0.211	0.334	0.246	0.238	0.190	0.200	0.222	0.222	0.193	0.263	0.264	0.246	
December	0.182	0.219	0.207	0.197	0.241	0.246	0.211	0.198	0.216	0.285	0.233	0.238	0.197	0.223	0.247	0.228	0.207	0.260	0.298	0.275	

Annexure E: Mean Monthly Leaf Area Index of Karachi City

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.204	0.239	0.211	0.203	0.268	0.275	0.264	0.275	0.303	0.305	0.258	0.256	0.210	0.207	0.243	0.275	0.203	0.305	0.321	0.291
February		0.199	0.248	0.204	0.204	0.278	0.279	0.268	0.271	0.305	0.304	0.259	0.258	0.214	0.210	0.249	0.260	0.214	0.300	0.308	0.311
March		0.199	0.245	0.206	0.209	0.273	0.273	0.257	0.255	0.299	0.278	0.264	0.263	0.221	0.207	0.244	0.253	0.225	0.284	0.293	0.294
April		0.197	0.228	0.214	0.198	0.282	0.249	0.239	0.240	0.275	0.255	0.258	0.256	0.208	0.202	0.237	0.240	0.220	0.276	0.274	0.268
May		0.181	0.212	0.205	0.183	0.255	0.236	0.221	0.232	0.259	0.249	0.256	0.240	0.204	0.194	0.223	0.225	0.212	0.272	0.272	0.247
June		0.162	0.192	0.184	0.165	0.228	0.211	0.205	0.240	0.221	0.228	0.225	0.222	0.201	0.181	0.198	0.206	0.194	0.251	0.244	0.236
July	0.146	0.167	0.165	0.144	0.147	0.259	0.172	0.188	0.287	0.185	0.199	0.179	0.180	0.153	0.141	0.214	0.177	0.173	0.239	0.236	
August	0.146	0.258	0.172	0.140	0.181	0.284	0.246	0.252	0.404	0.217	0.197	0.196	0.179	0.175	0.185	0.275	0.165	0.226	0.309	0.260	
September	0.199	0.304	0.191	0.179	0.382	0.477	0.300	0.389	0.518	0.357	0.257	0.323	0.227	0.229	0.284	0.406	0.187	0.530	0.563	0.395	
October	0.225	0.273	0.219	0.238	0.373	0.413	0.291	0.374	0.467	0.534	0.339	0.327	0.232	0.252	0.291	0.390	0.226	0.527	0.538	0.455	
November	0.213	0.263	0.237	0.231	0.300	0.353	0.278	0.311	0.387	0.429	0.295	0.309	0.221	0.239	0.264	0.321	0.216	0.409	0.407	0.363	
December	0.202	0.240	0.213	0.209	0.276	0.304	0.255	0.272	0.327	0.337	0.264	0.272	0.213	0.218	0.244	0.274	0.204	0.330	0.355	0.294	

Annexure E: Mean Monthly Leaf Area Index of Kashmore

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.329	0.324	0.432	0.330	0.417	0.401	0.433	0.477	0.385	0.421	0.422	0.526	0.542	0.610	0.673	0.773	0.685	0.600	0.717	0.802
February		0.524	0.611	0.612	0.556	0.741	0.645	0.768	0.753	0.710	0.677	0.735	0.891	0.890	0.874	1.016	0.979	1.104	1.056	0.995	1.188
March		0.617	0.675	0.711	0.667	0.829	0.690	0.619	0.676	0.878	0.698	0.834	0.845	0.829	0.769	0.758	0.790	1.014	0.927	0.809	0.883
April		0.401	0.360	0.436	0.397	0.463	0.375	0.360	0.325	0.453	0.392	0.446	0.458	0.412	0.351	0.323	0.324	0.456	0.414	0.343	0.391
May		0.263	0.236	0.279	0.270	0.294	0.246	0.268	0.239	0.278	0.260	0.290	0.283	0.276	0.256	0.242	0.227	0.269	0.266	0.259	0.273
June		0.219	0.226	0.228	0.224	0.254	0.208	0.235	0.222	0.218	0.230	0.255	0.242	0.250	0.246	0.239	0.224	0.245	0.263	0.265	0.241
July	0.322	0.337	0.361	0.300	0.311	0.364	0.263	0.323	0.256	0.237	0.258	0.281	0.283	0.250	0.343	0.315	0.239	0.264	0.352	0.258	
August	0.669	0.704	0.752	0.695	0.779	0.772	0.693	0.709	0.476	0.578	0.621	0.656	0.738	0.607	0.896	0.781	0.547	0.716	0.857	0.552	
September	1.021	1.085	1.040	1.188	1.181	1.135	1.060	1.221	0.755	1.164	1.014	1.190	1.179	1.152	1.224	1.243	1.042	1.389	1.282	1.245	
October	0.855	0.851	0.811	0.952	0.952	0.819	0.851	0.919	0.669	1.013	0.849	0.969	0.846	0.879	0.813	0.879	0.854	1.033	0.945	1.143	
November	0.426	0.456	0.366	0.436	0.429	0.387	0.348	0.371	0.340	0.481	0.363	0.455	0.383	0.397	0.332	0.381	0.393	0.479	0.365	0.491	
December	0.243	0.255	0.271	0.256	0.279	0.261	0.246	0.254	0.239	0.299	0.282	0.330	0.306	0.317	0.400	0.410	0.407	0.375	0.410	0.387	

Annexure E: Mean Monthly Leaf Area Index of Khairpur

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.409	0.366	0.448	0.384	0.478	0.405	0.530	0.559	0.537	0.512	0.509	0.522	0.522	0.649	0.667	0.690	0.720	0.677	0.787	0.929
February		0.633	0.651	0.632	0.654	0.787	0.665	0.842	0.816	0.856	0.745	0.843	0.816	0.843	0.902	0.960	0.879	1.067	1.091	0.997	1.112
March		0.629	0.697	0.743	0.715	0.792	0.714	0.656	0.670	0.883	0.712	0.846	0.800	0.778	0.773	0.738	0.723	0.921	0.933	0.797	0.782
April		0.382	0.406	0.445	0.404	0.465	0.432	0.376	0.341	0.480	0.414	0.455	0.491	0.421	0.384	0.384	0.374	0.465	0.465	0.401	0.405
May		0.275	0.269	0.300	0.281	0.341	0.296	0.304	0.272	0.335	0.317	0.335	0.350	0.328	0.332	0.322	0.297	0.350	0.353	0.349	0.337
June		0.299	0.285	0.311	0.279	0.362	0.291	0.347	0.341	0.337	0.319	0.385	0.363	0.388	0.412	0.407	0.353	0.433	0.443	0.479	0.352
July	0.365	0.448	0.369	0.413	0.333	0.473	0.360	0.471	0.463	0.446	0.415	0.508	0.455	0.482	0.573	0.549	0.488	0.569	0.650	0.661	
August	0.440	0.685	0.538	0.559	0.614	0.607	0.577	0.606	0.674	0.614	0.544	0.646	0.630	0.647	0.704	0.724	0.568	0.711	0.840	0.758	
September	0.573	0.835	0.671	0.719	0.775	0.754	0.745	0.734	0.782	0.778	0.666	0.810	0.750	0.704	0.800	0.863	0.626	0.885	0.934	0.742	
October	0.547	0.733	0.650	0.664	0.721	0.650	0.648	0.621	0.656	0.780	0.726	0.689	0.626	0.596	0.639	0.703	0.539	0.769	0.727	0.672	
November	0.427	0.548	0.475	0.467	0.490	0.455	0.402	0.390	0.448	0.513	0.481	0.474	0.409	0.416	0.413	0.452	0.369	0.499	0.435	0.444	
December	0.302	0.340	0.320	0.288	0.337	0.309	0.312	0.294	0.351	0.371	0.362	0.360	0.307	0.330	0.384	0.390	0.429	0.391	0.473	0.505	

Annexure E: Mean Monthly Leaf Area Index of Larkana

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.359	0.339	0.355	0.275	0.334	0.323	0.328	0.394	0.339	0.391	0.342	0.397	0.405	0.538	0.619	0.595	0.533	0.550	0.655	0.714
February		0.580	0.673	0.518	0.498	0.653	0.547	0.657	0.690	0.713	0.668	0.700	0.783	0.837	0.917	1.145	1.023	1.204	1.143	1.138	1.314
March		0.670	0.751	0.803	0.713	0.821	0.677	0.677	0.728	1.001	0.759	0.972	0.950	0.999	0.980	0.998	1.043	1.334	1.185	1.079	1.119
April		0.430	0.412	0.523	0.466	0.518	0.441	0.428	0.390	0.608	0.480	0.575	0.622	0.541	0.491	0.461	0.455	0.683	0.545	0.474	0.494
May		0.272	0.250	0.303	0.284	0.314	0.271	0.292	0.255	0.351	0.303	0.321	0.348	0.307	0.292	0.280	0.263	0.337	0.295	0.298	0.309
June		0.226	0.228	0.241	0.230	0.253	0.223	0.239	0.223	0.254	0.239	0.248	0.254	0.240	0.246	0.232	0.225	0.244	0.247	0.261	0.236
July	0.262	0.319	0.234	0.267	0.252	0.304	0.249	0.293	0.242	0.265	0.235	0.256	0.252	0.252	0.297	0.277	0.221	0.226	0.280	0.270	
August	0.635	0.774	0.581	0.687	0.724	0.756	0.745	0.700	0.526	0.653	0.511	0.577	0.637	0.618	0.811	0.701	0.376	0.565	0.646	0.471	
September	1.177	1.222	1.152	1.417	1.431	1.288	1.325	1.439	1.063	1.397	1.152	1.371	1.420	1.367	1.492	1.591	1.037	1.501	1.345	1.263	
October	1.126	0.980	1.231	1.349	1.371	1.108	1.266	1.324	1.182	1.437	1.529	1.484	1.371	1.329	1.299	1.519	1.362	1.558	1.422	1.606	
November	0.556	0.508	0.545	0.617	0.626	0.552	0.509	0.542	0.612	0.672	0.696	0.726	0.654	0.614	0.495	0.644	0.744	0.730	0.559	0.763	
December	0.272	0.272	0.286	0.267	0.293	0.277	0.258	0.256	0.272	0.311	0.329	0.307	0.269	0.289	0.321	0.304	0.320	0.322	0.367	0.339	

Annexure E: Mean Monthly Leaf Area Index of Matiari

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.584	0.455	0.591	0.592	0.648	0.628	0.752	0.739	0.640	0.542	0.667	0.743	0.849	0.922	0.979	0.895	1.011	1.021	0.923	1.232
February		0.828	0.757	0.846	0.864	0.988	0.886	1.086	1.071	1.008	0.809	0.972	1.074	1.154	1.183	1.232	1.109	1.316	1.299	1.136	1.290
March		0.663	0.747	0.793	0.790	0.897	0.858	0.808	0.826	0.945	0.751	0.825	0.957	0.811	0.807	0.824	0.778	0.951	0.900	0.823	0.739
April		0.376	0.428	0.428	0.468	0.548	0.497	0.442	0.390	0.470	0.431	0.453	0.485	0.389	0.369	0.407	0.395	0.458	0.445	0.419	0.417
May		0.309	0.330	0.347	0.380	0.452	0.364	0.367	0.341	0.373	0.369	0.405	0.389	0.363	0.380	0.380	0.350	0.421	0.426	0.432	0.414
June		0.372	0.356	0.396	0.421	0.480	0.378	0.489	0.490	0.442	0.400	0.524	0.468	0.562	0.501	0.546	0.459	0.568	0.524	0.563	0.479
July	0.434	0.586	0.493	0.498	0.545	0.652	0.491	0.706	0.725	0.601	0.547	0.680	0.623	0.668	0.693	0.711	0.649	0.650	0.661	0.669	
August	0.499	0.801	0.673	0.672	0.838	0.811	0.742	0.816	0.890	0.803	0.645	0.807	0.832	0.840	0.795	0.837	0.738	0.788	0.812	0.753	
September	0.663	0.900	0.803	0.822	1.074	0.940	0.858	0.987	0.866	0.846	0.771	0.902	0.940	0.819	0.891	1.019	0.814	1.061	0.951	0.838	
October	0.636	0.830	0.868	0.868	0.964	0.779	0.750	0.920	0.782	0.897	0.874	0.911	0.812	0.753	0.808	0.890	0.759	0.927	0.828	0.805	
November	0.494	0.668	0.684	0.694	0.651	0.569	0.538	0.619	0.612	0.668	0.631	0.682	0.546	0.529	0.552	0.564	0.534	0.586	0.537	0.560	
December	0.389	0.437	0.447	0.463	0.459	0.466	0.459	0.402	0.463	0.428	0.460	0.502	0.469	0.468	0.556	0.500	0.602	0.591	0.596	0.698	

Annexure E: Mean Monthly Leaf Area Index of Mirpur Khas

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.398	0.473	0.462	0.483	0.537	0.448	0.463	0.528	0.496	0.326	0.490	0.495	0.548	0.556	0.542	0.503	0.449	0.594	0.548	0.625
February		0.434	0.610	0.512	0.581	0.630	0.532	0.568	0.594	0.626	0.456	0.581	0.575	0.632	0.598	0.585	0.512	0.492	0.672	0.626	0.623
March		0.349	0.475	0.422	0.451	0.491	0.446	0.405	0.413	0.528	0.408	0.438	0.443	0.434	0.414	0.401	0.373	0.385	0.496	0.462	0.418
April		0.283	0.293	0.283	0.301	0.338	0.294	0.268	0.255	0.309	0.263	0.279	0.286	0.271	0.270	0.280	0.268	0.288	0.315	0.293	0.309
May		0.277	0.254	0.278	0.270	0.316	0.250	0.273	0.248	0.270	0.247	0.302	0.301	0.293	0.315	0.301	0.259	0.329	0.339	0.329	0.321
June		0.333	0.280	0.366	0.300	0.391	0.261	0.379	0.346	0.301	0.283	0.411	0.408	0.445	0.401	0.402	0.289	0.440	0.434	0.422	0.358
July	0.286	0.437	0.331	0.430	0.347	0.520	0.297	0.465	0.434	0.372	0.367	0.454	0.440	0.454	0.435	0.475	0.346	0.434	0.527	0.488	
August	0.303	0.550	0.385	0.506	0.470	0.583	0.451	0.480	0.515	0.412	0.402	0.550	0.511	0.503	0.481	0.560	0.372	0.513	0.603	0.516	
September	0.413	0.606	0.478	0.622	0.564	0.666	0.580	0.651	0.666	0.341	0.471	0.657	0.656	0.613	0.671	0.729	0.473	0.802	0.651	0.650	
October	0.405	0.557	0.550	0.612	0.599	0.545	0.551	0.617	0.612	0.308	0.627	0.644	0.584	0.585	0.604	0.625	0.483	0.684	0.570	0.646	
November	0.359	0.429	0.476	0.454	0.443	0.404	0.408	0.415	0.456	0.275	0.480	0.460	0.422	0.413	0.428	0.438	0.398	0.460	0.374	0.467	
December	0.324	0.359	0.376	0.362	0.398	0.378	0.342	0.353	0.391	0.240	0.398	0.387	0.392	0.385	0.423	0.396	0.395	0.433	0.410	0.456	

Annexure E: Mean Monthly Leaf Area Index of Naushahro Feroze

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.494	0.472	0.586	0.547	0.641	0.588	0.701	0.755	0.683	0.618	0.652	0.691	0.700	0.830	0.851	0.812	0.903	0.873	0.977	1.180
February		0.801	0.903	0.855	0.912	1.065	0.939	1.150	1.126	1.171	0.995	1.141	1.135	1.155	1.215	1.306	1.173	1.470	1.531	1.358	1.550
March		0.764	0.881	0.969	0.926	0.987	0.945	0.868	0.884	1.141	0.951	1.111	1.079	1.001	0.992	0.985	0.976	1.276	1.242	1.086	1.058
April		0.420	0.434	0.499	0.448	0.517	0.511	0.439	0.395	0.544	0.500	0.518	0.568	0.481	0.420	0.456	0.434	0.567	0.536	0.471	0.465
May		0.286	0.284	0.331	0.317	0.382	0.331	0.346	0.308	0.370	0.351	0.374	0.388	0.349	0.365	0.357	0.315	0.406	0.371	0.374	0.357
June		0.288	0.288	0.338	0.318	0.397	0.324	0.386	0.369	0.374	0.335	0.425	0.394	0.405	0.420	0.423	0.353	0.445	0.430	0.471	0.350
July	0.338	0.417	0.346	0.424	0.364	0.505	0.387	0.511	0.479	0.499	0.422	0.552	0.487	0.509	0.564	0.565	0.510	0.572	0.645	0.665	
August	0.425	0.613	0.516	0.572	0.629	0.667	0.630	0.694	0.650	0.725	0.589	0.712	0.722	0.732	0.786	0.791	0.655	0.828	0.977	0.839	
September	0.598	0.765	0.676	0.766	0.791	0.813	0.825	0.846	0.735	0.889	0.738	0.898	0.869	0.805	0.938	1.017	0.770	1.083	1.133	0.912	
October	0.571	0.704	0.664	0.692	0.729	0.682	0.699	0.686	0.625	0.849	0.771	0.732	0.691	0.651	0.762	0.827	0.654	0.917	0.842	0.803	
November	0.442	0.514	0.471	0.477	0.505	0.468	0.433	0.416	0.429	0.544	0.504	0.492	0.451	0.436	0.472	0.493	0.429	0.561	0.453	0.476	
December	0.327	0.338	0.350	0.335	0.398	0.366	0.369	0.348	0.367	0.393	0.403	0.411	0.363	0.366	0.430	0.397	0.464	0.425	0.507	0.516	

Annexure E: Mean Monthly Leaf Area Index of Qambar Shahdadkot

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.329	0.280	0.346	0.245	0.281	0.282	0.195	0.357	0.269	0.338	0.295	0.354	0.330	0.430	0.511	0.484	0.382	0.416	0.474	0.535
February		0.497	0.498	0.442	0.388	0.500	0.441	0.387	0.571	0.535	0.557	0.573	0.656	0.656	0.723	0.940	0.840	0.889	0.876	0.844	1.026
March		0.516	0.539	0.631	0.523	0.597	0.519	0.464	0.571	0.705	0.607	0.774	0.730	0.802	0.748	0.816	0.844	1.052	0.923	0.801	0.881
April		0.335	0.327	0.423	0.354	0.400	0.348	0.370	0.335	0.427	0.381	0.480	0.470	0.441	0.370	0.379	0.361	0.532	0.427	0.374	0.395
May		0.230	0.225	0.272	0.247	0.273	0.244	0.280	0.242	0.259	0.248	0.285	0.287	0.259	0.237	0.243	0.224	0.280	0.251	0.244	0.261
June		0.189	0.198	0.223	0.208	0.224	0.199	0.227	0.205	0.198	0.197	0.218	0.217	0.201	0.197	0.198	0.191	0.210	0.210	0.203	0.205
July	0.188	0.202	0.173	0.215	0.196	0.189	0.187	0.229	0.196	0.199	0.188	0.204	0.192	0.186	0.202	0.198	0.172	0.185	0.205	0.186	
August	0.416	0.466	0.327	0.481	0.425	0.438	0.463	0.449	0.330	0.410	0.303	0.348	0.372	0.439	0.480	0.451	0.236	0.362	0.380	0.283	
September	0.817	0.849	0.733	1.075	0.998	0.857	0.933	1.043	0.607	0.939	0.675	0.968	0.961	1.067	1.068	1.204	0.666	1.046	0.964	0.795	
October	0.891	0.843	0.962	1.141	1.145	0.853	1.082	1.156	0.722	1.154	1.150	1.225	1.127	1.126	1.177	1.323	1.077	1.252	1.275	1.182	
November	0.493	0.499	0.497	0.546	0.586	0.490	0.515	0.552	0.419	0.610	0.675	0.653	0.624	0.552	0.521	0.596	0.700	0.663	0.580	0.674	
December	0.248	0.250	0.276	0.238	0.257	0.253	0.236	0.261	0.220	0.296	0.333	0.292	0.259	0.264	0.308	0.274	0.299	0.297	0.330	0.328	

Annexure E: Mean Monthly Leaf Area Index of Sanghar

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.384	0.389	0.416	0.384	0.418	0.402	0.409	0.475	0.430	0.318	0.448	0.465	0.511	0.530	0.565	0.537	0.570	0.631	0.619	0.731
February		0.475	0.554	0.506	0.525	0.563	0.539	0.576	0.597	0.614	0.442	0.589	0.616	0.646	0.643	0.638	0.630	0.669	0.764	0.677	0.713
March		0.358	0.477	0.457	0.452	0.470	0.493	0.432	0.436	0.557	0.411	0.477	0.520	0.446	0.450	0.413	0.433	0.463	0.523	0.455	0.422
April		0.221	0.275	0.270	0.259	0.302	0.289	0.248	0.239	0.294	0.260	0.266	0.285	0.228	0.234	0.237	0.243	0.241	0.264	0.249	0.260
May		0.201	0.225	0.229	0.214	0.263	0.224	0.225	0.217	0.238	0.230	0.252	0.242	0.218	0.250	0.242	0.226	0.261	0.271	0.279	0.276
June		0.252	0.255	0.279	0.240	0.308	0.232	0.327	0.326	0.299	0.282	0.379	0.332	0.360	0.356	0.377	0.286	0.425	0.396	0.414	0.335
July	0.274	0.415	0.328	0.374	0.314	0.445	0.308	0.462	0.499	0.427	0.400	0.500	0.436	0.468	0.499	0.510	0.399	0.470	0.556	0.500	
August	0.318	0.666	0.417	0.484	0.529	0.556	0.490	0.535	0.783	0.556	0.479	0.594	0.571	0.620	0.593	0.648	0.470	0.573	0.656	0.576	
September	0.411	0.791	0.490	0.562	0.673	0.637	0.580	0.673	0.853	0.551	0.544	0.660	0.653	0.615	0.665	0.788	0.539	0.840	0.729	0.628	
October	0.383	0.605	0.508	0.541	0.596	0.481	0.484	0.575	0.664	0.478	0.624	0.591	0.511	0.512	0.507	0.596	0.455	0.670	0.549	0.565	
November	0.289	0.436	0.416	0.388	0.390	0.335	0.344	0.371	0.428	0.341	0.428	0.409	0.320	0.345	0.321	0.349	0.318	0.367	0.315	0.381	
December	0.254	0.317	0.316	0.273	0.296	0.301	0.283	0.284	0.318	0.249	0.337	0.321	0.305	0.309	0.354	0.320	0.394	0.379	0.407	0.487	

Annexure E: Mean Monthly Leaf Area Index of Shaheed Benazirabad

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.559	0.491	0.608	0.590	0.638	0.560	0.653	0.713	0.611	0.545	0.656	0.679	0.697	0.773	0.832	0.798	0.875	0.909	0.888	1.040
February		0.785	0.822	0.781	0.848	0.929	0.811	0.932	0.937	0.928	0.787	0.941	0.944	0.952	0.994	1.053	0.975	1.175	1.244	1.092	1.159
March		0.602	0.731	0.718	0.734	0.783	0.756	0.674	0.677	0.829	0.704	0.800	0.827	0.718	0.708	0.716	0.693	0.886	0.880	0.781	0.714
April		0.311	0.353	0.359	0.350	0.421	0.403	0.356	0.318	0.397	0.377	0.391	0.427	0.356	0.321	0.348	0.327	0.401	0.384	0.357	0.357
May		0.245	0.257	0.278	0.275	0.344	0.292	0.301	0.283	0.314	0.303	0.326	0.329	0.303	0.329	0.321	0.281	0.343	0.333	0.341	0.330
June		0.279	0.276	0.323	0.300	0.380	0.308	0.374	0.381	0.366	0.328	0.424	0.386	0.426	0.421	0.443	0.359	0.476	0.443	0.482	0.381
July	0.316	0.442	0.350	0.434	0.359	0.513	0.381	0.518	0.518	0.505	0.448	0.577	0.502	0.566	0.584	0.619	0.515	0.602	0.646	0.642	
August	0.385	0.661	0.489	0.567	0.622	0.662	0.574	0.662	0.685	0.691	0.575	0.722	0.708	0.762	0.751	0.774	0.624	0.774	0.796	0.777	
September	0.547	0.766	0.603	0.695	0.835	0.776	0.699	0.765	0.755	0.647	0.672	0.820	0.811	0.764	0.839	0.923	0.702	0.992	0.895	0.882	
October	0.519	0.666	0.608	0.659	0.744	0.646	0.586	0.640	0.618	0.657	0.702	0.710	0.655	0.629	0.687	0.752	0.604	0.839	0.722	0.732	
November	0.397	0.493	0.462	0.466	0.502	0.473	0.403	0.410	0.441	0.473	0.499	0.504	0.445	0.427	0.441	0.448	0.420	0.492	0.416	0.460	
December	0.333	0.360	0.366	0.353	0.406	0.390	0.389	0.359	0.377	0.377	0.429	0.437	0.403	0.391	0.466	0.428	0.523	0.481	0.521	0.570	

Annexure E: Mean Monthly Leaf Area Index of Shikarpur

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.322	0.313	0.356	0.262	0.312	0.298	0.278	0.330	0.271	0.289	0.283	0.344	0.343	0.399	0.495	0.502	0.477	0.409	0.526	0.590
February		0.495	0.578	0.510	0.458	0.569	0.464	0.551	0.556	0.519	0.455	0.530	0.630	0.641	0.641	0.861	0.813	0.976	0.809	0.845	1.009
March		0.649	0.697	0.710	0.661	0.744	0.599	0.577	0.645	0.796	0.573	0.761	0.783	0.813	0.750	0.805	0.867	1.062	0.923	0.850	0.946
April		0.477	0.418	0.488	0.470	0.506	0.427	0.403	0.390	0.546	0.443	0.544	0.580	0.532	0.458	0.431	0.428	0.591	0.519	0.443	0.500
May		0.301	0.265	0.310	0.293	0.318	0.280	0.291	0.268	0.355	0.311	0.353	0.351	0.329	0.289	0.279	0.257	0.320	0.298	0.287	0.320
June		0.237	0.240	0.252	0.231	0.254	0.229	0.245	0.236	0.256	0.249	0.267	0.255	0.256	0.245	0.241	0.223	0.242	0.245	0.246	0.238
July	0.246	0.283	0.285	0.290	0.265	0.307	0.258	0.294	0.247	0.256	0.242	0.278	0.274	0.282	0.337	0.324	0.227	0.240	0.291	0.257	
August	0.566	0.632	0.678	0.675	0.713	0.703	0.688	0.637	0.437	0.539	0.511	0.586	0.673	0.697	0.871	0.766	0.452	0.618	0.723	0.532	
September	1.119	1.127	1.137	1.269	1.300	1.174	1.150	1.335	0.737	1.200	1.022	1.212	1.316	1.325	1.412	1.446	1.063	1.463	1.297	1.268	
October	1.145	1.019	1.061	1.191	1.229	1.048	1.111	1.246	0.811	1.348	1.245	1.273	1.213	1.193	1.190	1.310	1.244	1.432	1.285	1.458	
November	0.600	0.554	0.455	0.553	0.569	0.531	0.459	0.531	0.453	0.689	0.565	0.646	0.570	0.548	0.469	0.561	0.630	0.665	0.495	0.671	
December	0.280	0.282	0.282	0.268	0.286	0.277	0.239	0.259	0.238	0.300	0.292	0.304	0.272	0.270	0.313	0.301	0.309	0.301	0.348	0.319	

Annexure E: Mean Monthly Leaf Area Index of Sujawal

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.279	0.283	0.311	0.267	0.322	0.302	0.293	0.300	0.295	0.298	0.299	0.280	0.281	0.306	0.296	0.291	0.266	0.306	0.310	0.308
February		0.277	0.313	0.303	0.297	0.351	0.314	0.313	0.317	0.316	0.294	0.297	0.281	0.307	0.326	0.329	0.308	0.290	0.346	0.344	0.348
March		0.268	0.326	0.313	0.319	0.371	0.309	0.305	0.305	0.340	0.288	0.315	0.302	0.304	0.314	0.309	0.300	0.316	0.352	0.343	0.351
April		0.263	0.294	0.301	0.294	0.358	0.287	0.285	0.281	0.322	0.294	0.346	0.320	0.292	0.293	0.291	0.277	0.302	0.335	0.311	0.323
May		0.259	0.264	0.273	0.260	0.324	0.247	0.261	0.260	0.303	0.293	0.344	0.292	0.284	0.289	0.279	0.259	0.280	0.309	0.280	0.282
June		0.235	0.234	0.251	0.232	0.319	0.210	0.240	0.259	0.256	0.249	0.289	0.281	0.279	0.277	0.259	0.234	0.253	0.307	0.241	0.258
July	0.190	0.235	0.198	0.233	0.220	0.309	0.187	0.232	0.230	0.239	0.208	0.227	0.245	0.235	0.263	0.214	0.195	0.235	0.380	0.206	
August	0.242	0.289	0.253	0.288	0.259	0.445	0.284	0.317	0.297	0.350	0.246	0.292	0.311	0.296	0.354	0.333	0.210	0.278	0.563	0.247	
September	0.440	0.411	0.390	0.498	0.485	0.654	0.520	0.598	0.418	0.492	0.423	0.574	0.564	0.526	0.572	0.689	0.433	0.659	0.709	0.658	
October	0.487	0.477	0.491	0.549	0.636	0.620	0.620	0.679	0.482	0.628	0.682	0.689	0.618	0.557	0.530	0.717	0.633	0.791	0.660	0.843	
November	0.414	0.408	0.454	0.440	0.515	0.485	0.472	0.481	0.397	0.499	0.546	0.513	0.456	0.409	0.388	0.478	0.517	0.562	0.421	0.567	
December	0.306	0.318	0.352	0.315	0.380	0.355	0.342	0.322	0.330	0.364	0.385	0.338	0.318	0.306	0.303	0.307	0.318	0.340	0.329	0.340	

Annexure E: Mean Monthly Leaf Area Index of Sukkur

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.331	0.334	0.379	0.325	0.418	0.366	0.484	0.478	0.438	0.443	0.510	0.541	0.533	0.687	0.702	0.707	0.675	0.704	0.858	1.086
February		0.476	0.572	0.514	0.562	0.708	0.570	0.863	0.788	0.778	0.714	0.886	0.932	0.924	0.980	1.048	0.957	1.140	1.183	1.068	1.235
March		0.580	0.679	0.720	0.713	0.811	0.648	0.697	0.736	0.968	0.732	0.934	0.911	0.894	0.863	0.799	0.810	1.034	0.995	0.819	0.783
April		0.424	0.430	0.510	0.465	0.520	0.441	0.411	0.388	0.542	0.433	0.497	0.536	0.482	0.405	0.383	0.386	0.494	0.485	0.397	0.388
May		0.292	0.284	0.331	0.317	0.358	0.303	0.318	0.278	0.345	0.307	0.335	0.343	0.342	0.308	0.289	0.271	0.318	0.343	0.331	0.314
June		0.258	0.263	0.295	0.265	0.318	0.258	0.300	0.280	0.285	0.274	0.312	0.299	0.329	0.327	0.321	0.286	0.325	0.360	0.398	0.310
July	0.285	0.336	0.310	0.314	0.283	0.365	0.272	0.356	0.320	0.335	0.306	0.356	0.324	0.365	0.448	0.435	0.390	0.426	0.497	0.536	
August	0.420	0.528	0.473	0.448	0.504	0.499	0.473	0.503	0.424	0.510	0.420	0.482	0.484	0.505	0.640	0.601	0.498	0.615	0.715	0.652	
September	0.648	0.800	0.693	0.766	0.786	0.750	0.729	0.767	0.591	0.797	0.625	0.744	0.756	0.654	0.801	0.828	0.629	0.871	0.829	0.706	
October	0.684	0.838	0.747	0.825	0.848	0.750	0.735	0.736	0.654	0.839	0.766	0.785	0.733	0.628	0.698	0.757	0.590	0.765	0.670	0.622	
November	0.521	0.645	0.553	0.585	0.579	0.532	0.464	0.446	0.469	0.565	0.514	0.528	0.462	0.438	0.450	0.478	0.404	0.517	0.421	0.431	
December	0.348	0.373	0.371	0.345	0.387	0.334	0.306	0.302	0.328	0.368	0.376	0.369	0.315	0.350	0.418	0.396	0.384	0.408	0.507	0.574	

Annexure E: Mean Monthly Leaf Area Index of Tando Allah Yar

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.456	0.468	0.534	0.518	0.602	0.579	0.629	0.658	0.566	0.453	0.588	0.605	0.637	0.641	0.708	0.646	0.718	0.760	0.707	0.837
February		0.543	0.651	0.635	0.653	0.714	0.683	0.779	0.791	0.733	0.568	0.712	0.692	0.743	0.723	0.771	0.679	0.811	0.854	0.759	0.826
March		0.460	0.540	0.539	0.550	0.597	0.589	0.565	0.575	0.653	0.485	0.570	0.565	0.531	0.522	0.553	0.529	0.621	0.646	0.589	0.580
April		0.366	0.358	0.362	0.401	0.458	0.405	0.380	0.354	0.399	0.338	0.389	0.384	0.352	0.368	0.398	0.390	0.445	0.459	0.436	0.469
May		0.366	0.335	0.366	0.382	0.447	0.359	0.384	0.367	0.378	0.365	0.450	0.430	0.414	0.448	0.443	0.392	0.496	0.510	0.516	0.511
June		0.415	0.361	0.439	0.431	0.516	0.397	0.543	0.555	0.479	0.441	0.615	0.564	0.637	0.554	0.600	0.488	0.644	0.630	0.666	0.584
July	0.399	0.537	0.426	0.505	0.507	0.692	0.467	0.675	0.737	0.606	0.585	0.718	0.633	0.641	0.667	0.683	0.605	0.654	0.745	0.730	
August	0.401	0.688	0.517	0.623	0.716	0.737	0.638	0.692	0.815	0.707	0.634	0.776	0.741	0.773	0.712	0.766	0.600	0.772	0.808	0.779	
September	0.501	0.780	0.601	0.739	0.846	0.811	0.711	0.857	0.920	0.709	0.701	0.882	0.846	0.826	0.823	0.959	0.674	1.067	0.953	0.898	
October	0.486	0.657	0.653	0.708	0.814	0.659	0.634	0.810	0.831	0.735	0.842	0.823	0.721	0.744	0.755	0.826	0.642	0.908	0.865	0.894	
November	0.439	0.510	0.558	0.541	0.583	0.506	0.486	0.558	0.671	0.583	0.638	0.635	0.556	0.555	0.569	0.596	0.533	0.640	0.586	0.666	
December	0.378	0.382	0.434	0.411	0.474	0.477	0.436	0.423	0.524	0.421	0.511	0.537	0.505	0.481	0.565	0.517	0.579	0.583	0.613	0.645	

Annexure E: Mean Monthly Leaf Area Index of Tando Muhammad Khan

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.331	0.301	0.328	0.310	0.350	0.328	0.329	0.333	0.343	0.315	0.318	0.317	0.337	0.326	0.372	0.364	0.328	0.356	0.379	0.422
February		0.338	0.347	0.356	0.362	0.385	0.352	0.384	0.386	0.384	0.324	0.356	0.351	0.401	0.375	0.423	0.392	0.389	0.456	0.476	0.509
March		0.325	0.355	0.369	0.369	0.397	0.343	0.362	0.350	0.416	0.306	0.379	0.361	0.372	0.348	0.368	0.366	0.402	0.452	0.441	0.459
April		0.308	0.314	0.318	0.318	0.375	0.301	0.310	0.289	0.353	0.286	0.358	0.331	0.307	0.306	0.306	0.295	0.325	0.367	0.336	0.360
May		0.320	0.306	0.312	0.305	0.379	0.271	0.286	0.295	0.337	0.303	0.364	0.331	0.318	0.322	0.312	0.264	0.298	0.344	0.314	0.314
June		0.353	0.304	0.363	0.334	0.449	0.265	0.321	0.357	0.353	0.299	0.366	0.369	0.384	0.365	0.347	0.268	0.305	0.356	0.305	0.296
July	0.369	0.455	0.335	0.448	0.373	0.545	0.294	0.407	0.421	0.430	0.305	0.373	0.402	0.444	0.521	0.399	0.288	0.324	0.620	0.334	
August	0.485	0.641	0.473	0.658	0.546	0.743	0.555	0.605	0.577	0.583	0.429	0.625	0.641	0.658	0.742	0.727	0.380	0.543	1.098	0.548	
September	0.749	0.803	0.684	0.858	0.795	0.905	0.884	1.012	0.972	0.644	0.810	1.031	1.050	0.849	0.899	1.184	0.806	1.226	1.261	1.273	
October	0.730	0.692	0.705	0.725	0.882	0.747	0.861	0.871	1.005	0.716	1.027	0.981	0.867	0.659	0.637	0.964	1.053	1.205	0.858	1.318	
November	0.570	0.511	0.526	0.505	0.619	0.550	0.558	0.528	0.690	0.530	0.647	0.619	0.544	0.425	0.432	0.566	0.738	0.696	0.427	0.696	
December	0.389	0.350	0.372	0.344	0.414	0.390	0.383	0.333	0.444	0.369	0.410	0.373	0.355	0.307	0.359	0.363	0.378	0.367	0.352	0.385	

Annexure E: Mean Monthly Leaf Area Index of Tharparkar

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.141	0.229	0.179	0.173	0.230	0.200	0.190	0.206	0.225	0.227	0.214	0.223	0.190	0.222	0.216	0.220	0.183	0.222	0.229	0.228
February		0.131	0.222	0.168	0.168	0.221	0.200	0.187	0.199	0.217	0.216	0.208	0.210	0.181	0.210	0.204	0.210	0.172	0.211	0.217	0.206
March		0.147	0.212	0.168	0.161	0.210	0.198	0.191	0.192	0.208	0.207	0.203	0.205	0.176	0.204	0.200	0.202	0.175	0.204	0.208	0.200
April		0.169	0.201	0.162	0.143	0.205	0.193	0.184	0.187	0.199	0.203	0.199	0.198	0.170	0.199	0.194	0.197	0.175	0.197	0.201	0.198
May		0.159	0.188	0.160	0.136	0.200	0.176	0.178	0.176	0.192	0.201	0.199	0.192	0.166	0.198	0.185	0.195	0.172	0.195	0.200	0.191
June		0.136	0.186	0.155	0.131	0.189	0.152	0.168	0.165	0.172	0.186	0.187	0.185	0.164	0.190	0.172	0.186	0.165	0.189	0.193	0.183
July	0.151	0.156	0.164	0.136	0.126	0.198	0.132	0.154	0.145	0.153	0.166	0.173	0.163	0.132	0.154	0.170	0.169	0.143	0.174	0.195	
August	0.146	0.369	0.172	0.170	0.191	0.313	0.188	0.222	0.271	0.197	0.176	0.317	0.156	0.154	0.180	0.369	0.173	0.171	0.205	0.244	
September	0.178	0.568	0.192	0.214	0.463	0.488	0.307	0.444	0.602	0.395	0.290	0.431	0.234	0.249	0.400	0.629	0.214	0.469	0.398	0.385	
October	0.177	0.425	0.202	0.272	0.474	0.394	0.289	0.379	0.607	0.528	0.448	0.389	0.248	0.348	0.406	0.475	0.206	0.582	0.467	0.651	
November	0.152	0.291	0.215	0.221	0.328	0.279	0.223	0.247	0.357	0.372	0.312	0.371	0.209	0.320	0.303	0.306	0.199	0.382	0.337	0.434	
December	0.144	0.241	0.195	0.183	0.255	0.219	0.199	0.208	0.244	0.269	0.242	0.271	0.193	0.242	0.242	0.235	0.189	0.249	0.268	0.269	

Annexure E: Mean Monthly Leaf Area Index of Thatta

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.317	0.310	0.323	0.300	0.347	0.332	0.345	0.366	0.345	0.342	0.340	0.331	0.337	0.351	0.376	0.362	0.342	0.364	0.370	0.404
February		0.333	0.363	0.344	0.347	0.402	0.369	0.387	0.409	0.398	0.371	0.384	0.366	0.393	0.400	0.420	0.396	0.390	0.424	0.417	0.444
March		0.327	0.380	0.356	0.366	0.421	0.368	0.374	0.379	0.412	0.351	0.395	0.385	0.368	0.369	0.375	0.377	0.393	0.406	0.403	0.413
April		0.320	0.349	0.339	0.347	0.406	0.333	0.350	0.344	0.366	0.327	0.372	0.366	0.316	0.327	0.332	0.333	0.354	0.372	0.352	0.379
May		0.300	0.300	0.320	0.309	0.366	0.294	0.317	0.319	0.339	0.309	0.353	0.331	0.300	0.307	0.307	0.298	0.334	0.359	0.331	0.340
June		0.260	0.251	0.300	0.261	0.327	0.236	0.287	0.316	0.275	0.258	0.308	0.306	0.310	0.311	0.282	0.256	0.307	0.352	0.284	0.311
July	0.202	0.266	0.209	0.252	0.240	0.285	0.194	0.271	0.308	0.258	0.220	0.268	0.289	0.261	0.292	0.257	0.209	0.274	0.466	0.277	
August	0.243	0.337	0.258	0.269	0.276	0.367	0.287	0.334	0.403	0.349	0.247	0.323	0.348	0.320	0.317	0.337	0.216	0.293	0.544	0.300	
September	0.413	0.447	0.367	0.418	0.482	0.567	0.469	0.570	0.554	0.480	0.388	0.509	0.485	0.431	0.443	0.592	0.347	0.570	0.611	0.569	
October	0.456	0.476	0.445	0.477	0.551	0.542	0.519	0.585	0.586	0.592	0.545	0.514	0.460	0.420	0.408	0.554	0.462	0.594	0.547	0.630	
November	0.401	0.412	0.426	0.415	0.457	0.442	0.427	0.438	0.457	0.483	0.438	0.422	0.376	0.346	0.357	0.417	0.402	0.452	0.401	0.477	
December	0.318	0.326	0.337	0.320	0.375	0.360	0.337	0.337	0.357	0.364	0.353	0.348	0.325	0.306	0.339	0.327	0.332	0.353	0.365	0.372	

Annexure E: Mean Monthly Leaf Area Index of Umerkot

Unit: m^2/m^2

Mon/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
January		0.220	0.351	0.309	0.274	0.372	0.321	0.291	0.342	0.353	0.315	0.370	0.343	0.339	0.396	0.400	0.378	0.273	0.360	0.387	0.447
February		0.236	0.402	0.311	0.311	0.411	0.363	0.334	0.367	0.402	0.362	0.417	0.387	0.390	0.440	0.424	0.406	0.283	0.419	0.441	0.444
March		0.213	0.342	0.271	0.257	0.351	0.312	0.270	0.285	0.363	0.327	0.342	0.330	0.283	0.341	0.312	0.300	0.238	0.345	0.349	0.304
April		0.193	0.243	0.206	0.177	0.268	0.225	0.202	0.205	0.250	0.242	0.241	0.227	0.181	0.229	0.210	0.210	0.191	0.229	0.229	0.221
May		0.179	0.210	0.187	0.158	0.233	0.187	0.184	0.186	0.209	0.215	0.224	0.204	0.169	0.218	0.193	0.198	0.193	0.214	0.225	0.210
June		0.175	0.217	0.197	0.159	0.232	0.169	0.198	0.199	0.200	0.216	0.251	0.219	0.211	0.239	0.222	0.200	0.225	0.242	0.255	0.213
July	0.179	0.221	0.227	0.204	0.171	0.307	0.171	0.224	0.235	0.217	0.238	0.265	0.234	0.228	0.246	0.286	0.231	0.217	0.277	0.283	
August	0.184	0.494	0.247	0.274	0.294	0.416	0.271	0.312	0.428	0.273	0.260	0.334	0.275	0.286	0.307	0.480	0.307	0.310	0.365	0.339	
September	0.235	0.732	0.292	0.344	0.524	0.541	0.400	0.532	0.677	0.438	0.359	0.448	0.390	0.432	0.540	0.649	0.377	0.620	0.528	0.467	
October	0.232	0.563	0.342	0.370	0.573	0.416	0.380	0.469	0.631	0.502	0.558	0.447	0.375	0.515	0.484	0.488	0.329	0.605	0.506	0.612	
November	0.205	0.410	0.345	0.295	0.425	0.309	0.301	0.318	0.422	0.374	0.424	0.353	0.281	0.393	0.333	0.323	0.273	0.384	0.324	0.405	
December	0.191	0.326	0.292	0.240	0.347	0.300	0.254	0.274	0.330	0.302	0.345	0.303	0.256	0.305	0.318	0.294	0.256	0.295	0.311	0.347	

ANNEXURE-F

STATISTICAL APPROACH FOR WET & DRY YEARS

ANNEX F

STATISTICAL APPROACH

Dry and wet years threshold were established using the basic information available regarding number of drought years in Tharparkar district. Tharparkar district experienced 16 drought years from 1968 to 2015 (from National Drought Plan for Pakistan).

The same information has been used to iteratively determine the threshold for dry year i.e., determining the rainfall annual amount which produces 16 dry years for 1968-2015 in Tharparkar District.

Iterative process indicated that annual rainfall below 185 mm in Tharparkar District produces 16 dry years during 1968-2015. 185 mm corresponds to annual rainfall which is equal to half standard deviation less than the annual average rainfall of the district (i.e., $\mu - 0.5\sigma$; where μ is the annual average rainfall for Tharparkar District and σ is the standard deviation of annual rainfall of Tharparkar district). To be consistence with dry year threshold, wet year threshold was defined as $\mu + 0.5\sigma$.

For the other 23 districts thresholds for dry and wet years were assumed to be at $\mu - 0.5\sigma$ and $\mu + 0.5\sigma$ using each district's average annual rainfall and standard deviation of average rainfall.
Dry and wet threshold analysis above indicates that for any district a year having rainfall between $\mu - 0.5\sigma$ and $\mu + 0.5\sigma$ is a normal year. In statistical terms, this range contain 40% of the data i.e., it translates to roughly 4 normal years in a decade.

Table below shows the dry and wet year thresholds for each district based on the 74 years of annual rainfall data within the districts.

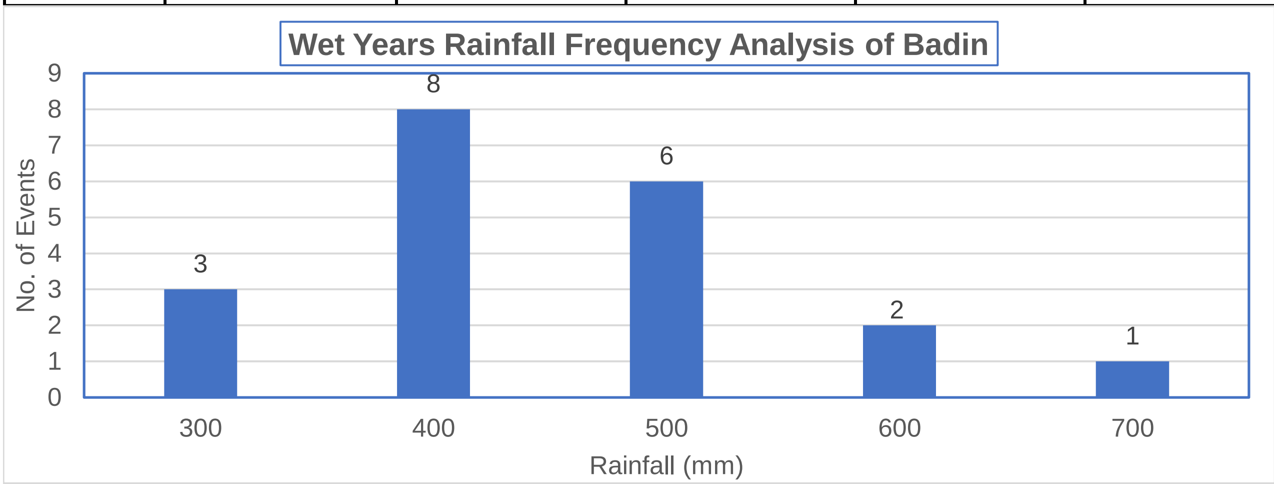
District	Dry Threshold (mm/yr)	Wet Threshold (mm/yr)
Badin	137	278
Dadu	93	181
Ghotki	76	167
Hyderabad	100	213
Jacobabad	78	161
Jamshoro	92	194
Karachi City	105	227
Kashmore	82	167
Khairpur	77	167
Larkana	75	161
Matiari	91	200
Mirpur Khas	124	250
Naushahro Feroze	78	166
Qambar Shahdadkot	92	175
Sanghar	99	203
Shaheed Benazirabad	79	169
Shikarpur	72	158
Sujawal	130	269
Sukkur	67	159
Tando Allah Yar	103	215
Tando Muhammad Khan	115	241
Tharparkar	185	331
Thatta	113	241
Umerkot	130	253

ANNEXURE-G

RAINFALL PROBABILITIES FOR WET YEARS

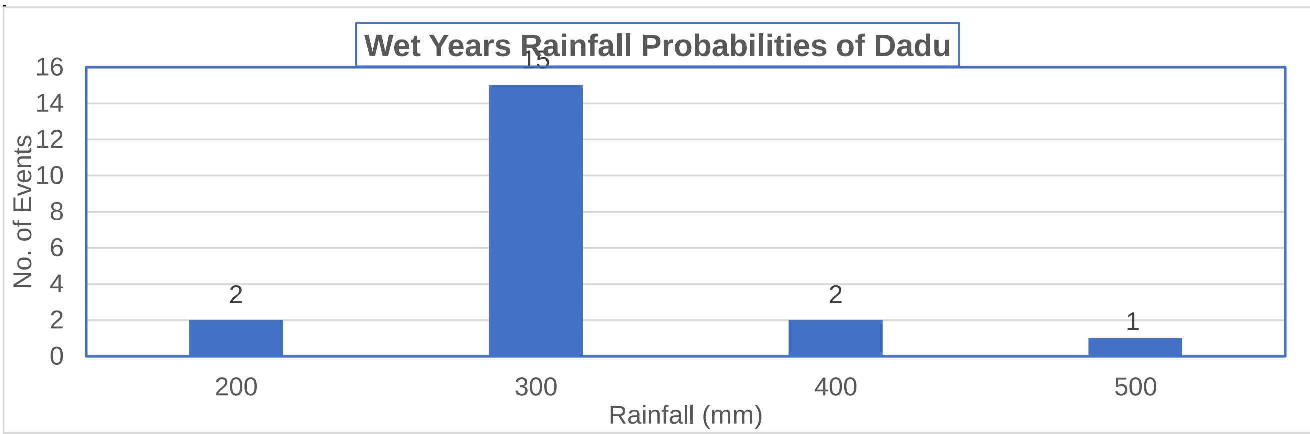
Annexure G   Wet Years Rainfall Probabilties of Badin

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1956	416	0.10	0.40	0.64	0.92
1959	378	0.14	0.53	0.78	0.98
1961	404	0.11	0.44	0.69	0.94
1967	436	0.08	0.34	0.57	0.88
1970	338	0.19	0.65	0.88	0.99
1976	353	0.17	0.61	0.84	0.99
1978	347	0.18	0.63	0.86	0.99
1983	302	0.25	0.76	0.94	1.00
1988	296	0.26	0.77	0.95	1.00
1992	288	0.27	0.79	0.96	1.00
1994	297	0.25	0.77	0.95	1.00
2003	359	0.16	0.59	0.83	0.99
2006	460	0.06	0.27	0.47	0.80
2007	342	0.18	0.64	0.87	0.99
2015	408	0.11	0.43	0.67	0.94
2016	323	0.21	0.70	0.91	1.00
2017	542	0.03	0.12	0.23	0.48
2019	506	0.04	0.18	0.32	0.62
2020	728	0.01	0.03	0.07	0.16
2021	414	0.10	0.41	0.65	0.93
No.	20	20	20	20	20
Min	288	0.01	0.03	0.07	0.16
Max	728	0.27	0.79	0.96	1.00
Average	397	0.14	0.50	0.70	0.88
STD	105	0.08	0.23	0.26	0.22



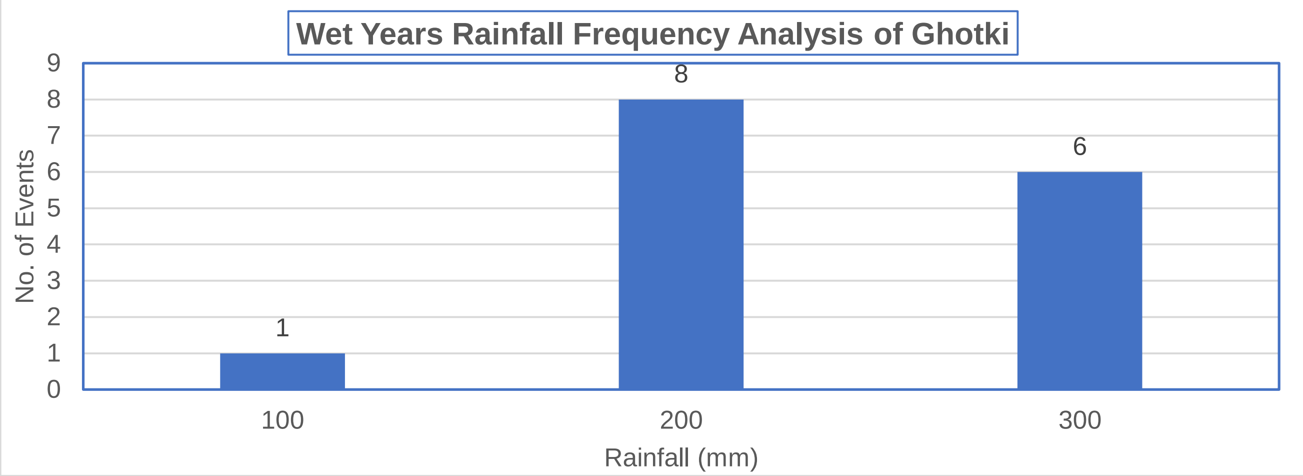
Annexure G   Wet Years Rainfall Probabilties of Dadu

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	192	0.26	0.79	0.95	1.00
1953	192	0.26	0.79	0.95	1.00
1956	255	0.12	0.46	0.71	0.95
1959	230	0.17	0.60	0.84	0.99
1961	271	0.09	0.38	0.62	0.91
1967	337	0.04	0.17	0.30	0.60
1970	212	0.21	0.69	0.91	1.00
1975	212	0.21	0.69	0.90	1.00
1976	225	0.18	0.62	0.86	0.99
1978	293	0.07	0.29	0.49	0.82
1992	211	0.21	0.70	0.91	1.00
1994	271	0.09	0.38	0.61	0.91
1997	211	0.21	0.70	0.91	1.00
2003	239	0.15	0.55	0.79	0.98
2007	201	0.24	0.74	0.93	1.00
2015	274	0.09	0.37	0.60	0.90
2016	209	0.22	0.71	0.91	1.00
2017	247	0.13	0.51	0.76	0.97
2019	374	0.02	0.10	0.19	0.40
2020	407	0.01	0.05	0.10	0.22
No.	20	20	20	20	20
Min	192	0.01	0.05	0.10	0.22
Max	407	0.26	0.79	0.95	1.00
Average	253	0.15	0.51	0.71	0.88
STD	60	0.08	0.23	0.26	0.22



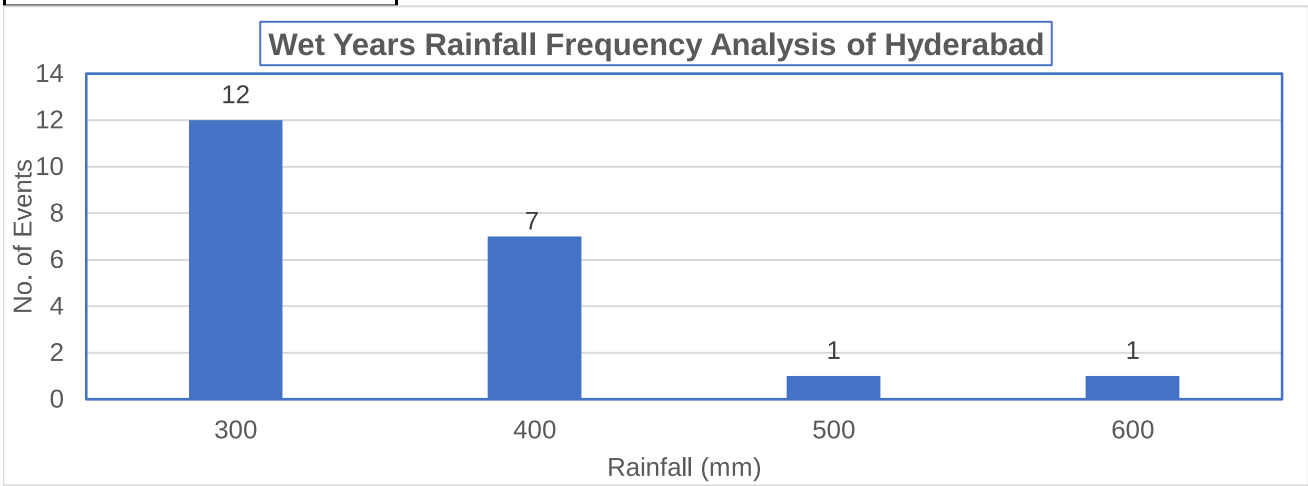
Annexure G   Wet Years Rainfall Probabilties of Ghotki

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	286	0.09	0.39	0.63	0.91
1967	214	0.17	0.60	0.84	0.99
1975	291	0.09	0.37	0.61	0.90
1978	328	0.05	0.24	0.42	0.75
1989	179	0.22	0.70	0.91	1.00
1994	342	0.04	0.18	0.32	0.62
1997	230	0.15	0.55	0.80	0.98
2003	257	0.12	0.47	0.72	0.96
2010	216	0.16	0.59	0.84	0.99
2015	341	0.04	0.18	0.33	0.64
2016	236	0.14	0.53	0.78	0.98
2017	308	0.07	0.32	0.53	0.85
2019	353	0.03	0.13	0.25	0.51
2020	356	0.03	0.12	0.22	0.47
2021	224	0.15	0.57	0.81	0.99
No.	15	15	15	15	15
Min	179	0.03	0.12	0.22	0.47
Max	356	0.22	0.70	0.91	1.00
Average	277	0.10	0.40	0.60	0.84
STD	59	0.06	0.19	0.24	0.19



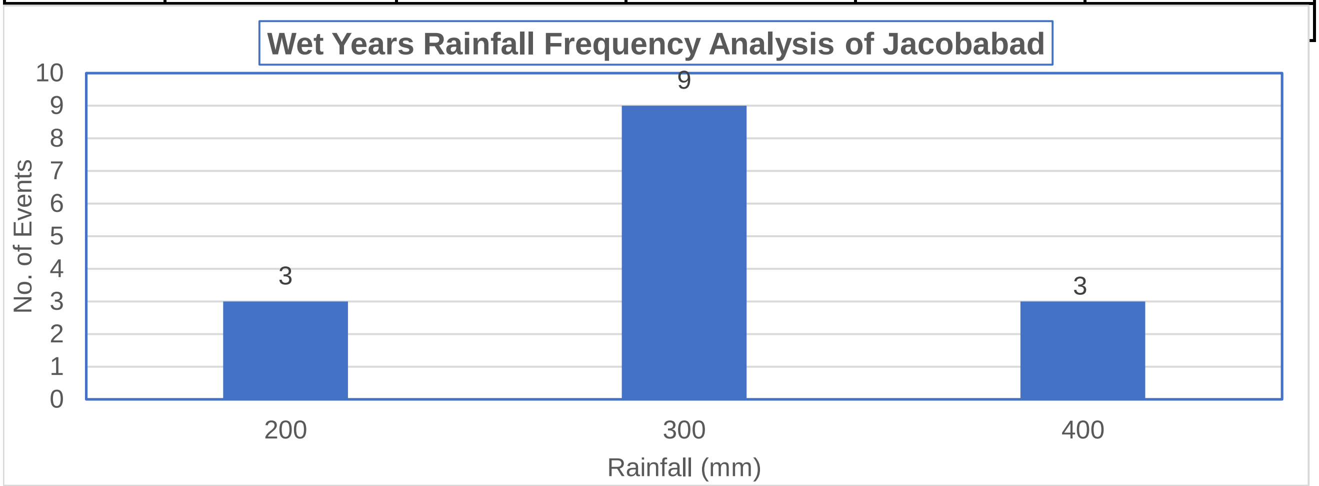
Annexure G Wet Years Rainfall Probabilties of Hyderabad

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	217	0.28	0.81	0.96	1.00
1956	376	0.05	0.23	0.40	0.72
1959	272	0.18	0.62	0.86	0.99
1961	316	0.11	0.44	0.69	0.95
1967	397	0.04	0.17	0.31	0.61
1970	263	0.19	0.66	0.88	1.00
1976	314	0.11	0.45	0.70	0.95
1978	339	0.08	0.35	0.58	0.88
1983	254	0.21	0.69	0.90	1.00
1988	242	0.23	0.73	0.93	1.00
1992	248	0.22	0.71	0.92	1.00
1994	297	0.14	0.52	0.77	0.97
2003	298	0.13	0.52	0.77	0.97
2006	315	0.11	0.45	0.69	0.95
2007	250	0.22	0.71	0.91	1.00
2015	257	0.20	0.68	0.90	1.00
2016	247	0.22	0.72	0.92	1.00
2017	340	0.08	0.35	0.57	0.88
2019	411	0.03	0.14	0.26	0.53
2020	556	0.01	0.03	0.07	0.16
2021	244	0.23	0.73	0.93	1.00
No.	21	21.00	21.00	21.00	21.00
Min	217	0.01	0.03	0.07	0.16
Max	556	0.28	0.81	0.96	1.00
Average	307	0.15	0.51	0.71	0.88
STD	78	0.08	0.23	0.26	0.21



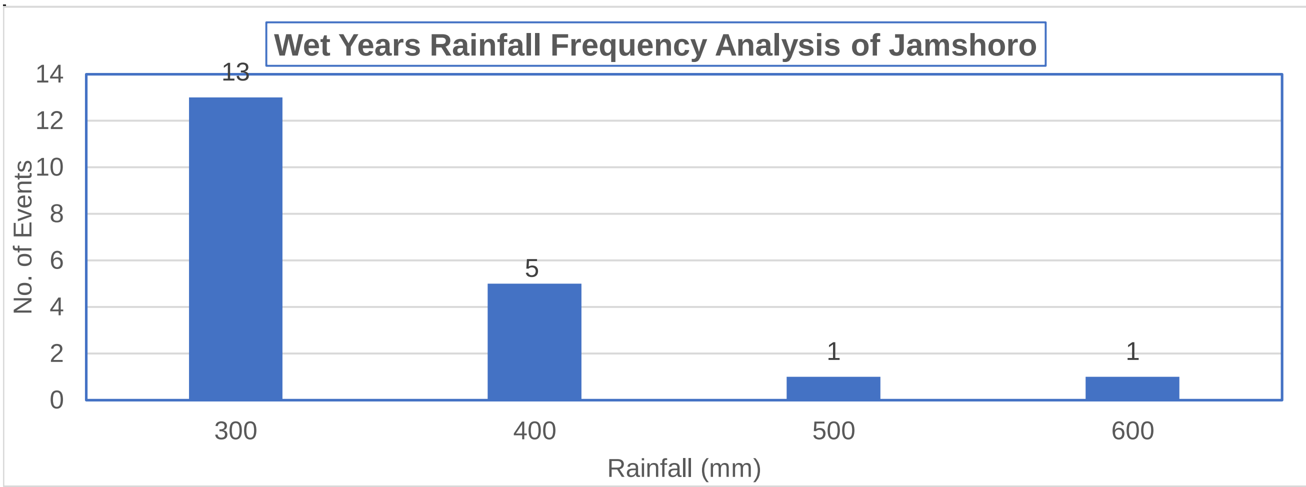
Annexure G Wet Years Rainfall Probabilties of Jacobabad

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	280	0.07	0.30	0.50	0.83
1956	189	0.19	0.64	0.87	0.99
1967	255	0.10	0.42	0.66	0.93
1975	286	0.06	0.27	0.47	0.79
1976	174	0.22	0.70	0.91	1.00
1978	329	0.03	0.12	0.23	0.47
1985	185	0.19	0.66	0.88	1.00
1989	219	0.15	0.55	0.80	0.98
1994	375	0.01	0.04	0.07	0.17
1997	260	0.10	0.39	0.63	0.92
2003	253	0.10	0.42	0.67	0.94
2010	220	0.15	0.55	0.80	0.98
2015	256	0.10	0.41	0.65	0.93
2019	313	0.04	0.17	0.30	0.60
2020	265	0.09	0.37	0.60	0.90
No.	15	15.00	15.00	15.00	15.00
Min	174	0.01	0.04	0.07	0.17
Max	375	0.22	0.70	0.91	1.00
Average	257	0.11	0.40	0.60	0.83
STD	56	0.06	0.20	0.25	0.24



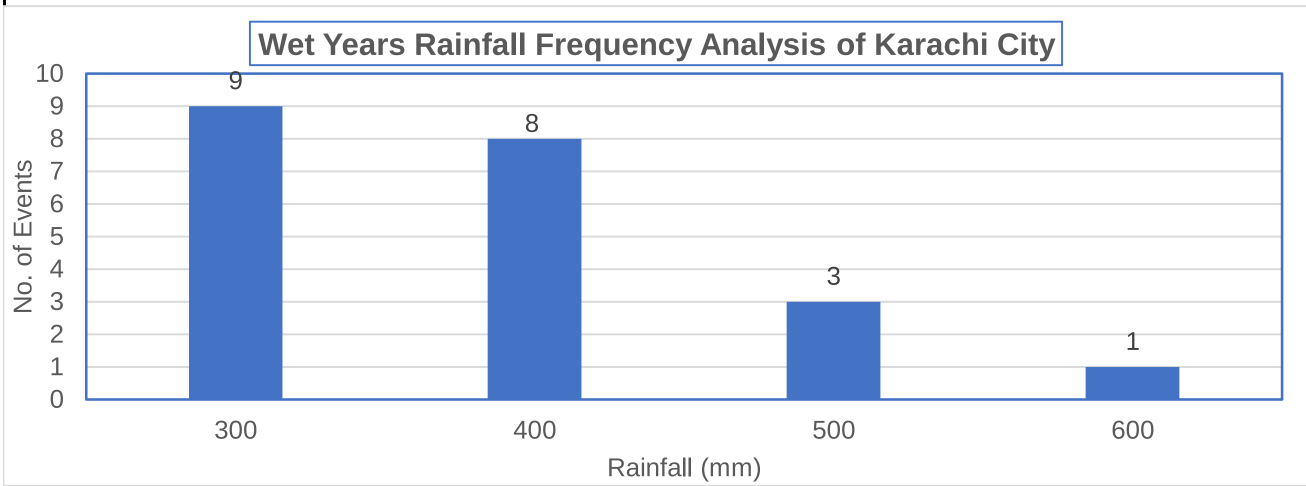
Annexure G Wet Years Rainfall Probabilties of Jamshoro

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	204	0.26	0.77	0.95	1.00
1956	320	0.07	0.31	0.52	0.84
1959	248	0.16	0.59	0.83	0.99
1961	311	0.08	0.34	0.56	0.87
1967	407	0.02	0.12	0.22	0.47
1970	226	0.21	0.69	0.90	1.00
1976	268	0.13	0.51	0.76	0.97
1977	220	0.22	0.71	0.92	1.00
1978	329	0.06	0.28	0.48	0.81
1992	203	0.26	0.77	0.95	1.00
1994	259	0.15	0.54	0.79	0.98
2003	254	0.15	0.57	0.81	0.98
2006	208	0.25	0.76	0.94	1.00
2007	223	0.21	0.70	0.91	1.00
2015	252	0.16	0.58	0.82	0.99
2016	239	0.18	0.64	0.87	0.99
2017	306	0.08	0.35	0.58	0.89
2019	382	0.03	0.16	0.29	0.57
2020	501	0.01	0.03	0.07	0.16
2021	247	0.17	0.60	0.84	0.99
No.	20	20.00	20.00	20.00	20.00
Min	203	0.01	0.03	0.07	0.16
Max	501	0.26	0.77	0.95	1.00
Average	280	0.14	0.50	0.70	0.87
STD	77	0.08	0.23	0.26	0.22



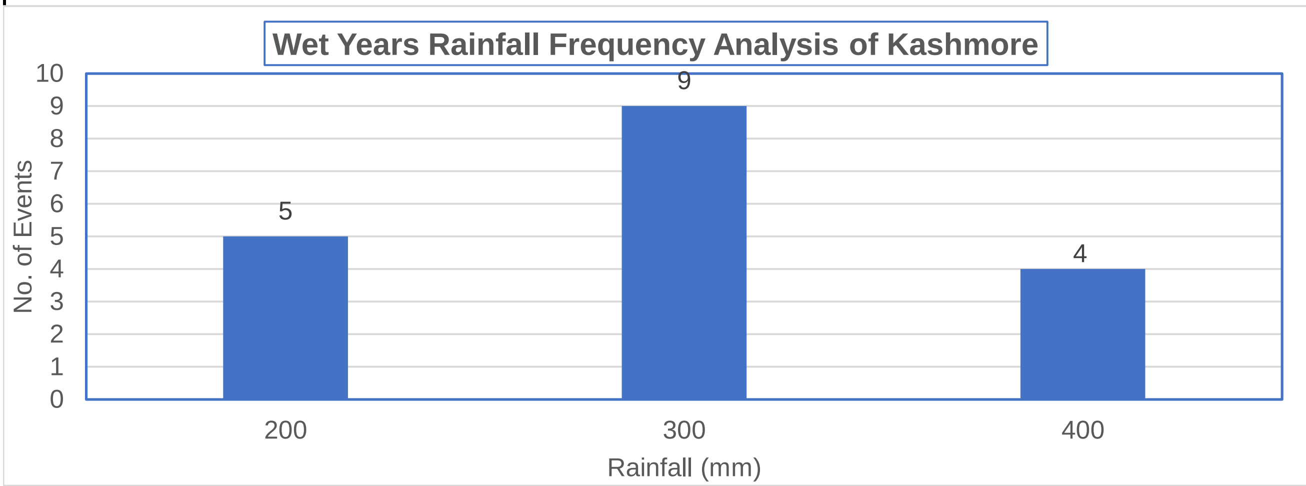
Annexure G   Wet Years Rainfall Probabilties of Karachi City

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	228	0.27	0.79	0.96	1.00
1954	232	0.26	0.78	0.95	1.00
1956	346	0.10	0.42	0.66	0.93
1959	314	0.14	0.52	0.77	0.97
1961	465	0.03	0.14	0.26	0.53
1967	472	0.03	0.13	0.25	0.51
1970	254	0.22	0.71	0.92	1.00
1976	306	0.15	0.55	0.80	0.98
1977	360	0.09	0.38	0.61	0.91
1978	363	0.09	0.37	0.60	0.90
1979	265	0.20	0.68	0.90	1.00
1994	361	0.09	0.37	0.61	0.90
2003	247	0.23	0.74	0.93	1.00
2007	267	0.20	0.67	0.89	1.00
2009	233	0.26	0.78	0.95	1.00
2015	228	0.27	0.79	0.96	1.00
2016	241	0.24	0.75	0.94	1.00
2017	348	0.10	0.41	0.66	0.93
2019	403	0.06	0.26	0.45	0.77
2020	599	0.01	0.03	0.07	0.16
2021	300	0.15	0.57	0.81	0.98
No.	21	21.00	21.00	21.00	21.00
Min	228	0.01	0.03	0.07	0.16
Max	599	0.27	0.79	0.96	1.00
Average	325	0.15	0.52	0.71	0.88
STD	97	0.09	0.24	0.27	0.22



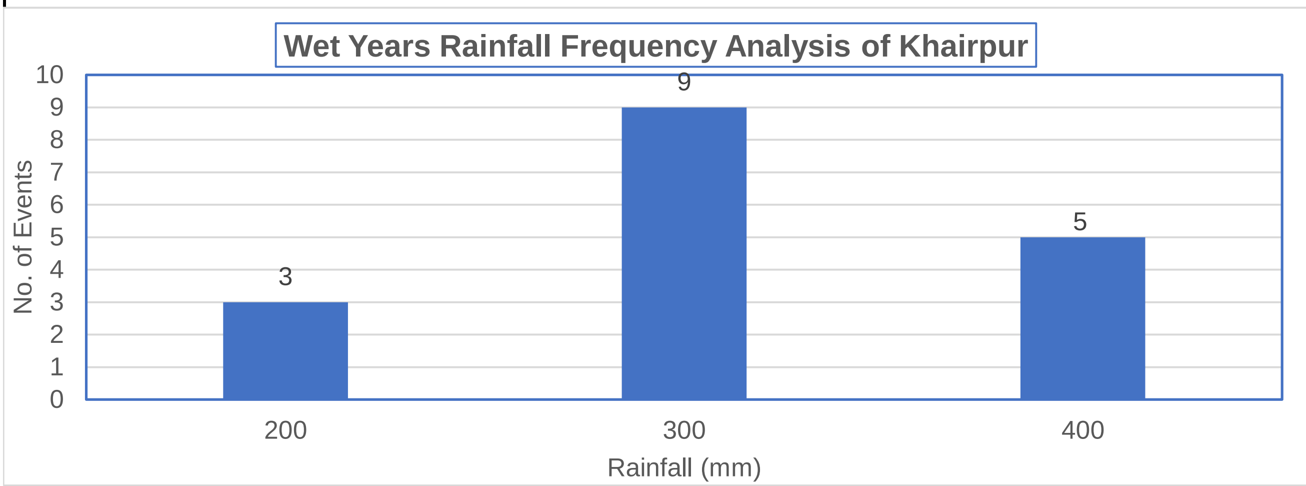
Annexure G   Wet Years Rainfall Probabilties of Kashmore

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	291	0.07	0.30	0.51	0.83
1956	186	0.22	0.71	0.91	1.00
1967	245	0.13	0.50	0.75	0.97
1975	303	0.05	0.24	0.43	0.75
1976	184	0.22	0.71	0.92	1.00
1978	334	0.03	0.13	0.24	0.49
1985	181	0.23	0.73	0.93	1.00
1989	211	0.17	0.62	0.85	0.99
1994	386	0.01	0.04	0.07	0.17
1997	258	0.11	0.45	0.69	0.95
2003	253	0.12	0.47	0.72	0.96
2010	256	0.11	0.46	0.70	0.95
2015	291	0.07	0.30	0.51	0.83
2016	199	0.19	0.66	0.88	1.00
2017	206	0.18	0.63	0.86	0.99
2019	305	0.05	0.24	0.42	0.74
2020	283	0.08	0.34	0.56	0.87
2021	190	0.21	0.69	0.91	1.00
No.	18	18.00	18.00	18.00	18.00
Min	181	0.01	0.04	0.07	0.17
Max	386	0.23	0.73	0.93	1.00
Average	253	0.13	0.46	0.66	0.86
STD	59	0.07	0.22	0.25	0.22



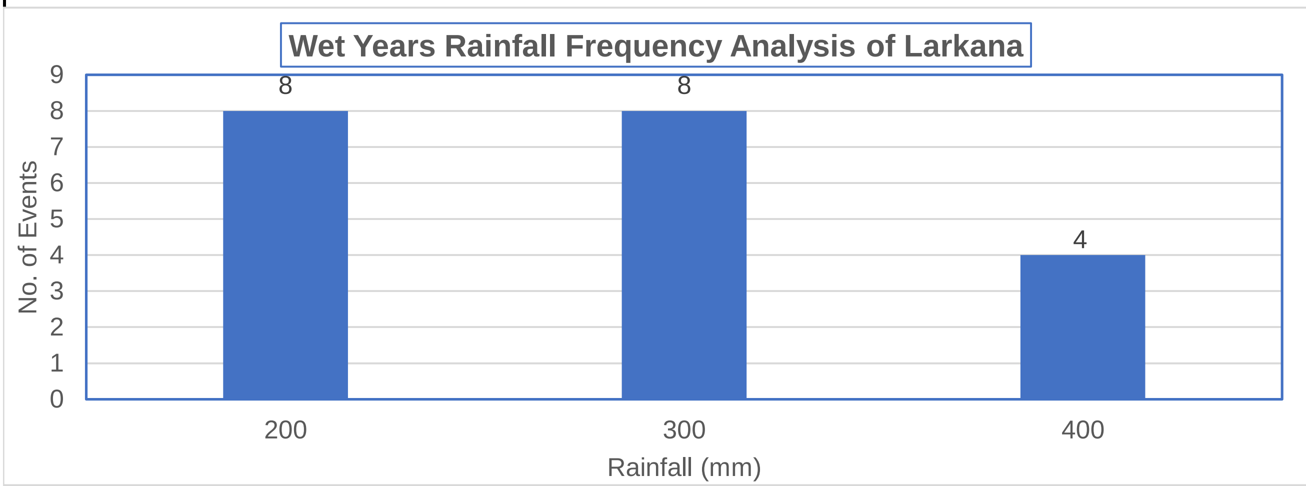
Annexure G Wet Years Rainfall Probabilties of Khairpur

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	257	0.12	0.46	0.71	0.95
1961	210	0.18	0.63	0.86	0.99
1967	241	0.14	0.52	0.77	0.97
1975	263	0.11	0.44	0.68	0.94
1978	340	0.04	0.18	0.33	0.63
1989	176	0.24	0.74	0.93	1.00
1994	337	0.04	0.19	0.35	0.66
1997	188	0.21	0.70	0.91	1.00
2003	283	0.09	0.37	0.60	0.90
2006	203	0.19	0.65	0.88	0.99
2010	191	0.21	0.69	0.90	1.00
2015	266	0.11	0.43	0.67	0.94
2016	254	0.12	0.47	0.72	0.96
2017	334	0.04	0.20	0.36	0.67
2019	350	0.03	0.15	0.27	0.54
2020	367	0.02	0.09	0.17	0.37
2021	223	0.16	0.58	0.82	0.99
No.	17	17.00	17.00	17.00	17.00
Min	176	0.02	0.09	0.17	0.37
Max	367	0.24	0.74	0.93	1.00
Average	264	0.12	0.44	0.64	0.85
STD	62	0.07	0.21	0.25	0.20



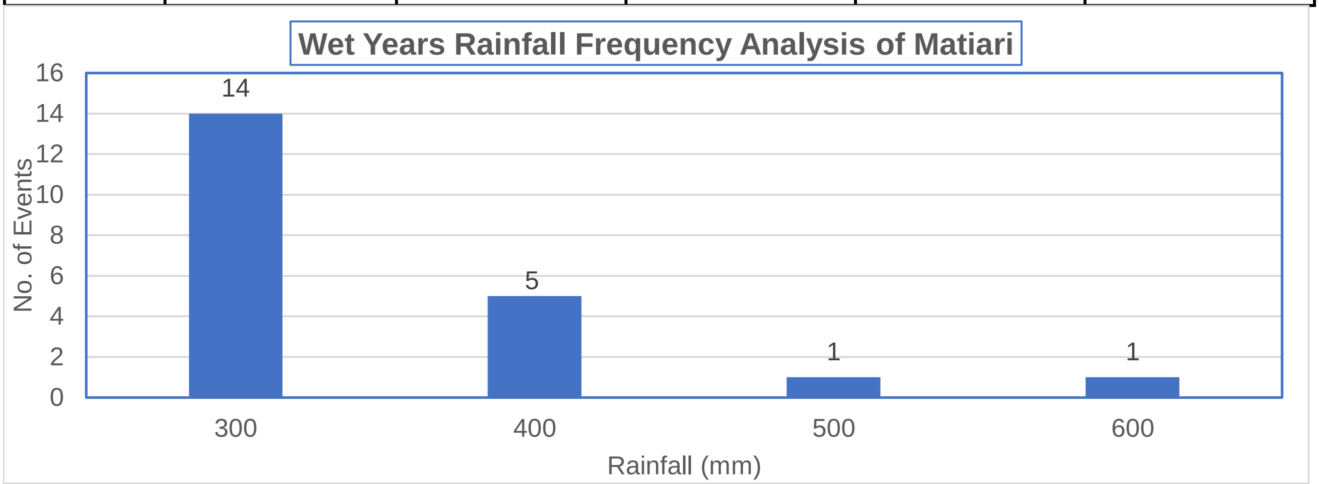
Annexure G Wet Years Rainfall Probabilties of Larkana

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	248	0.11	0.45	0.69	0.95
1959	162	0.27	0.79	0.96	1.00
1961	181	0.22	0.71	0.92	1.00
1967	271	0.08	0.36	0.59	0.89
1975	258	0.10	0.41	0.65	0.93
1976	161	0.27	0.79	0.96	1.00
1978	317	0.04	0.19	0.35	0.65
1985	168	0.25	0.77	0.95	1.00
1989	196	0.19	0.65	0.88	0.99
1994	354	0.02	0.08	0.16	0.35
1997	219	0.15	0.56	0.80	0.98
2003	248	0.11	0.45	0.69	0.95
2007	166	0.26	0.77	0.95	1.00
2010	180	0.22	0.71	0.92	1.00
2015	271	0.08	0.36	0.58	0.89
2016	188	0.21	0.68	0.90	1.00
2017	264	0.09	0.38	0.62	0.91
2019	323	0.04	0.17	0.31	0.61
2020	343	0.02	0.11	0.21	0.44
2021	203	0.18	0.62	0.86	0.99
No.	20	20	20	20	20
Min	161	0.02	0.08	0.16	0.35
Max	354	0.27	0.79	0.96	1.00
Average	236	0.15	0.50	0.70	0.88
STD	63	0.09	0.24	0.26	0.20



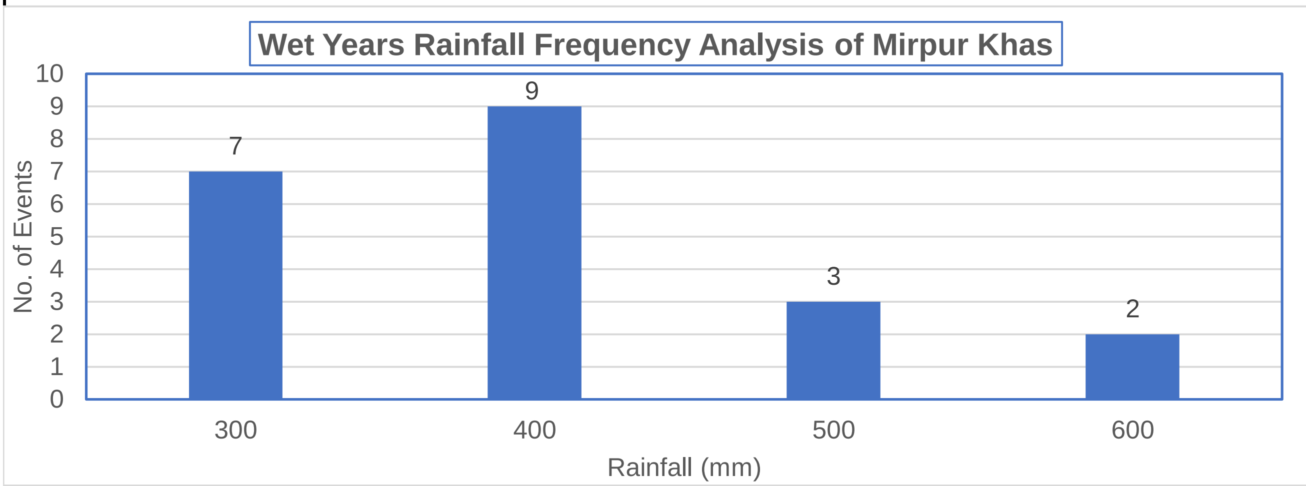
Annexure G Wet Years Rainfall Probabilties of Matiari

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	217	0.25	0.76	0.94	1.00
1956	318	0.08	0.35	0.58	0.89
1959	237	0.21	0.69	0.90	1.00
1961	280	0.13	0.51	0.76	0.97
1967	354	0.05	0.22	0.40	0.72
1970	233	0.22	0.70	0.91	1.00
1976	281	0.13	0.51	0.76	0.97
1978	341	0.06	0.26	0.46	0.78
1983	236	0.21	0.69	0.91	1.00
1988	219	0.24	0.75	0.94	1.00
1992	211	0.26	0.78	0.95	1.00
1994	301	0.10	0.42	0.67	0.94
2003	293	0.11	0.46	0.70	0.95
2006	285	0.13	0.49	0.74	0.97
2007	219	0.24	0.75	0.94	1.00
2015	257	0.17	0.61	0.85	0.99
2016	246	0.19	0.65	0.88	0.99
2017	339	0.06	0.27	0.47	0.79
2019	411	0.02	0.11	0.21	0.44
2020	557	0.01	0.03	0.07	0.16
2021	240	0.20	0.68	0.90	1.00
No.	21	21.00	21.00	21.00	21.00
Min	211	0.01	0.03	0.07	0.16
Max	557	0.26	0.78	0.95	1.00
Average	289	0.15	0.51	0.71	0.88
STD	81	0.08	0.23	0.26	0.22



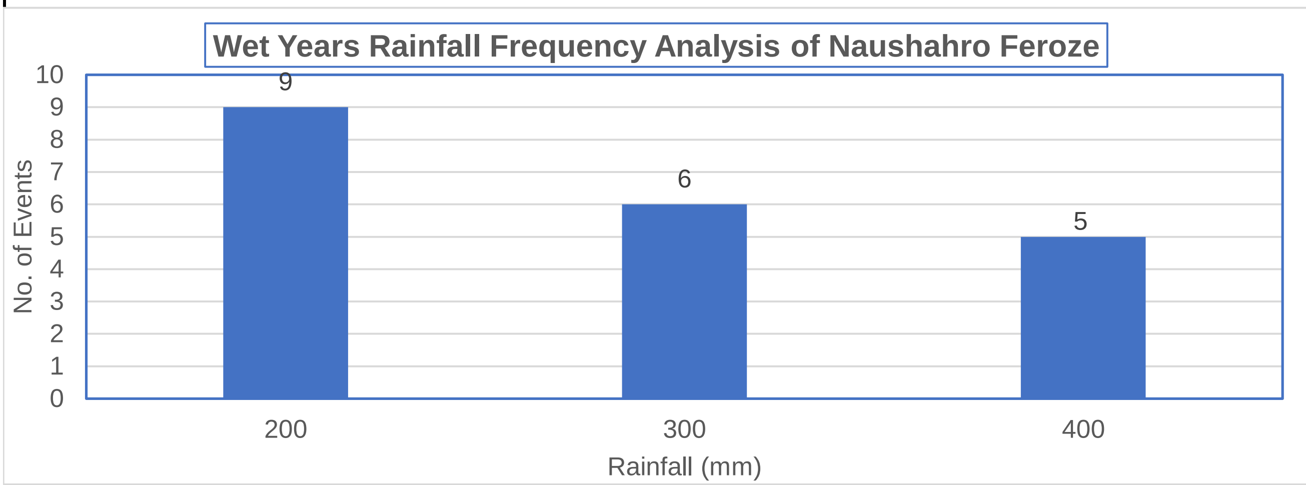
Annexure G Wet Years Rainfall Probabilties of Mirpur Khas

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1956	353	0.13	0.50	0.75	0.97
1959	313	0.18	0.64	0.87	0.99
1961	373	0.11	0.43	0.68	0.94
1967	340	0.15	0.55	0.79	0.98
1970	280	0.23	0.74	0.93	1.00
1975	259	0.27	0.80	0.96	1.00
1976	314	0.18	0.63	0.86	0.99
1978	364	0.12	0.46	0.71	0.96
1983	293	0.21	0.70	0.91	1.00
1988	271	0.25	0.76	0.94	1.00
1990	269	0.25	0.77	0.95	1.00
1994	256	0.28	0.80	0.96	1.00
2003	372	0.11	0.43	0.68	0.94
2006	455	0.04	0.20	0.36	0.67
2007	271	0.25	0.77	0.94	1.00
2015	408	0.07	0.32	0.53	0.85
2016	337	0.15	0.56	0.80	0.98
2017	501	0.02	0.11	0.22	0.46
2019	448	0.05	0.21	0.38	0.70
2020	558	0.01	0.04	0.09	0.20
2021	378	0.10	0.41	0.66	0.93
No.	21	21	21	21	21
Min	256	0.01	0.04	0.09	0.20
Max	558	0.28	0.80	0.96	1.00
Average	353	0.15	0.52	0.71	0.88
STD	83	0.09	0.23	0.26	0.21



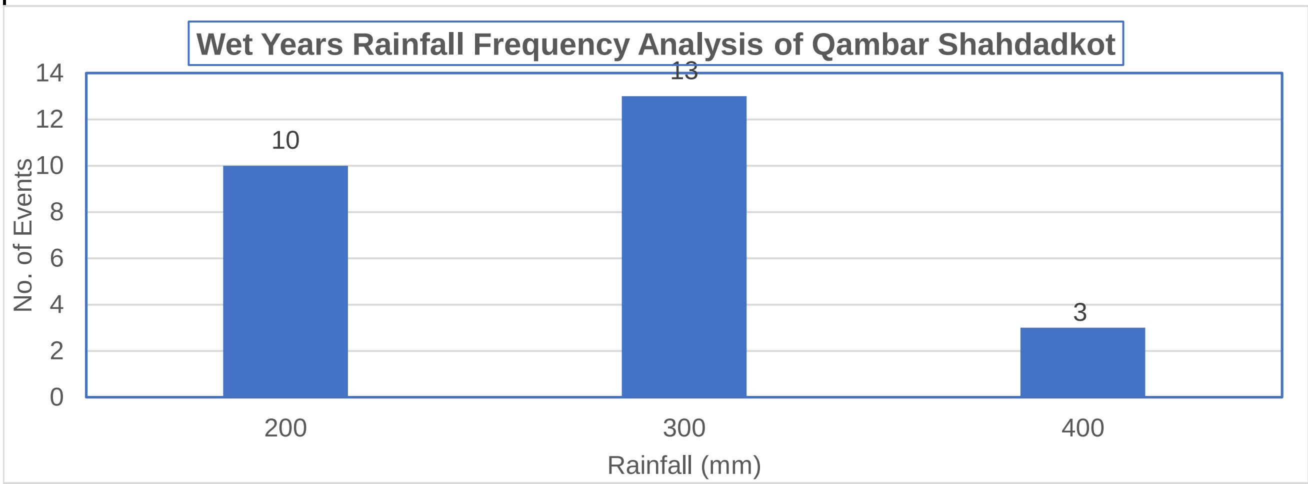
Annexure G   Wet Years Rainfall Probabilties of Naushahro Feroze

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	227	0.13	0.51	0.76	0.97
1956	171	0.26	0.77	0.95	1.00
1959	185	0.22	0.71	0.91	1.00
1961	214	0.15	0.57	0.81	0.98
1967	309	0.05	0.24	0.42	0.75
1975	233	0.12	0.48	0.73	0.96
1976	185	0.22	0.71	0.92	1.00
1978	321	0.04	0.20	0.37	0.68
1989	178	0.24	0.74	0.93	1.00
1994	317	0.05	0.22	0.39	0.71
1997	189	0.21	0.69	0.90	1.00
2003	248	0.10	0.42	0.67	0.94
2007	183	0.22	0.72	0.92	1.00
2010	169	0.26	0.78	0.95	1.00
2015	238	0.12	0.46	0.71	0.95
2016	199	0.18	0.64	0.87	0.99
2017	285	0.07	0.31	0.53	0.84
2019	355	0.02	0.11	0.21	0.45
2020	394	0.01	0.04	0.09	0.20
2021	189	0.21	0.69	0.90	1.00
No.	20	20	20	20	20
Min	169	0.01	0.04	0.09	0.20
Max	394	0.26	0.78	0.95	1.00
Average	240	0.14	0.50	0.70	0.87
STD	68	0.08	0.24	0.27	0.22



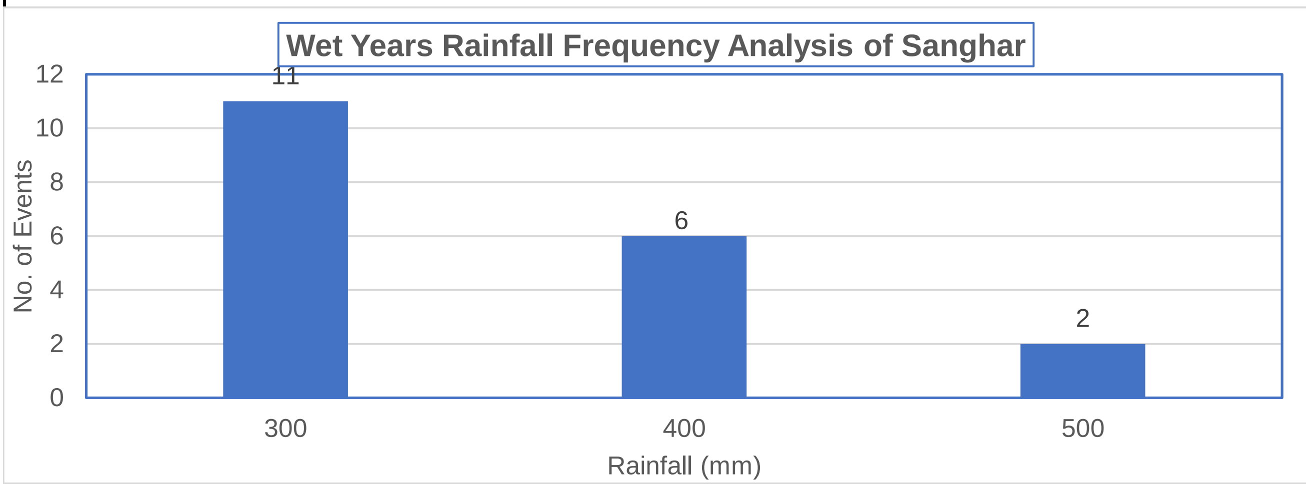
Annexure G   Wet Years Rainfall Probabilties of Qambar Shahdadkot

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	185	0.28	0.81	0.96	1.00
1949	216	0.19	0.66	0.88	1.00
1950	177	0.31	0.84	0.97	1.00
1953	179	0.30	0.83	0.97	1.00
1956	224	0.17	0.61	0.85	0.99
1959	207	0.22	0.70	0.91	1.00
1961	225	0.17	0.61	0.85	0.99
1967	278	0.08	0.33	0.55	0.86
1970	187	0.28	0.80	0.96	1.00
1975	245	0.13	0.49	0.74	0.97
1976	200	0.24	0.74	0.93	1.00
1978	294	0.06	0.26	0.46	0.78
1985	193	0.26	0.77	0.95	1.00
1986	187	0.28	0.80	0.96	1.00
1989	206	0.22	0.71	0.92	1.00
1992	213	0.20	0.68	0.90	1.00
1994	322	0.04	0.17	0.31	0.61
1997	236	0.15	0.54	0.79	0.98
2003	245	0.13	0.49	0.74	0.97
2007	178	0.30	0.83	0.97	1.00
2010	183	0.29	0.82	0.97	1.00
2015	272	0.08	0.35	0.58	0.89
2016	210	0.21	0.69	0.90	1.00
2017	199	0.24	0.75	0.94	1.00
2019	376	0.01	0.06	0.11	0.25
2020	340	0.03	0.13	0.24	0.49
No.	26	26	26	26	26
Min	177	0.01	0.06	0.11	0.25
Max	376	0.31	0.84	0.97	1.00
Average	230	0.19	0.60	0.78	0.91
STD	54	0.09	0.24	0.25	0.19



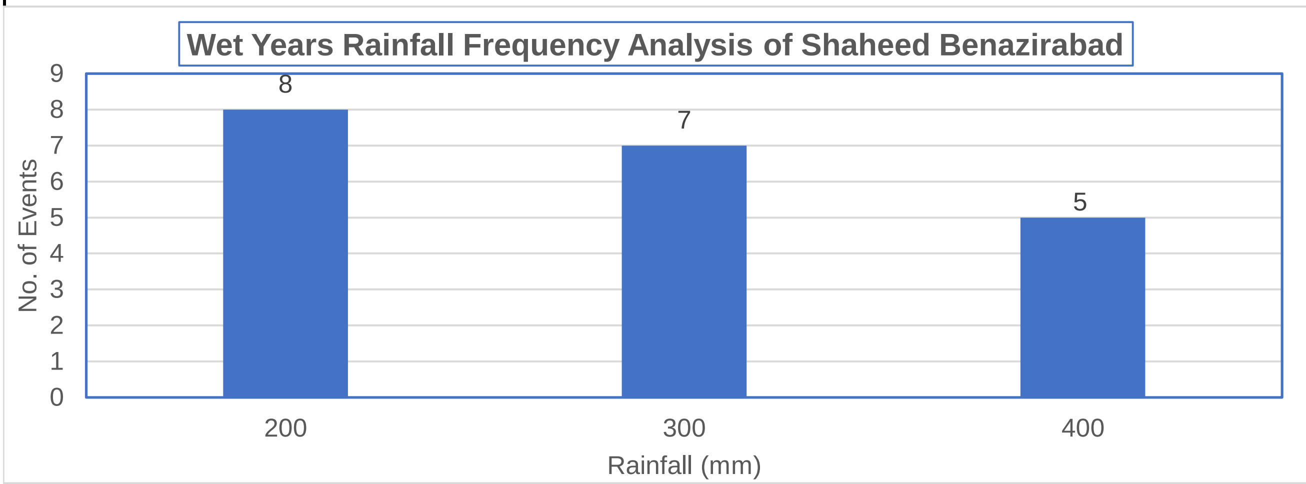
Annexure G Wet Years Rainfall Probabilties of Sanghar

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	225	0.24	0.74	0.93	1.00
1956	247	0.20	0.66	0.89	1.00
1959	225	0.24	0.74	0.93	1.00
1961	305	0.11	0.44	0.69	0.95
1967	262	0.17	0.61	0.84	0.99
1975	250	0.19	0.65	0.88	0.99
1976	234	0.22	0.71	0.92	1.00
1978	356	0.06	0.26	0.45	0.77
1983	240	0.21	0.69	0.90	1.00
1994	286	0.13	0.52	0.77	0.97
2003	334	0.08	0.33	0.55	0.87
2006	342	0.07	0.31	0.52	0.84
2010	231	0.22	0.72	0.92	1.00
2015	316	0.10	0.40	0.64	0.92
2016	295	0.12	0.48	0.73	0.96
2017	400	0.03	0.14	0.26	0.53
2019	393	0.03	0.15	0.29	0.57
2020	459	0.01	0.04	0.08	0.20
2021	287	0.13	0.51	0.76	0.97
No.	19	19	19	19	19
Min	225	0.01	0.04	0.08	0.20
Max	459	0.24	0.74	0.93	1.00
Average	299	0.13	0.48	0.68	0.87
STD	67	0.08	0.22	0.26	0.22



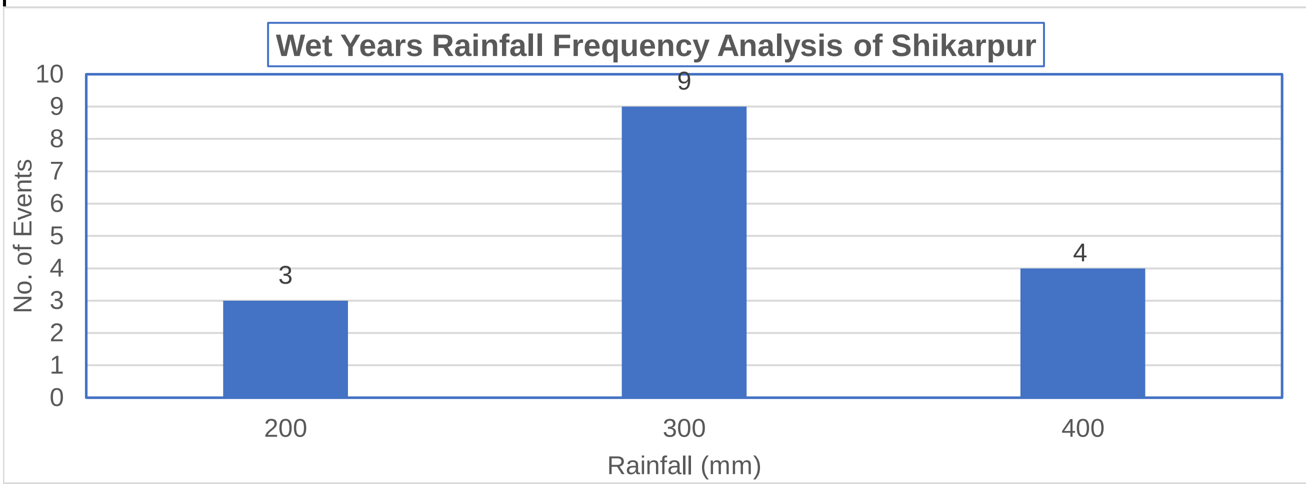
Annexure G   Wet Years Rainfall Probabilties of Shaheed Benazirabad

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	228	0.13	0.51	0.76	0.97
1956	197	0.20	0.67	0.89	1.00
1959	194	0.20	0.68	0.90	1.00
1961	223	0.14	0.53	0.78	0.98
1967	319	0.05	0.24	0.42	0.74
1970	178	0.25	0.76	0.94	1.00
1975	217	0.15	0.56	0.81	0.98
1976	207	0.17	0.62	0.85	0.99
1978	339	0.04	0.18	0.33	0.64
1983	173	0.26	0.79	0.95	1.00
1994	316	0.06	0.25	0.43	0.76
2003	265	0.09	0.38	0.62	0.91
2006	193	0.21	0.69	0.90	1.00
2007	188	0.22	0.71	0.92	1.00
2015	191	0.21	0.70	0.91	1.00
2016	203	0.18	0.64	0.87	0.99
2017	298	0.07	0.30	0.50	0.83
2019	372	0.02	0.10	0.18	0.39
2020	387	0.01	0.06	0.12	0.28
2021	191	0.21	0.70	0.91	1.00
No.	20	20	20	20	20
Min	173	0.01	0.06	0.12	0.28
Max	387	0.26	0.79	0.95	1.00
Average	244	0.14	0.50	0.70	0.87
STD	69	0.08	0.23	0.27	0.21



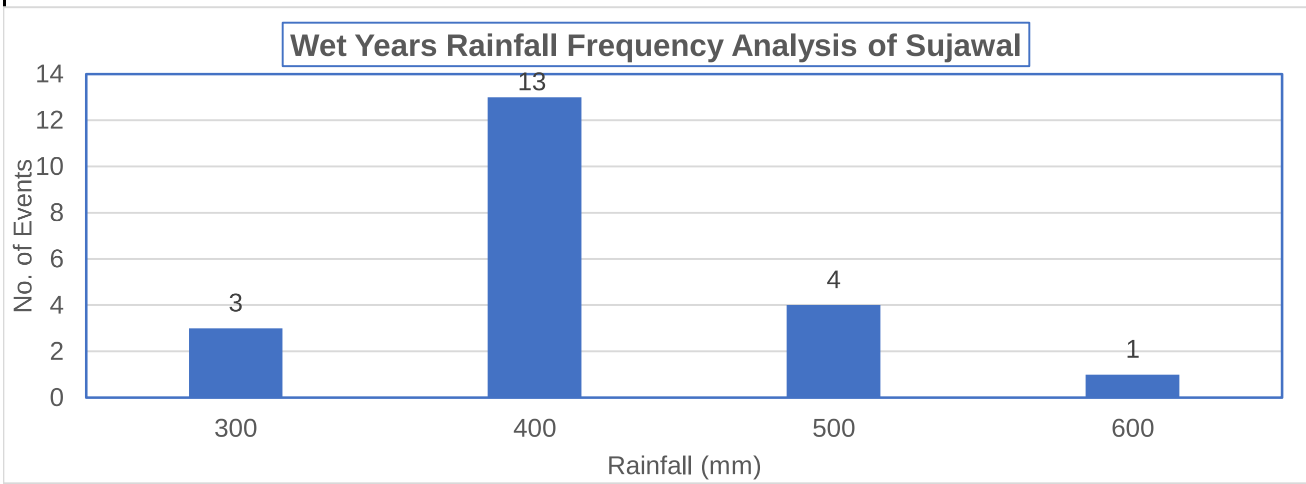
Annexure G   Wet Years Rainfall Probabilties of Shikarpur

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	276	0.08	0.34	0.56	0.87
1967	255	0.10	0.42	0.66	0.93
1975	278	0.08	0.33	0.55	0.86
1978	328	0.03	0.15	0.27	0.55
1985	173	0.22	0.71	0.91	1.00
1989	207	0.16	0.59	0.83	0.99
1994	374	0.01	0.04	0.08	0.20
1997	240	0.12	0.48	0.72	0.96
2003	251	0.11	0.44	0.68	0.94
2010	201	0.17	0.61	0.85	0.99
2015	266	0.09	0.38	0.61	0.91
2016	171	0.22	0.72	0.92	1.00
2017	222	0.14	0.54	0.79	0.98
2019	320	0.04	0.17	0.32	0.62
2020	317	0.04	0.18	0.33	0.64
2021	186	0.19	0.66	0.88	1.00
No.	16	16	16	16	16
Min	171	0.01	0.04	0.08	0.20
Max	374	0.22	0.72	0.92	1.00
Average	254	0.11	0.42	0.62	0.84
STD	60	0.07	0.21	0.26	0.23



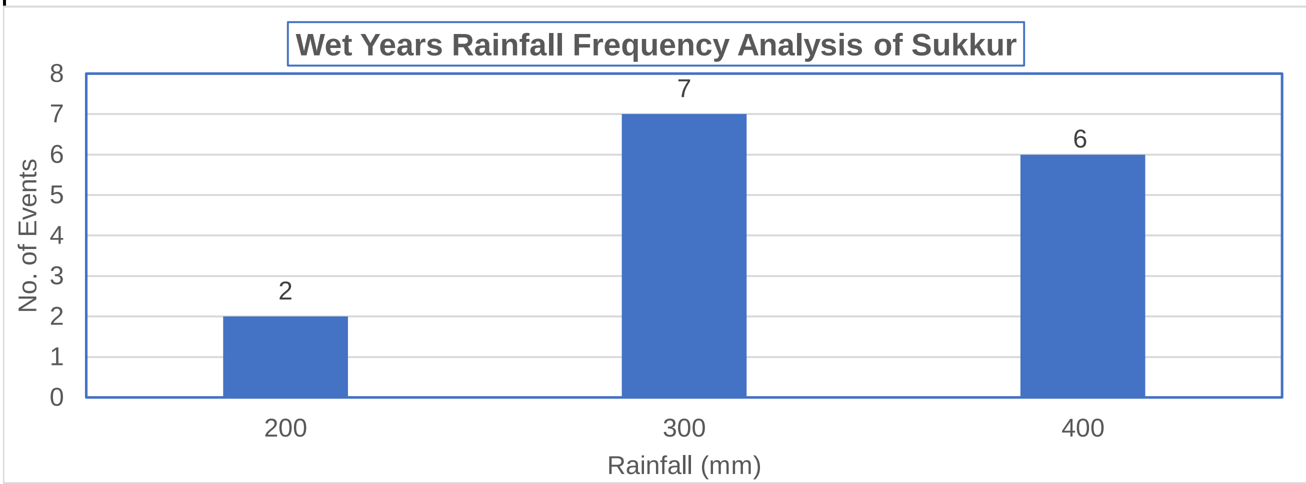
Annexure G Wet Years Rainfall Probabilties of Sujawal

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1956	384	0.11	0.44	0.69	0.95
1959	356	0.14	0.54	0.79	0.98
1961	445	0.06	0.28	0.48	0.80
1967	497	0.04	0.18	0.32	0.62
1970	317	0.20	0.68	0.90	1.00
1976	319	0.20	0.67	0.89	1.00
1977	318	0.20	0.67	0.89	1.00
1978	312	0.21	0.69	0.91	1.00
1979	275	0.28	0.80	0.96	1.00
1992	278	0.27	0.79	0.96	1.00
1994	295	0.24	0.75	0.94	1.00
2003	308	0.22	0.71	0.91	1.00
2006	354	0.15	0.54	0.79	0.98
2007	356	0.14	0.54	0.79	0.98
2009	302	0.23	0.73	0.93	1.00
2010	303	0.23	0.72	0.92	1.00
2015	371	0.12	0.49	0.74	0.96
2016	301	0.23	0.73	0.93	1.00
2017	505	0.03	0.16	0.30	0.59
2019	495	0.04	0.18	0.33	0.63
2020	753	0.01	0.03	0.07	0.16
2021	402	0.09	0.39	0.62	0.91
No.	22	22	22	22	22
Min	275	0.01	0.03	0.07	0.16
Max	753	0.28	0.80	0.96	1.00
Average	375	0.16	0.53	0.73	0.89
STD	110	0.08	0.23	0.26	0.21



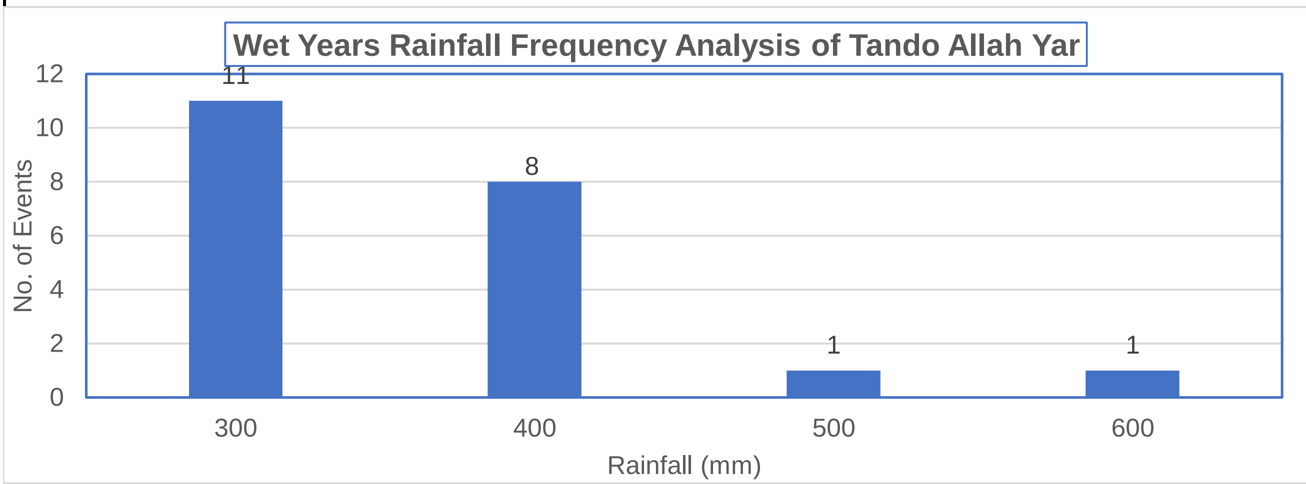
Annexure G Wet Years Rainfall Probabilties of Sukkur

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	279	0.09	0.39	0.63	0.92
1967	237	0.14	0.52	0.77	0.97
1975	282	0.09	0.38	0.62	0.91
1978	328	0.05	0.21	0.38	0.70
1989	188	0.19	0.65	0.88	0.99
1994	363	0.02	0.09	0.17	0.37
1997	216	0.16	0.58	0.82	0.99
2003	259	0.12	0.46	0.71	0.95
2010	187	0.19	0.65	0.88	1.00
2015	308	0.07	0.29	0.50	0.82
2016	223	0.15	0.56	0.81	0.98
2017	304	0.07	0.30	0.52	0.84
2019	339	0.04	0.17	0.31	0.61
2020	360	0.02	0.10	0.19	0.41
2021	228	0.15	0.55	0.80	0.98
No.	15	15	15	15	15
Min	187	0.02	0.09	0.17	0.37
Max	363	0.19	0.65	0.88	1.00
Average	273	0.10	0.39	0.60	0.83
STD	59	0.06	0.19	0.24	0.21



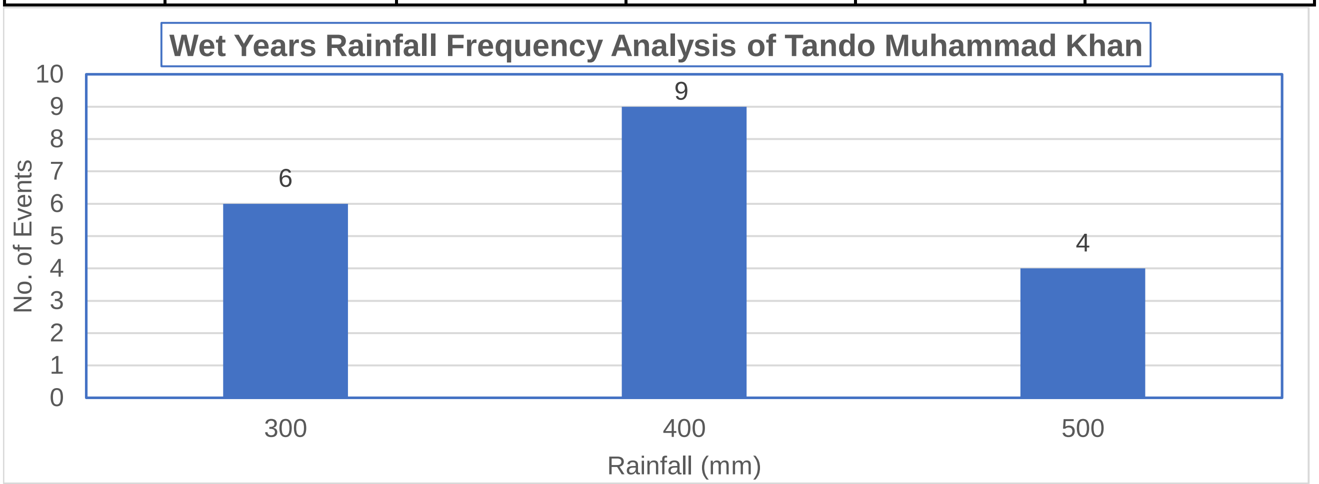
Annexure G   Wet Years Rainfall Probabilties of Tando Allah Yar

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1949	222	0.28	0.80	0.96	1.00
1956	348	0.07	0.32	0.54	0.85
1959	266	0.19	0.65	0.88	0.99
1961	317	0.11	0.45	0.70	0.95
1967	349	0.07	0.31	0.53	0.85
1970	259	0.20	0.68	0.90	1.00
1976	305	0.13	0.50	0.75	0.97
1978	349	0.07	0.32	0.53	0.85
1983	269	0.18	0.64	0.87	0.99
1988	250	0.22	0.71	0.92	1.00
1992	217	0.29	0.82	0.97	1.00
1994	287	0.15	0.57	0.81	0.99
2003	328	0.10	0.40	0.64	0.92
2006	363	0.06	0.26	0.46	0.78
2007	241	0.24	0.74	0.93	1.00
2015	257	0.21	0.68	0.90	1.00
2016	247	0.23	0.72	0.92	1.00
2017	340	0.08	0.35	0.58	0.88
2019	411	0.03	0.13	0.24	0.49
2020	562	0.01	0.03	0.07	0.16
2021	245	0.23	0.73	0.93	1.00
No.	21	21	21	21	21
Min	217	0.01	0.03	0.07	0.16
Max	562	0.29	0.82	0.97	1.00
Average	306	0.15	0.51	0.71	0.89
STD	79	0.08	0.23	0.25	0.21



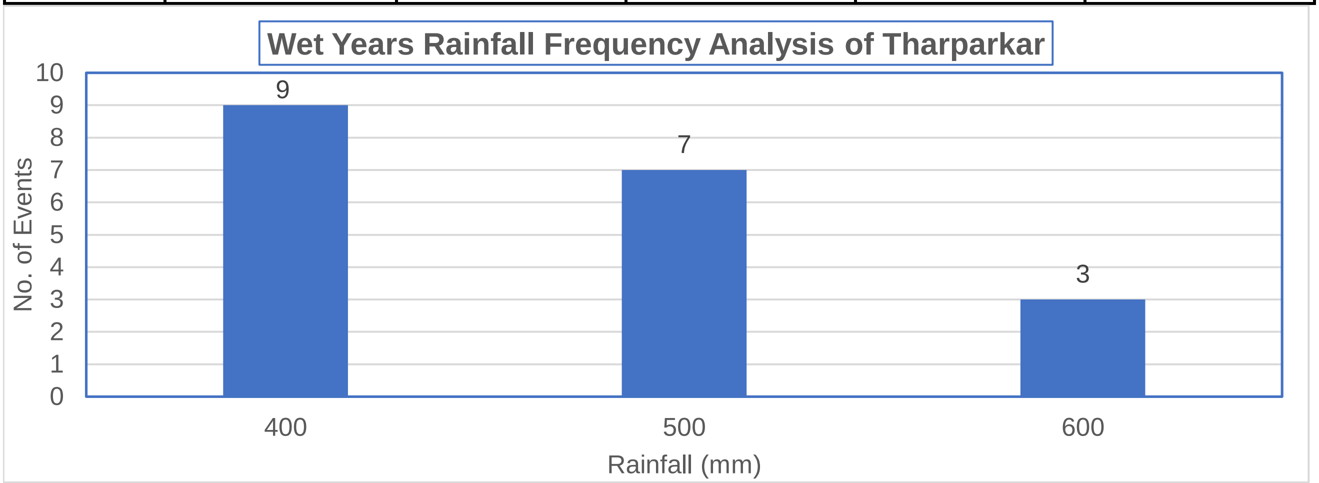
Annexure G Wet Years Rainfall Probabilties of Tando Muhammad Khan

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1956	407	0.06	0.27	0.46	0.79
1959	318	0.16	0.58	0.83	0.99
1961	356	0.11	0.44	0.68	0.94
1967	433	0.04	0.20	0.36	0.67
1970	295	0.20	0.66	0.89	1.00
1976	337	0.13	0.51	0.76	0.97
1978	341	0.13	0.50	0.75	0.97
1983	273	0.23	0.74	0.93	1.00
1988	266	0.25	0.76	0.94	1.00
1992	273	0.23	0.74	0.93	1.00
1994	302	0.19	0.64	0.87	0.99
2003	317	0.16	0.59	0.83	0.99
2006	365	0.10	0.40	0.64	0.92
2007	296	0.20	0.66	0.89	1.00
2015	326	0.15	0.55	0.80	0.98
2016	278	0.22	0.72	0.92	1.00
2017	422	0.05	0.22	0.40	0.72
2019	453	0.03	0.15	0.28	0.57
2020	638	0.01	0.03	0.07	0.16
2021	313	0.17	0.60	0.84	0.99
No.	20	20	20	20	20
Min	266	0.01	0.03	0.07	0.16
Max	638	0.25	0.76	0.94	1.00
Average	350	0.14	0.50	0.70	0.88
STD	88	0.07	0.22	0.25	0.21



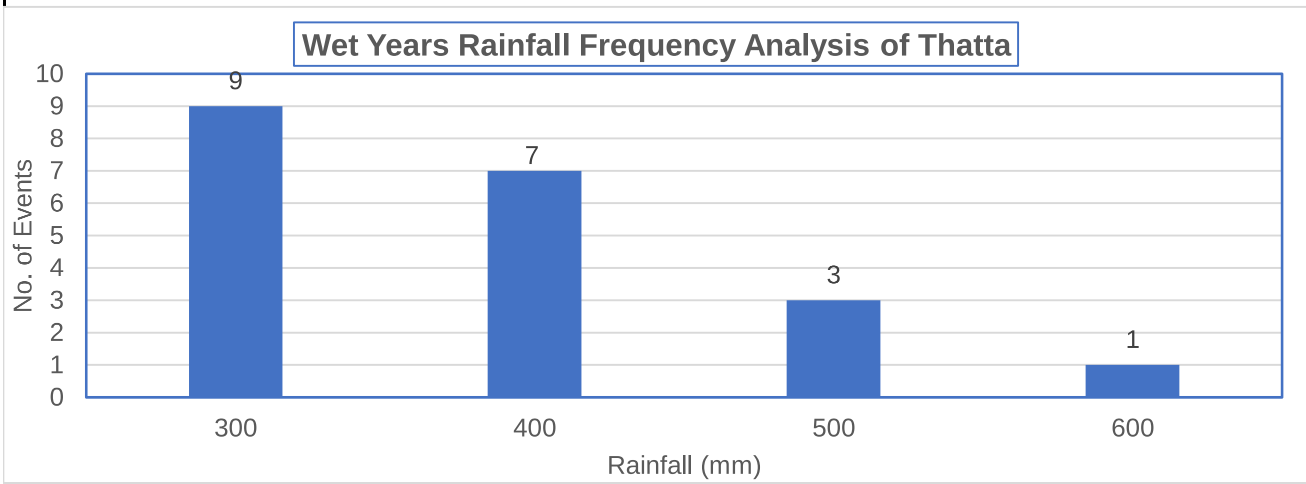
Annexure G   Wet Years Rainfall Probabilties of Tharparkar

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1956	447	0.12	0.48	0.73	0.96
1959	450	0.12	0.47	0.72	0.96
1961	549	0.06	0.25	0.44	0.77
1964	359	0.23	0.73	0.93	1.00
1967	346	0.25	0.76	0.94	1.00
1975	399	0.17	0.62	0.85	0.99
1976	348	0.25	0.76	0.94	1.00
1978	383	0.19	0.66	0.89	1.00
1983	337	0.27	0.79	0.95	1.00
1990	435	0.13	0.51	0.76	0.97
1994	357	0.23	0.73	0.93	1.00
2003	444	0.12	0.49	0.74	0.96
2006	576	0.05	0.21	0.38	0.70
2007	334	0.27	0.79	0.96	1.00
2010	414	0.16	0.57	0.82	0.99
2015	446	0.12	0.48	0.73	0.96
2016	348	0.25	0.76	0.94	1.00
2017	684	0.01	0.06	0.12	0.27
2019	592	0.04	0.19	0.34	0.64
2020	659	0.02	0.09	0.17	0.38
2021	485	0.09	0.38	0.61	0.91
No.	21	21	21	21	21
Min	334	0.01	0.06	0.12	0.27
Max	684	0.27	0.79	0.96	1.00
Average	447	0.15	0.51	0.71	0.88
STD	107	0.09	0.24	0.27	0.21



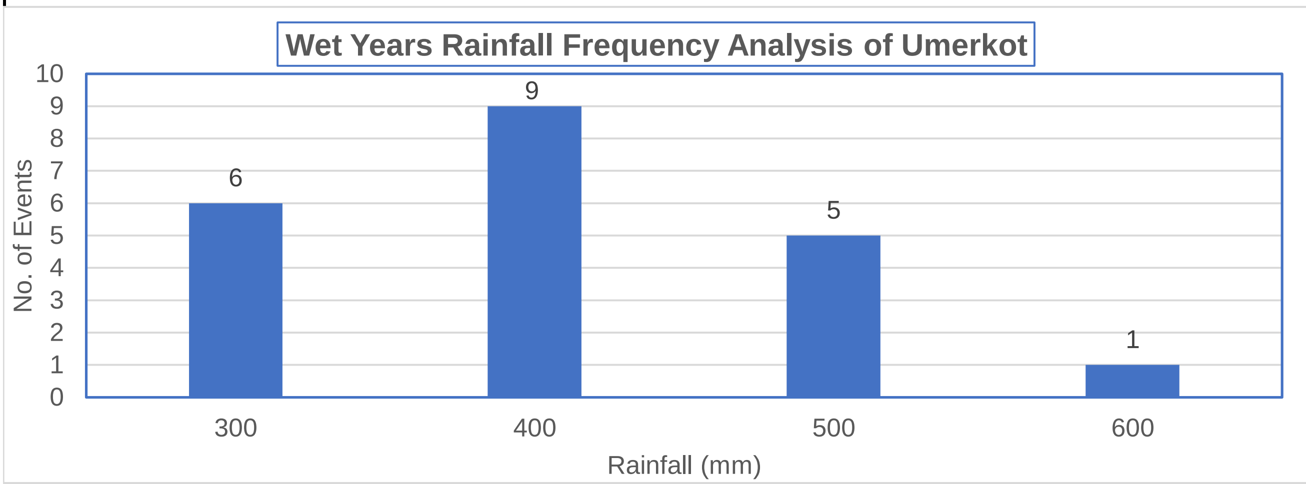
Annexure G Wet Years Rainfall Probabilties of Thatta

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1956	381	0.08	0.35	0.58	0.89
1959	322	0.14	0.54	0.79	0.98
1961	436	0.05	0.22	0.39	0.71
1967	504	0.02	0.12	0.22	0.46
1970	272	0.22	0.72	0.92	1.00
1976	313	0.16	0.57	0.82	0.99
1977	340	0.12	0.48	0.73	0.96
1978	343	0.12	0.47	0.72	0.96
1979	250	0.26	0.78	0.95	1.00
1992	246	0.27	0.80	0.96	1.00
1994	285	0.20	0.67	0.89	1.00
2003	279	0.21	0.70	0.91	1.00
2006	288	0.20	0.66	0.89	1.00
2007	311	0.16	0.58	0.83	0.99
2009	251	0.26	0.78	0.95	1.00
2015	255	0.25	0.77	0.95	1.00
2016	251	0.26	0.78	0.95	1.00
2017	407	0.06	0.28	0.49	0.81
2019	440	0.05	0.21	0.38	0.69
2020	675	0.01	0.03	0.07	0.16
2021	337	0.13	0.49	0.74	0.97
No.	21	21	21	21	21
Min	246	0.01	0.03	0.07	0.16
Max	675	0.27	0.80	0.96	1.00
Average	342	0.15	0.52	0.72	0.88
STD	105	0.09	0.24	0.27	0.22



Annexure G   Wet Years Rainfall Probabilties of Umerkot

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1956	325	0.17	0.60	0.84	0.99
1959	307	0.19	0.66	0.88	1.00
1961	421	0.07	0.30	0.51	0.83
1964	285	0.23	0.73	0.93	1.00
1967	277	0.24	0.75	0.94	1.00
1975	290	0.22	0.71	0.92	1.00
1976	284	0.23	0.73	0.93	1.00
1978	371	0.11	0.45	0.70	0.95
1983	304	0.20	0.67	0.89	1.00
1988	258	0.27	0.80	0.96	1.00
1990	329	0.16	0.59	0.83	0.99
1994	260	0.27	0.79	0.96	1.00
2003	394	0.09	0.38	0.62	0.91
2006	479	0.03	0.15	0.28	0.57
2010	314	0.18	0.64	0.87	0.99
2015	411	0.08	0.33	0.55	0.87
2016	342	0.15	0.55	0.80	0.98
2017	498	0.02	0.11	0.22	0.46
2019	437	0.06	0.26	0.45	0.77
2020	525	0.01	0.07	0.13	0.29
2021	383	0.10	0.41	0.66	0.93
No.	21	21	21	21	21
Min	258	0.01	0.07	0.13	0.29
Max	525	0.27	0.80	0.96	1.00
Average	357	0.15	0.51	0.71	0.88
STD	80	0.08	0.23	0.26	0.20

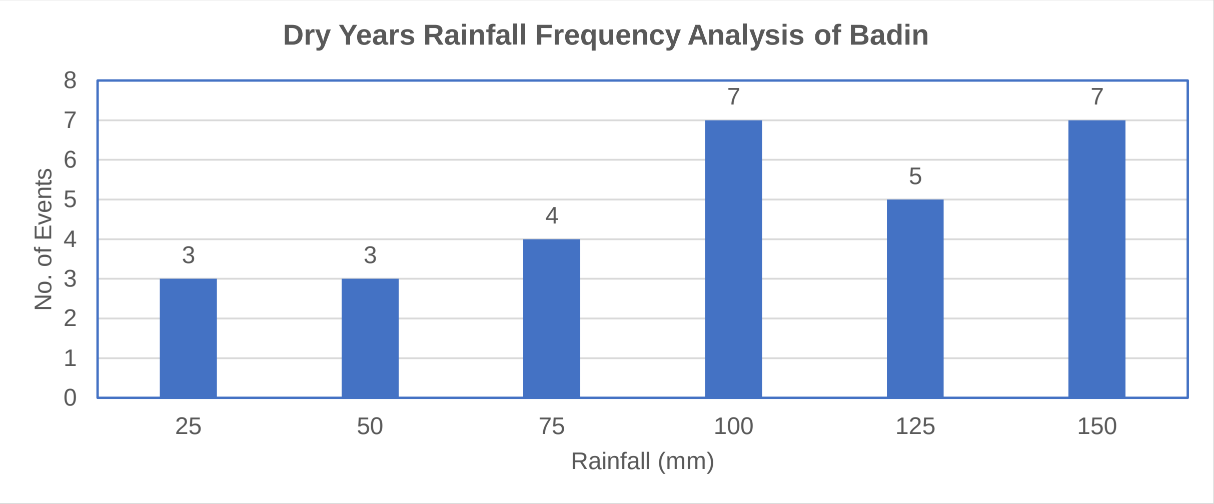


ANNEXURE-H

RAINFALL PROBABILITIES FOR DRY YEARS

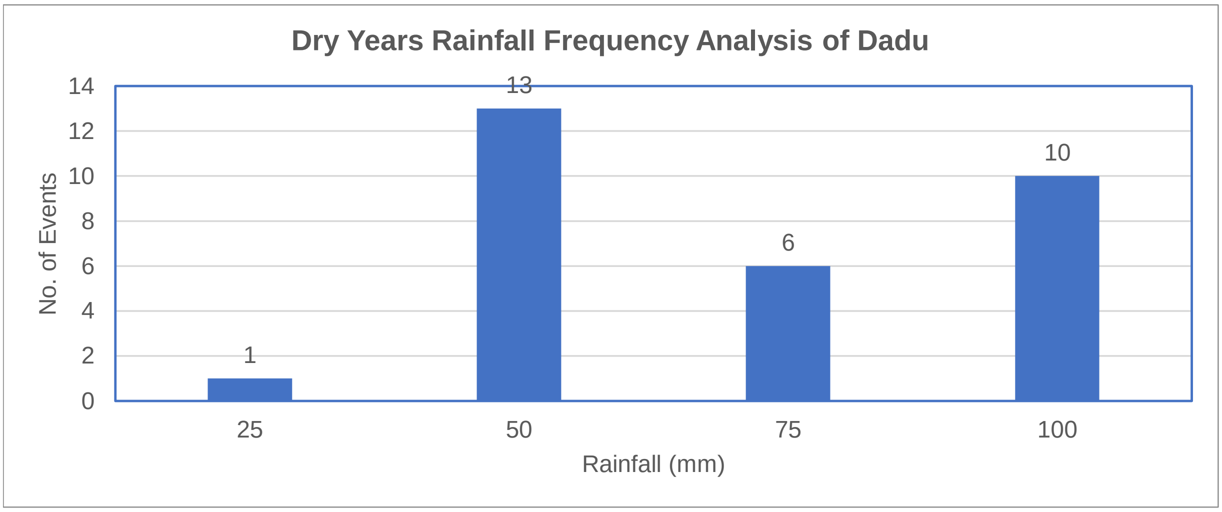
Annexure H   Dry Years Rainfall Probabilties of Badin

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	52	0.13	0.51	0.76	0.97
1950	130	0.35	0.89	0.99	1.00
1951	76	0.19	0.65	0.88	0.99
1957	105	0.27	0.80	0.96	1.00
1960	73	0.18	0.63	0.87	0.99
1963	78	0.20	0.66	0.89	1.00
1966	91	0.23	0.73	0.93	1.00
1968	47	0.12	0.47	0.72	0.96
1969	18	0.07	0.30	0.51	0.83
1972	57	0.14	0.54	0.79	0.98
1973	129	0.35	0.88	0.99	1.00
1974	24	0.08	0.33	0.55	0.87
1980	106	0.28	0.80	0.96	1.00
1981	53	0.13	0.51	0.76	0.97
1982	95	0.24	0.75	0.94	1.00
1986	126	0.34	0.87	0.98	1.00
1987	18	0.07	0.30	0.51	0.83
1989	134	0.36	0.90	0.99	1.00
1991	26	0.08	0.35	0.57	0.88
1993	109	0.29	0.81	0.97	1.00
1995	126	0.34	0.87	0.98	1.00
1996	77	0.19	0.66	0.88	1.00
1999	79	0.20	0.67	0.89	1.00
2000	125	0.33	0.87	0.98	1.00
2001	121	0.32	0.86	0.98	1.00
2002	36	0.10	0.41	0.65	0.93
2004	84	0.21	0.70	0.91	1.00
2012	135	0.36	0.90	0.99	1.00
2018	120	0.32	0.85	0.98	1.00
No.	29	29	29	29	29
Min	18	0.07	0.30	0.51	0.83
Max	135	0.36	0.90	0.99	1.00
Average	84	0.22	0.67	0.85	0.97
STD	38	0.10	0.20	0.16	0.05



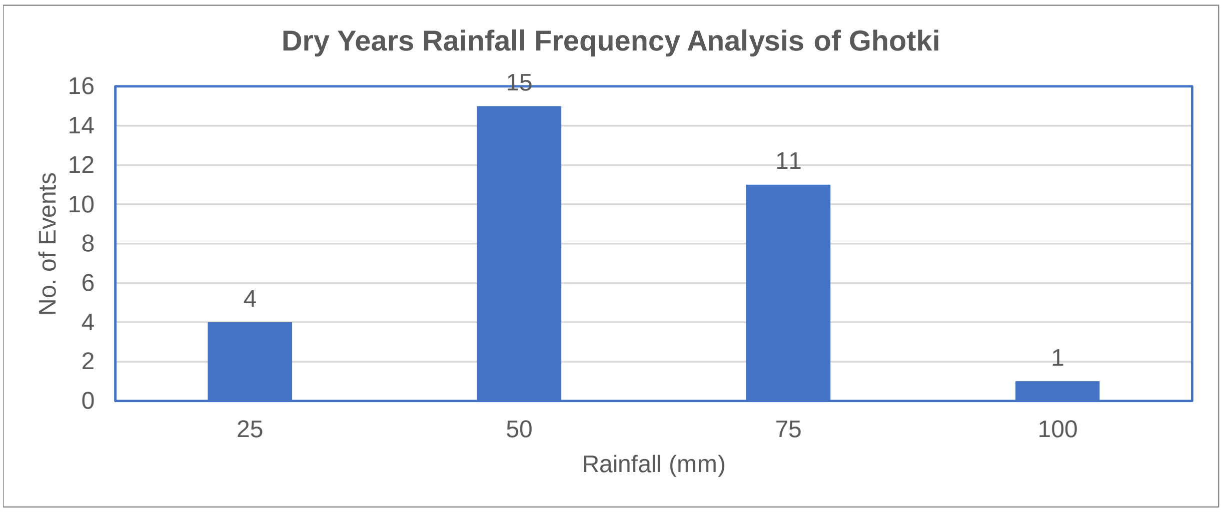
Annexure H Dry Years Rainfall Probabilties of Dadu

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1951	93	0.37	0.90	0.99	1.00
1955	90	0.36	0.89	0.99	1.00
1957	71	0.27	0.80	0.96	1.00
1963	23	0.10	0.39	0.63	0.92
1964	50	0.19	0.65	0.88	0.99
1965	57	0.21	0.70	0.91	1.00
1966	36	0.13	0.51	0.76	0.97
1968	26	0.10	0.42	0.67	0.94
1969	46	0.17	0.61	0.85	0.99
1971	36	0.13	0.51	0.76	0.97
1972	48	0.18	0.63	0.86	0.99
1973	58	0.22	0.71	0.92	1.00
1974	26	0.10	0.43	0.67	0.94
1980	76	0.30	0.83	0.97	1.00
1984	90	0.36	0.89	0.99	1.00
1987	26	0.10	0.42	0.66	0.93
1991	50	0.19	0.64	0.87	0.99
1993	42	0.16	0.58	0.82	0.99
1996	86	0.34	0.87	0.98	1.00
1998	81	0.32	0.85	0.98	1.00
1999	70	0.27	0.79	0.96	1.00
2000	42	0.16	0.57	0.82	0.99
2001	87	0.34	0.88	0.99	1.00
2002	27	0.11	0.43	0.68	0.94
2004	35	0.13	0.51	0.76	0.97
2005	84	0.33	0.87	0.98	1.00
2009	85	0.34	0.87	0.98	1.00
2012	38	0.14	0.53	0.78	0.98
2013	86	0.34	0.87	0.98	1.00
2014	70	0.27	0.79	0.96	1.00
No.	30	30	30	30	30
Min	23	0.10	0.39	0.63	0.92
Max	93	0.37	0.90	0.99	1.00
Average	58	0.22	0.68	0.87	0.98
STD	24	0.10	0.18	0.12	0.02



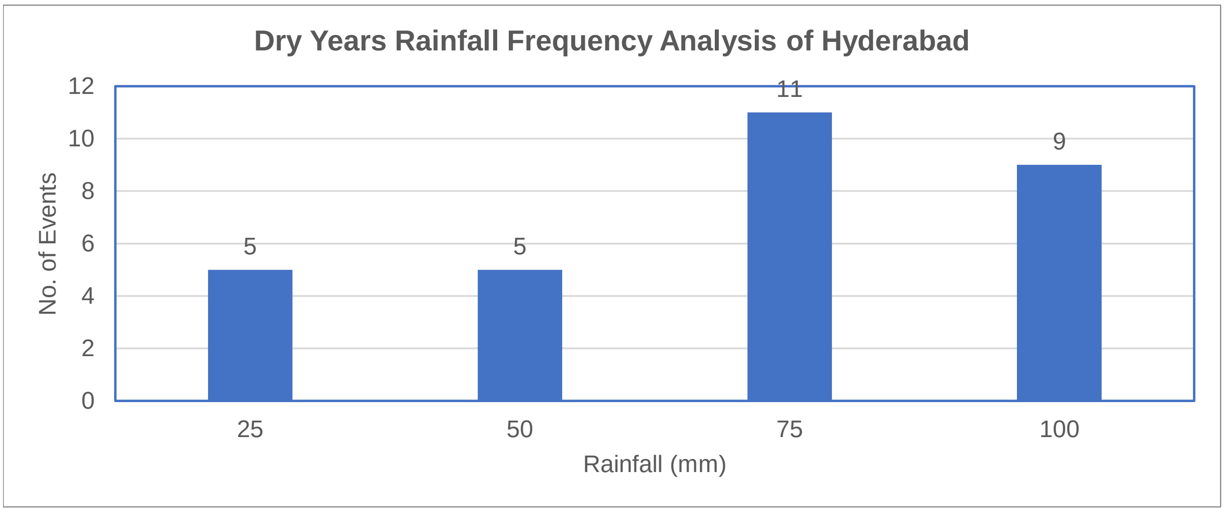
Annexure H   Dry Years Rainfall Probabilties of Ghotki

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1950	66	0.32	0.86	0.98	1.00
1951	43	0.19	0.66	0.88	1.00
1952	53	0.25	0.76	0.94	1.00
1954	72	0.36	0.89	0.99	1.00
1957	38	0.17	0.60	0.84	0.99
1958	41	0.18	0.64	0.87	0.99
1960	47	0.22	0.71	0.91	1.00
1963	38	0.17	0.61	0.85	0.99
1965	50	0.23	0.73	0.93	1.00
1966	48	0.22	0.71	0.92	1.00
1968	21	0.10	0.40	0.64	0.92
1969	22	0.10	0.40	0.64	0.92
1971	71	0.35	0.89	0.99	1.00
1972	44	0.20	0.68	0.90	1.00
1973	42	0.19	0.65	0.88	0.99
1974	34	0.15	0.55	0.80	0.98
1979	75	0.38	0.91	0.99	1.00
1980	26	0.12	0.46	0.71	0.95
1987	29	0.13	0.49	0.74	0.97
1988	60	0.29	0.81	0.97	1.00
1991	22	0.10	0.41	0.65	0.93
1993	48	0.22	0.71	0.92	1.00
1995	66	0.32	0.86	0.98	1.00
1998	69	0.34	0.88	0.98	1.00
2000	38	0.17	0.60	0.84	0.99
2001	66	0.33	0.86	0.98	1.00
2002	15	0.08	0.33	0.55	0.86
2004	49	0.22	0.72	0.92	1.00
2005	57	0.27	0.80	0.96	1.00
2009	62	0.30	0.83	0.97	1.00
2012	75	0.38	0.90	0.99	1.00
No.	31	31	31	31	31
Min	15	0.08	0.33	0.55	0.86
Max	75	0.38	0.91	0.99	1.00
Average	48	0.23	0.69	0.87	0.98
STD	17	0.09	0.17	0.12	0.03



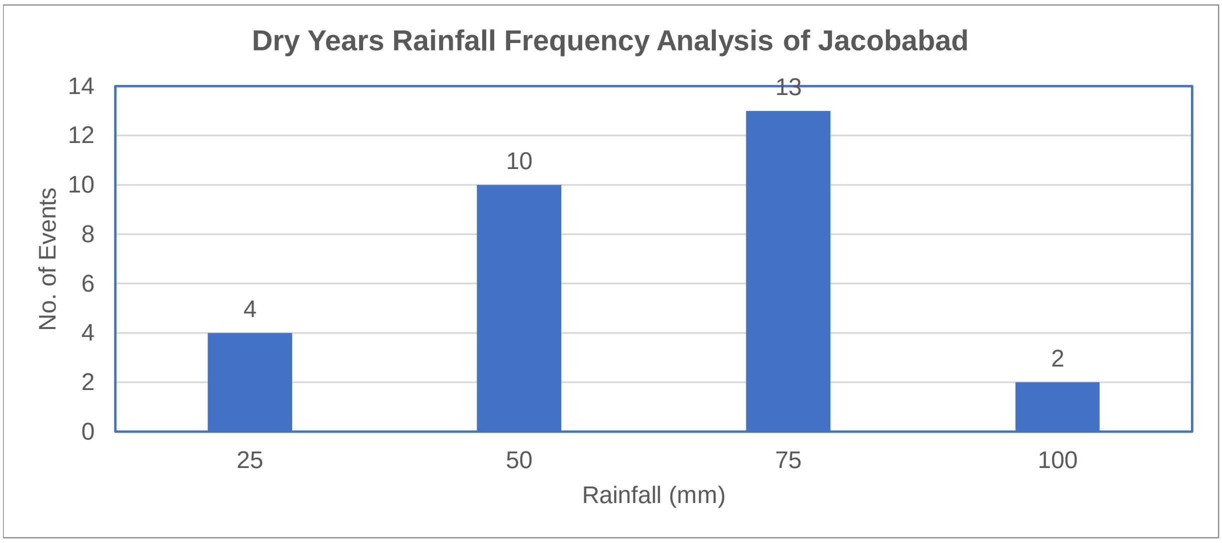
Annexure H   Dry Years Rainfall Probabilties of Hyderabad

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	56	0.20	0.68	0.90	1.00
1950	91	0.34	0.88	0.99	1.00
1951	53	0.19	0.66	0.88	1.00
1957	66	0.24	0.75	0.94	1.00
1960	66	0.24	0.75	0.94	1.00
1963	35	0.14	0.52	0.77	0.97
1966	67	0.25	0.76	0.94	1.00
1968	28	0.11	0.45	0.70	0.95
1969	13	0.08	0.33	0.56	0.87
1971	73	0.27	0.79	0.96	1.00
1972	30	0.12	0.47	0.72	0.96
1973	84	0.32	0.85	0.98	1.00
1974	18	0.09	0.37	0.61	0.90
1980	86	0.32	0.86	0.98	1.00
1981	67	0.25	0.76	0.94	1.00
1982	80	0.30	0.83	0.97	1.00
1987	13	0.08	0.34	0.56	0.87
1991	14	0.08	0.34	0.56	0.88
1993	61	0.22	0.72	0.92	1.00
1995	93	0.35	0.89	0.99	1.00
1996	41	0.16	0.57	0.81	0.99
1997	98	0.37	0.90	0.99	1.00
1998	64	0.23	0.74	0.93	1.00
1999	58	0.21	0.70	0.91	1.00
2000	67	0.25	0.76	0.94	1.00
2002	19	0.09	0.39	0.62	0.91
2004	37	0.14	0.53	0.78	0.98
2005	92	0.35	0.88	0.99	1.00
2008	95	0.36	0.89	0.99	1.00
2014	89	0.33	0.87	0.98	1.00
No.	30	30	30	30	30
Min	13	0.08	0.33	0.56	0.87
Max	98	0.37	0.90	0.99	1.00
Average	58	0.22	0.67	0.86	0.98
STD	28	0.10	0.19	0.15	0.04



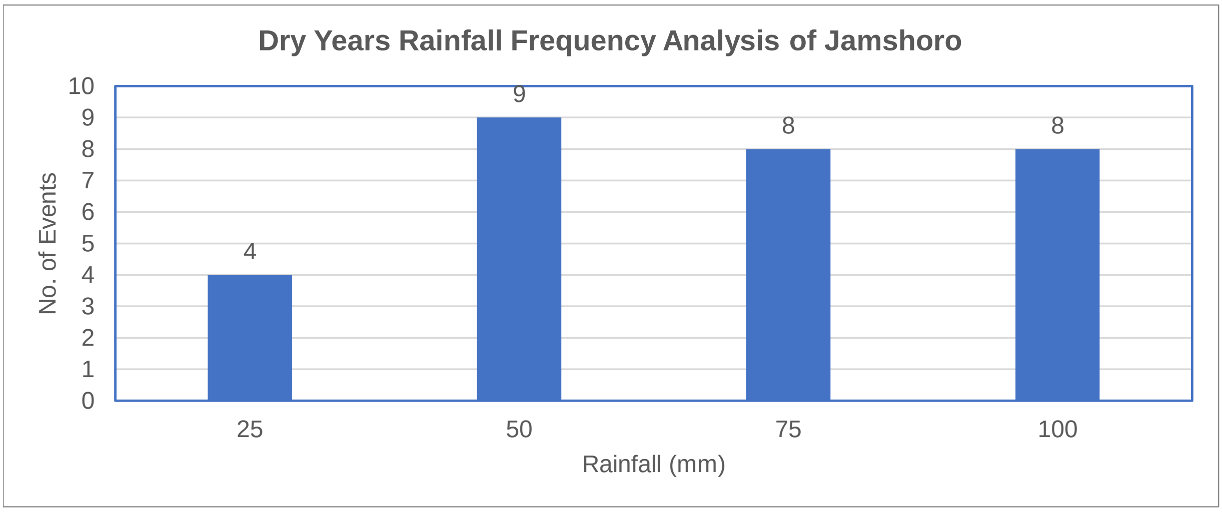
Annexure H   Dry Years Rainfall Probabilties of Jacobabad

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1951	75	0.36	0.89	0.99	1.00
1952	59	0.26	0.78	0.95	1.00
1954	77	0.37	0.90	0.99	1.00
1957	60	0.27	0.79	0.96	1.00
1958	56	0.25	0.75	0.94	1.00
1960	65	0.30	0.83	0.97	1.00
1962	72	0.34	0.87	0.98	1.00
1963	31	0.12	0.48	0.73	0.96
1964	61	0.28	0.80	0.96	1.00
1965	46	0.19	0.65	0.88	1.00
1966	35	0.14	0.53	0.78	0.98
1968	32	0.13	0.49	0.74	0.97
1969	22	0.09	0.37	0.60	0.90
1971	65	0.30	0.83	0.97	1.00
1972	39	0.16	0.57	0.82	0.99
1973	27	0.10	0.42	0.67	0.94
1974	22	0.08	0.36	0.59	0.89
1980	24	0.09	0.39	0.63	0.92
1984	75	0.35	0.89	0.99	1.00
1987	35	0.14	0.53	0.78	0.98
1991	41	0.17	0.60	0.84	0.99
1993	46	0.19	0.65	0.88	0.99
1998	72	0.34	0.87	0.98	1.00
2000	30	0.12	0.46	0.71	0.96
2002	20	0.08	0.34	0.56	0.87
2004	51	0.22	0.71	0.92	1.00
2005	67	0.31	0.84	0.97	1.00
2009	58	0.26	0.77	0.95	1.00
2012	57	0.25	0.77	0.95	1.00
2014	78	0.37	0.90	0.99	1.00
No.	30	30	30	30	30
Min	20	0.08	0.34	0.56	0.87
Max	78	0.37	0.90	0.99	1.00
Average	50	0.22	0.67	0.86	0.98
STD	19	0.10	0.19	0.14	0.04



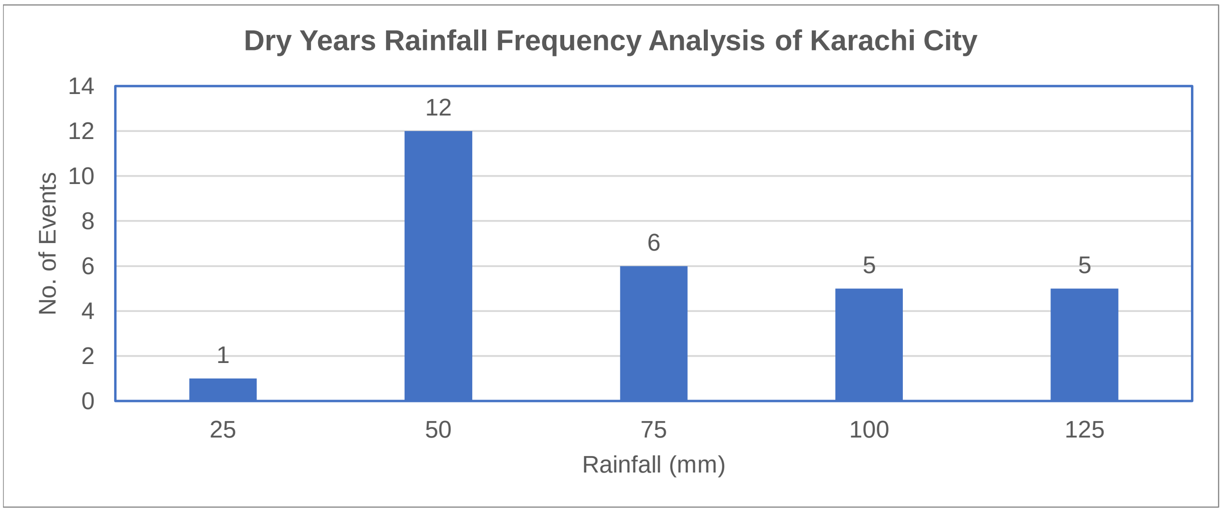
Annexure H   Dry Years Rainfall Probabilties of Jamshoro

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1951	51	0.20	0.68	0.89	1.00
1957	54	0.21	0.69	0.91	1.00
1960	81	0.32	0.86	0.98	1.00
1963	24	0.11	0.45	0.69	0.95
1964	80	0.32	0.85	0.98	1.00
1965	87	0.35	0.88	0.99	1.00
1966	49	0.19	0.66	0.89	1.00
1968	26	0.11	0.46	0.71	0.95
1969	25	0.11	0.45	0.70	0.95
1971	56	0.22	0.71	0.92	1.00
1972	28	0.12	0.48	0.73	0.96
1973	83	0.33	0.87	0.98	1.00
1974	23	0.11	0.43	0.68	0.94
1980	91	0.37	0.90	0.99	1.00
1987	10	0.07	0.32	0.54	0.86
1991	21	0.10	0.42	0.66	0.93
1993	43	0.17	0.61	0.85	0.99
1995	72	0.29	0.81	0.97	1.00
1996	61	0.24	0.75	0.94	1.00
1998	48	0.19	0.65	0.88	0.99
1999	55	0.22	0.71	0.91	1.00
2000	48	0.19	0.65	0.88	0.99
2002	29	0.12	0.49	0.74	0.96
2004	32	0.13	0.52	0.77	0.97
2005	73	0.29	0.82	0.97	1.00
2008	91	0.37	0.90	0.99	1.00
2011	80	0.32	0.86	0.98	1.00
2012	78	0.31	0.84	0.98	1.00
2014	63	0.25	0.76	0.94	1.00
No.	29	29	29	29	29
Min	10	0.07	0.32	0.54	0.86
Max	91	0.37	0.90	0.99	1.00
Average	54	0.22	0.67	0.86	0.98
STD	24	0.09	0.18	0.13	0.03



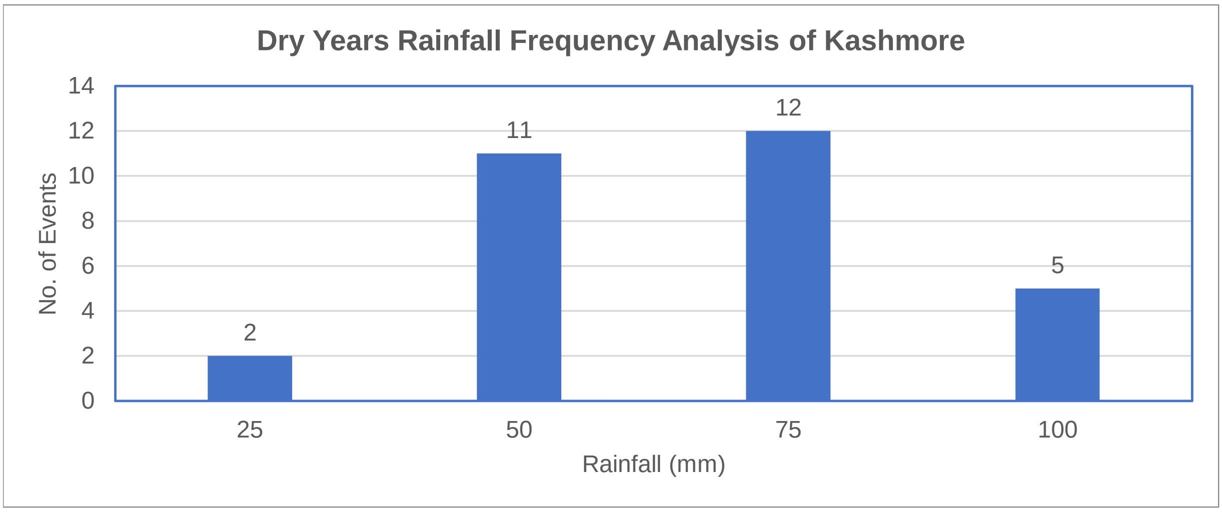
Annexure H Dry Years Rainfall Probabilties of Karachi City

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1951	52	0.19	0.65	0.87	0.99
1957	55	0.20	0.67	0.89	1.00
1960	103	0.37	0.90	0.99	1.00
1963	27	0.12	0.46	0.71	0.95
1964	100	0.36	0.89	0.99	1.00
1965	99	0.35	0.89	0.99	1.00
1966	57	0.20	0.68	0.90	1.00
1968	39	0.15	0.55	0.80	0.98
1969	43	0.16	0.58	0.82	0.99
1971	59	0.21	0.69	0.90	1.00
1972	46	0.17	0.60	0.84	0.99
1974	29	0.12	0.47	0.72	0.96
1987	9	0.07	0.32	0.53	0.85
1989	39	0.15	0.55	0.80	0.98
1991	32	0.13	0.50	0.75	0.97
1993	37	0.14	0.53	0.78	0.98
1995	32	0.13	0.50	0.75	0.97
1998	77	0.27	0.80	0.96	1.00
1999	48	0.18	0.62	0.85	0.99
2000	63	0.22	0.72	0.92	1.00
2001	102	0.36	0.90	0.99	1.00
2002	61	0.22	0.70	0.91	1.00
2004	42	0.15	0.57	0.81	0.98
2005	83	0.29	0.83	0.97	1.00
2008	104	0.37	0.90	0.99	1.00
2011	39	0.15	0.55	0.80	0.98
2012	94	0.33	0.87	0.98	1.00
2014	82	0.29	0.82	0.97	1.00
2018	104	0.37	0.90	0.99	1.00
No.	29	29	29	29	29
Min	9	0.07	0.32	0.53	0.85
Max	104	0.37	0.90	0.99	1.00
Average	61	0.22	0.68	0.87	0.98
STD	28	0.09	0.17	0.11	0.03



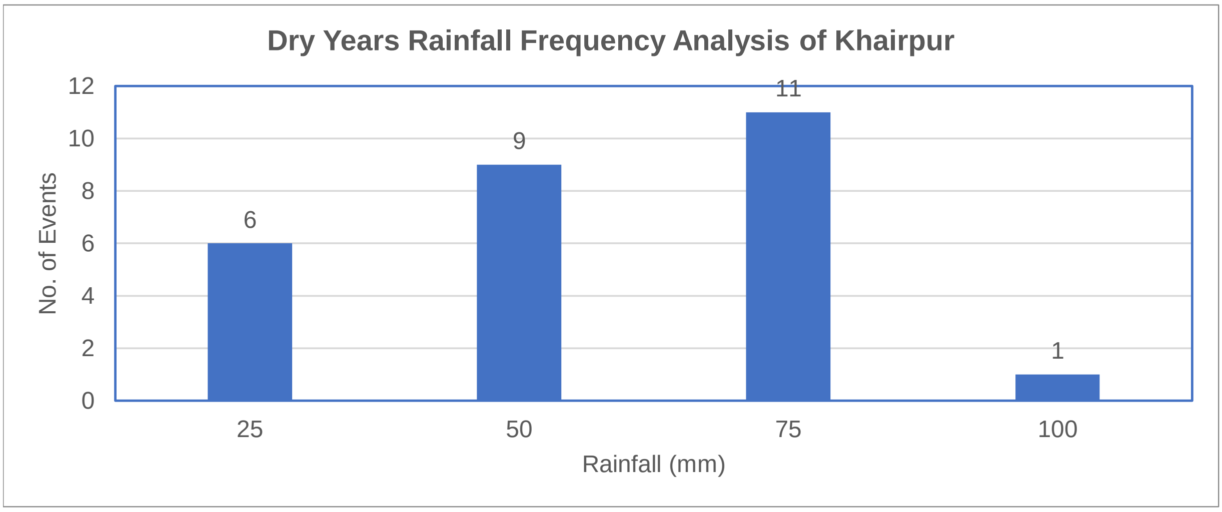
Annexure H   Dry Years Rainfall Probabilties of Kashmore

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1950	81	0.37	0.90	0.99	1.00
1951	68	0.30	0.83	0.97	1.00
1952	50	0.20	0.68	0.90	1.00
1954	66	0.29	0.81	0.97	1.00
1957	55	0.22	0.72	0.92	1.00
1958	39	0.15	0.55	0.79	0.98
1960	54	0.22	0.72	0.92	1.00
1962	76	0.34	0.88	0.99	1.00
1963	43	0.17	0.60	0.84	0.99
1964	81	0.38	0.91	0.99	1.00
1965	55	0.23	0.73	0.93	1.00
1966	45	0.17	0.61	0.85	0.99
1968	29	0.10	0.42	0.67	0.94
1969	20	0.07	0.32	0.54	0.86
1971	78	0.36	0.89	0.99	1.00
1972	40	0.15	0.56	0.81	0.98
1973	43	0.17	0.60	0.84	0.99
1974	38	0.14	0.53	0.78	0.98
1980	27	0.10	0.40	0.64	0.92
1987	42	0.16	0.58	0.82	0.99
1988	72	0.32	0.86	0.98	1.00
1991	37	0.14	0.52	0.77	0.97
1993	54	0.22	0.71	0.92	1.00
1998	72	0.32	0.86	0.98	1.00
2000	33	0.12	0.47	0.72	0.96
2002	22	0.08	0.34	0.56	0.87
2004	60	0.25	0.77	0.95	1.00
2005	76	0.35	0.88	0.99	1.00
2009	62	0.27	0.79	0.96	1.00
2012	74	0.33	0.87	0.98	1.00
No.	30	30	30	30	30
Min	20	0.07	0.32	0.54	0.86
Max	81	0.38	0.91	0.99	1.00
Average	53	0.22	0.68	0.86	0.98
STD	18	0.09	0.18	0.13	0.04



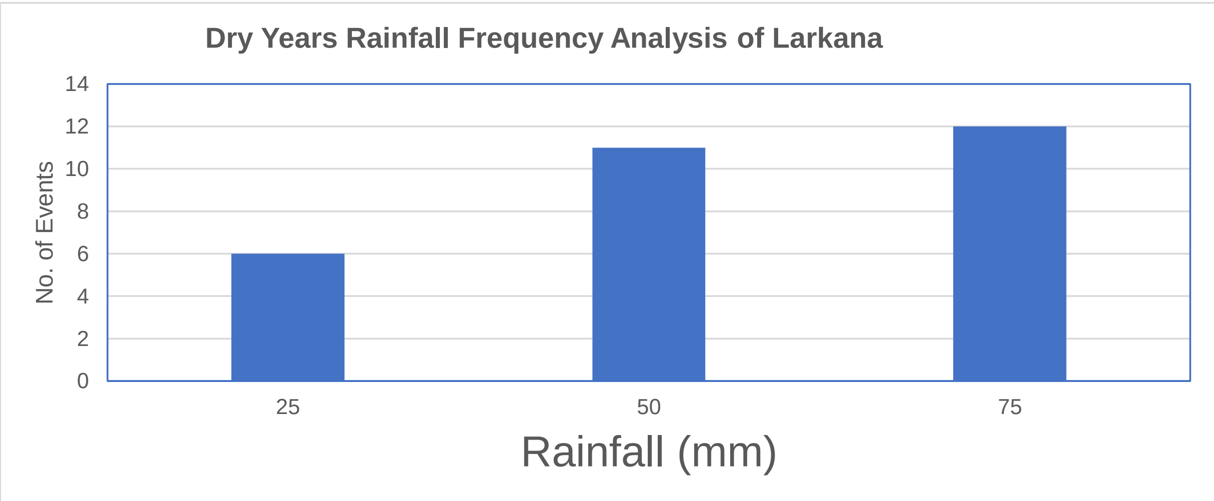
Annexure H Dry Years Rainfall Probabilties of Khairpur

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	71	0.35	0.88	0.99	1.00
1950	76	0.37	0.90	0.99	1.00
1951	30	0.14	0.53	0.78	0.98
1952	66	0.32	0.85	0.98	1.00
1957	35	0.16	0.58	0.82	0.99
1958	60	0.29	0.81	0.97	1.00
1960	50	0.23	0.73	0.93	1.00
1963	32	0.15	0.55	0.79	0.98
1965	58	0.27	0.80	0.96	1.00
1966	44	0.20	0.67	0.89	1.00
1968	19	0.10	0.40	0.64	0.92
1969	15	0.09	0.36	0.59	0.89
1972	35	0.16	0.58	0.82	0.99
1973	52	0.24	0.75	0.94	1.00
1974	18	0.09	0.39	0.63	0.92
1980	38	0.17	0.61	0.85	0.99
1987	20	0.10	0.41	0.66	0.93
1991	12	0.08	0.33	0.55	0.86
1993	73	0.35	0.89	0.99	1.00
1996	73	0.35	0.89	0.99	1.00
1998	62	0.29	0.83	0.97	1.00
2000	41	0.19	0.64	0.87	0.99
2001	64	0.31	0.84	0.97	1.00
2002	11	0.07	0.31	0.53	0.85
2004	36	0.16	0.59	0.83	0.99
2005	43	0.20	0.66	0.89	1.00
2014	61	0.29	0.82	0.97	1.00
No.	27	27	27	27	27
Min	11	0.07	0.31	0.53	0.85
Max	76	0.37	0.90	0.99	1.00
Average	44	0.21	0.65	0.84	0.97
STD	21	0.10	0.19	0.15	0.05



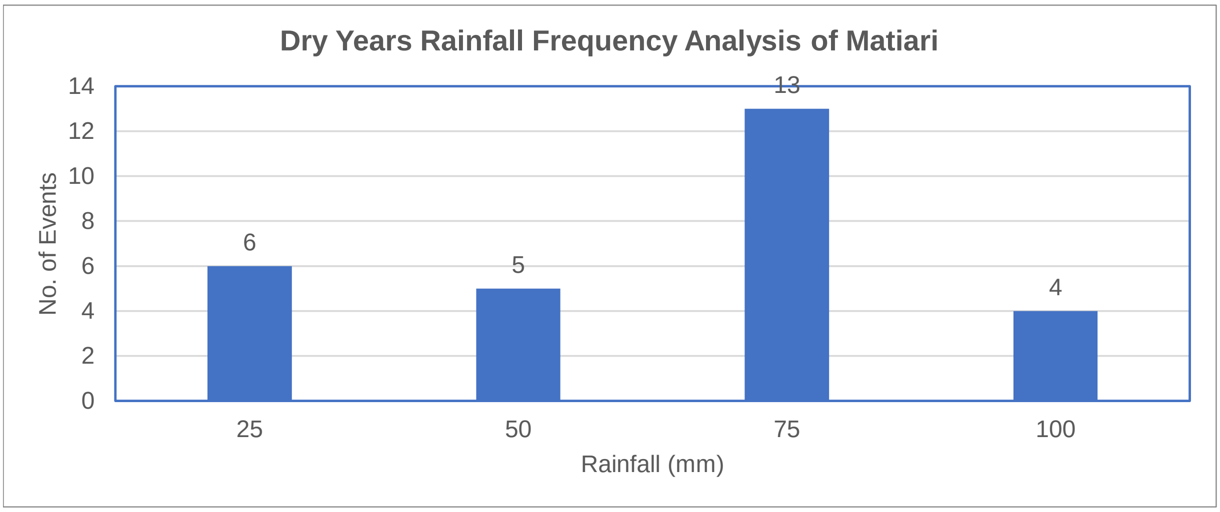
Annexure H Dry Years Rainfall Probabilties of Larkana

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1951	58	0.29	0.82	0.97	1.00
1952	70	0.35	0.89	0.99	1.00
1957	52	0.26	0.77	0.95	1.00
1958	72	0.36	0.90	0.99	1.00
1960	63	0.32	0.85	0.98	1.00
1963	21	0.12	0.46	0.71	0.96
1964	62	0.31	0.84	0.98	1.00
1965	40	0.20	0.67	0.89	1.00
1966	32	0.16	0.59	0.83	0.99
1968	24	0.13	0.50	0.75	0.97
1969	27	0.14	0.53	0.78	0.98
1971	50	0.25	0.76	0.94	1.00
1972	31	0.16	0.58	0.82	0.99
1973	24	0.13	0.50	0.75	0.97
1974	18	0.11	0.43	0.67	0.94
1980	37	0.18	0.64	0.87	0.99
1984	70	0.35	0.89	0.99	1.00
1987	24	0.13	0.50	0.75	0.97
1991	34	0.17	0.60	0.84	0.99
1993	40	0.20	0.67	0.89	1.00
1998	61	0.30	0.84	0.97	1.00
2000	31	0.16	0.58	0.82	0.99
2001	73	0.37	0.90	0.99	1.00
2002	18	0.11	0.43	0.67	0.94
2004	32	0.16	0.59	0.83	0.99
2005	53	0.26	0.78	0.95	1.00
2009	55	0.27	0.80	0.96	1.00
2012	40	0.20	0.67	0.89	1.00
2014	60	0.30	0.83	0.97	1.00
No.	29	29	29	29	29
Min	18	0.11	0.43	0.67	0.94
Max	73	0.37	0.90	0.99	1.00
Average	44	0.22	0.68	0.88	0.99
STD	18	0.09	0.16	0.10	0.02



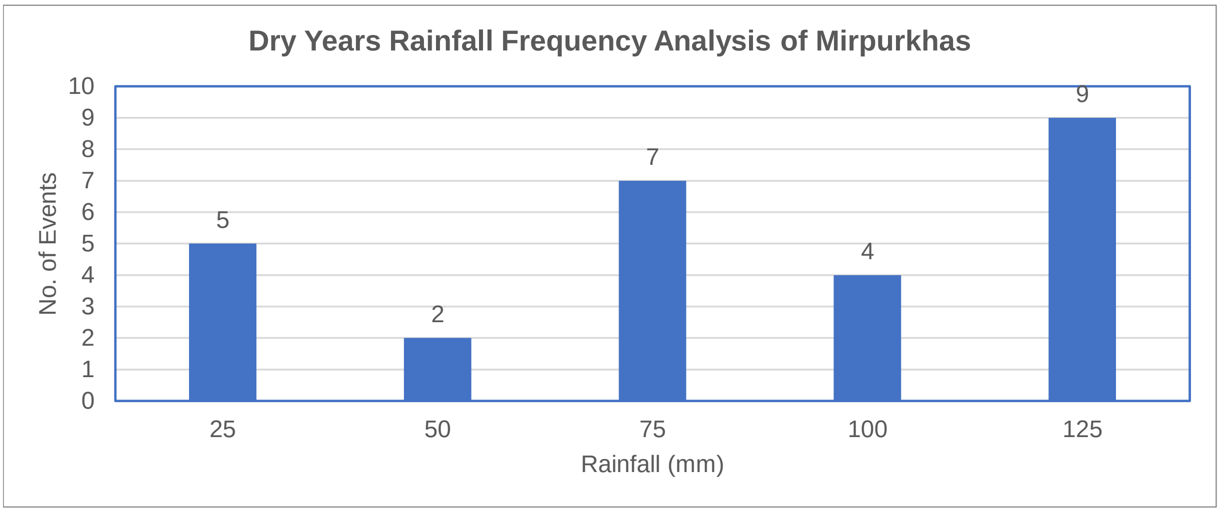
Annexure H Dry Years Rainfall Probabilties of Matiari

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	45	0.18	0.64	0.87	0.99
1950	85	0.35	0.88	0.99	1.00
1951	51	0.20	0.68	0.90	1.00
1957	57	0.23	0.73	0.93	1.00
1960	61	0.25	0.76	0.94	1.00
1963	30	0.13	0.51	0.76	0.97
1966	60	0.24	0.75	0.94	1.00
1968	24	0.11	0.45	0.70	0.95
1969	12	0.08	0.35	0.58	0.88
1971	68	0.27	0.80	0.96	1.00
1972	28	0.13	0.49	0.74	0.97
1973	71	0.29	0.82	0.97	1.00
1974	16	0.09	0.39	0.62	0.91
1980	72	0.29	0.82	0.97	1.00
1981	75	0.30	0.84	0.97	1.00
1982	81	0.33	0.87	0.98	1.00
1987	14	0.09	0.37	0.60	0.90
1991	11	0.08	0.34	0.57	0.88
1993	62	0.25	0.76	0.94	1.00
1996	41	0.17	0.60	0.84	0.99
1998	54	0.22	0.71	0.92	1.00
1999	63	0.25	0.77	0.95	1.00
2000	55	0.22	0.72	0.92	1.00
2002	13	0.08	0.36	0.59	0.89
2004	32	0.14	0.52	0.77	0.97
2005	76	0.31	0.84	0.98	1.00
2008	86	0.35	0.89	0.99	1.00
2014	74	0.30	0.83	0.97	1.00
No.	28	28	28	28	28
Min	11	0.08	0.34	0.57	0.88
Max	86	0.35	0.89	0.99	1.00
Average	51	0.21	0.66	0.85	0.97
STD	24	0.09	0.19	0.15	0.04



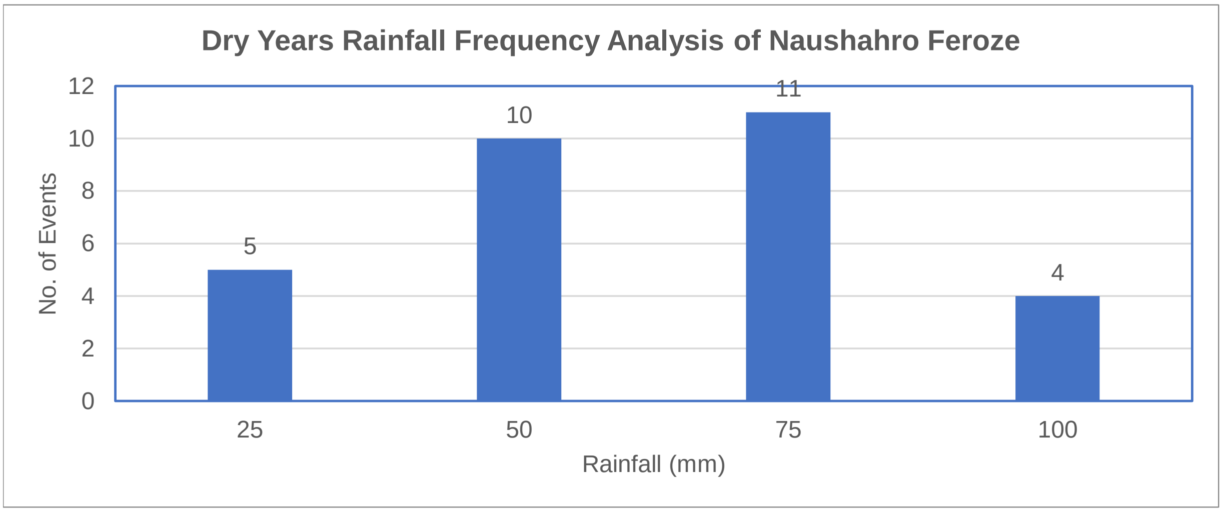
Annexure H   Dry Years Rainfall Probabilties of Mirpur Khas

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	29	0.10	0.39	0.63	0.92
1950	122	0.37	0.90	0.99	1.00
1951	64	0.18	0.63	0.86	0.99
1954	108	0.32	0.85	0.98	1.00
1957	98	0.28	0.81	0.96	1.00
1960	62	0.17	0.61	0.85	0.99
1963	67	0.19	0.65	0.88	0.99
1966	81	0.23	0.73	0.93	1.00
1968	52	0.15	0.55	0.79	0.98
1969	12	0.07	0.29	0.49	0.81
1972	63	0.18	0.62	0.86	0.99
1973	121	0.36	0.90	0.99	1.00
1974	17	0.07	0.32	0.53	0.85
1980	65	0.18	0.63	0.87	0.99
1981	39	0.12	0.46	0.71	0.95
1986	113	0.33	0.87	0.98	1.00
1987	22	0.08	0.35	0.58	0.88
1989	103	0.30	0.84	0.97	1.00
1991	18	0.07	0.32	0.54	0.85
1996	84	0.24	0.74	0.93	1.00
1999	77	0.22	0.70	0.91	1.00
2000	100	0.29	0.82	0.97	1.00
2001	102	0.30	0.83	0.97	1.00
2002	19	0.08	0.33	0.55	0.86
2004	72	0.20	0.67	0.89	1.00
2005	123	0.37	0.90	0.99	1.00
2008	118	0.35	0.89	0.99	1.00
No.	27	27	27	27	27
Min	12	0.07	0.29	0.49	0.81
Max	123	0.37	0.90	0.99	1.00
Average	72	0.21	0.65	0.84	0.97
STD	36	0.10	0.21	0.17	0.06



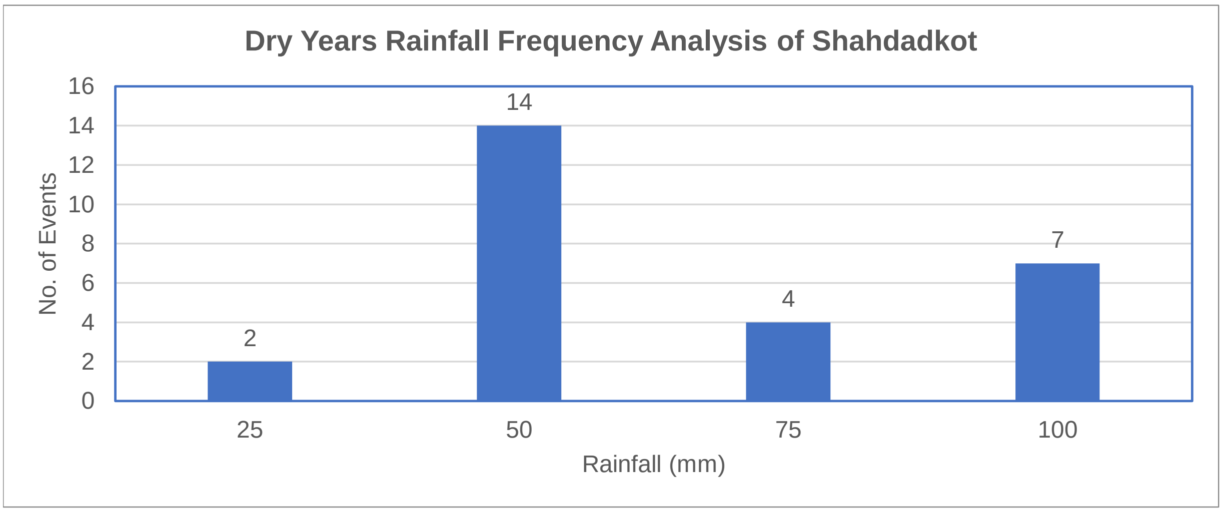
Annexure H   Dry Years Rainfall Probabilties of Naushahro Feroze

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1951	58	0.27	0.79	0.96	1.00
1952	77	0.37	0.90	0.99	1.00
1954	77	0.37	0.90	0.99	1.00
1957	46	0.21	0.70	0.91	1.00
1960	67	0.32	0.85	0.98	1.00
1963	22	0.11	0.44	0.69	0.95
1964	76	0.36	0.90	0.99	1.00
1965	53	0.25	0.76	0.94	1.00
1966	35	0.16	0.58	0.83	0.99
1968	18	0.10	0.40	0.63	0.92
1969	26	0.12	0.49	0.74	0.96
1971	51	0.24	0.74	0.93	1.00
1972	29	0.14	0.53	0.77	0.98
1973	42	0.19	0.66	0.88	1.00
1974	21	0.11	0.43	0.67	0.94
1980	57	0.27	0.79	0.96	1.00
1984	73	0.35	0.89	0.99	1.00
1987	18	0.10	0.39	0.63	0.92
1990	74	0.36	0.89	0.99	1.00
1991	25	0.12	0.48	0.73	0.96
1993	43	0.20	0.67	0.89	1.00
1996	65	0.31	0.84	0.97	1.00
1998	52	0.24	0.75	0.94	1.00
2000	33	0.15	0.57	0.81	0.98
2002	17	0.09	0.39	0.63	0.92
2004	28	0.13	0.51	0.76	0.97
2005	60	0.28	0.81	0.96	1.00
2009	78	0.37	0.90	0.99	1.00
2012	49	0.23	0.72	0.92	1.00
2014	50	0.23	0.73	0.93	1.00
No.	30	30	30	30	30
Min	17	0.09	0.39	0.63	0.92
Max	78	0.37	0.90	0.99	1.00
Average	47	0.22	0.68	0.87	0.98
STD	20	0.10	0.18	0.13	0.03



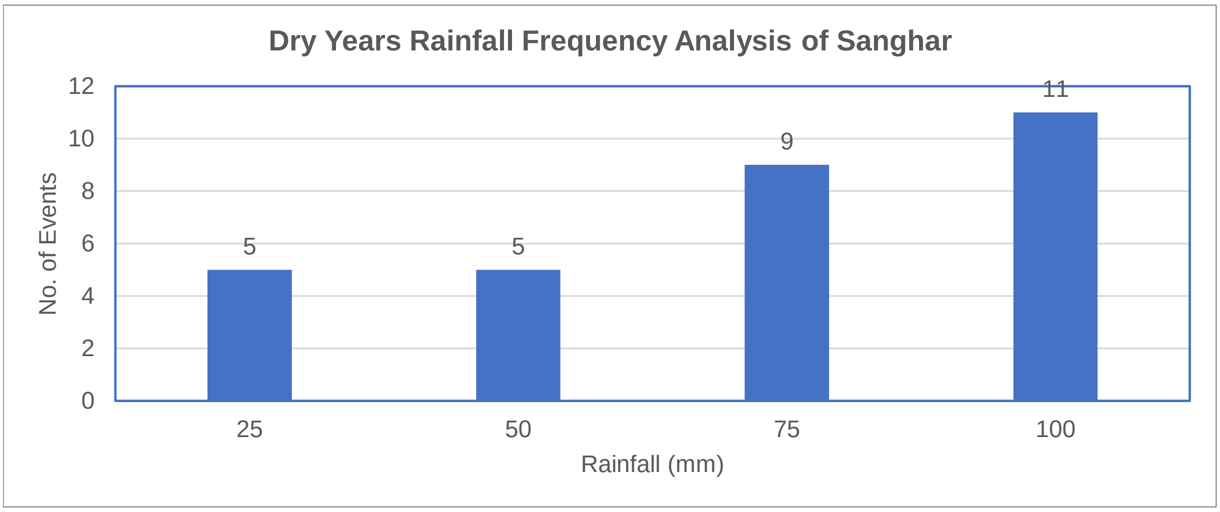
Annexure H Dry Years Rainfall Probabilties of Qamber Shahdadkot

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1955	91	0.37	0.90	0.99	1.00
1957	83	0.33	0.87	0.98	1.00
1963	22	0.10	0.41	0.66	0.93
1964	49	0.19	0.65	0.88	0.99
1965	47	0.18	0.64	0.87	0.99
1966	37	0.15	0.55	0.80	0.98
1968	32	0.13	0.51	0.76	0.97
1969	48	0.19	0.65	0.88	0.99
1971	34	0.14	0.52	0.77	0.97
1972	50	0.20	0.66	0.89	1.00
1973	32	0.13	0.50	0.75	0.97
1974	22	0.10	0.41	0.65	0.93
1977	91	0.37	0.90	0.99	1.00
1980	49	0.19	0.66	0.88	1.00
1984	69	0.27	0.80	0.96	1.00
1987	36	0.14	0.54	0.79	0.98
1991	63	0.25	0.76	0.94	1.00
1993	47	0.18	0.63	0.87	0.99
1999	89	0.36	0.89	0.99	1.00
2000	43	0.17	0.60	0.84	0.99
2001	86	0.35	0.88	0.99	1.00
2002	29	0.12	0.48	0.73	0.96
2004	44	0.17	0.61	0.85	0.99
2005	80	0.32	0.86	0.98	1.00
2009	68	0.27	0.79	0.96	1.00
2012	28	0.12	0.47	0.72	0.96
2014	83	0.33	0.87	0.98	1.00
No.	27	27	27	27	27
Min	22	0.10	0.41	0.65	0.93
Max	91	0.37	0.90	0.99	1.00
Average	54	0.22	0.67	0.86	0.99
STD	23	0.09	0.16	0.11	0.02



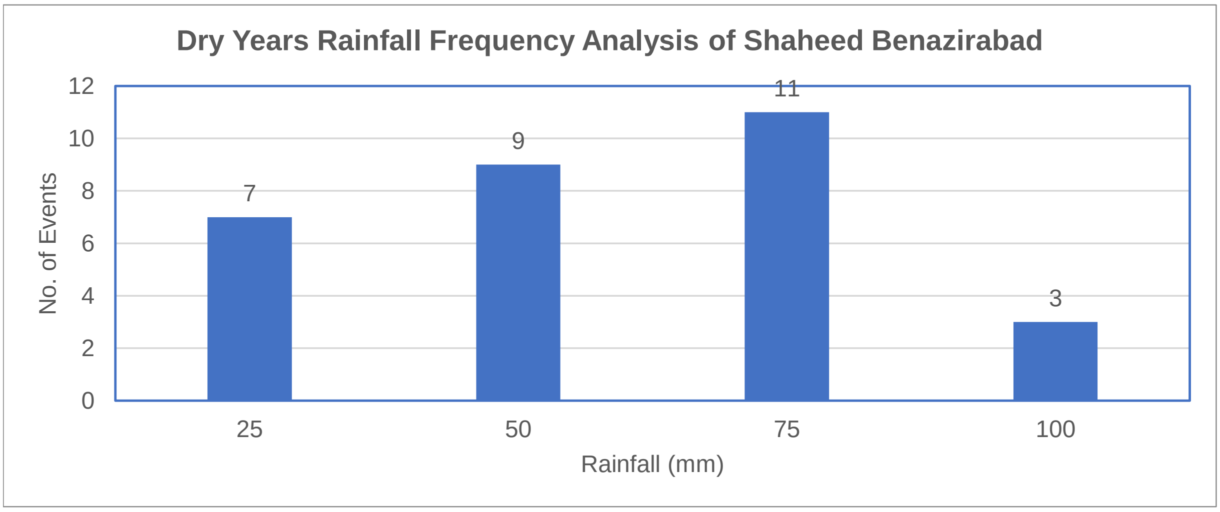
Annexure H Dry Years Rainfall Probabilties of Sanghar

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	42	0.14	0.54	0.79	0.98
1950	93	0.35	0.88	0.99	1.00
1951	47	0.16	0.59	0.83	0.99
1952	95	0.36	0.89	0.99	1.00
1954	87	0.32	0.86	0.98	1.00
1957	62	0.22	0.70	0.91	1.00
1958	98	0.37	0.90	0.99	1.00
1960	57	0.20	0.67	0.89	1.00
1963	45	0.16	0.58	0.82	0.99
1966	62	0.22	0.71	0.91	1.00
1968	37	0.13	0.51	0.76	0.97
1969	13	0.07	0.30	0.51	0.84
1972	56	0.19	0.66	0.88	1.00
1973	92	0.34	0.88	0.99	1.00
1974	18	0.08	0.34	0.56	0.87
1980	50	0.17	0.62	0.85	0.99
1981	67	0.24	0.75	0.94	1.00
1986	90	0.34	0.87	0.98	1.00
1987	22	0.09	0.37	0.60	0.90
1991	10	0.06	0.28	0.48	0.80
1996	74	0.27	0.79	0.95	1.00
1998	91	0.34	0.88	0.98	1.00
1999	79	0.29	0.82	0.97	1.00
2000	64	0.23	0.72	0.92	1.00
2001	90	0.34	0.87	0.98	1.00
2002	9	0.06	0.27	0.47	0.79
2004	48	0.17	0.60	0.84	0.99
2005	71	0.25	0.77	0.95	1.00
2008	86	0.32	0.85	0.98	1.00
2014	88	0.33	0.86	0.98	1.00
No.	30	30	29	29	29
Min	9	0.06	0.27	0.47	0.79
Max	98	0.37	0.90	0.99	1.00
Average	62	0.23	0.68	0.86	0.97
STD	28	0.10	0.20	0.17	0.06



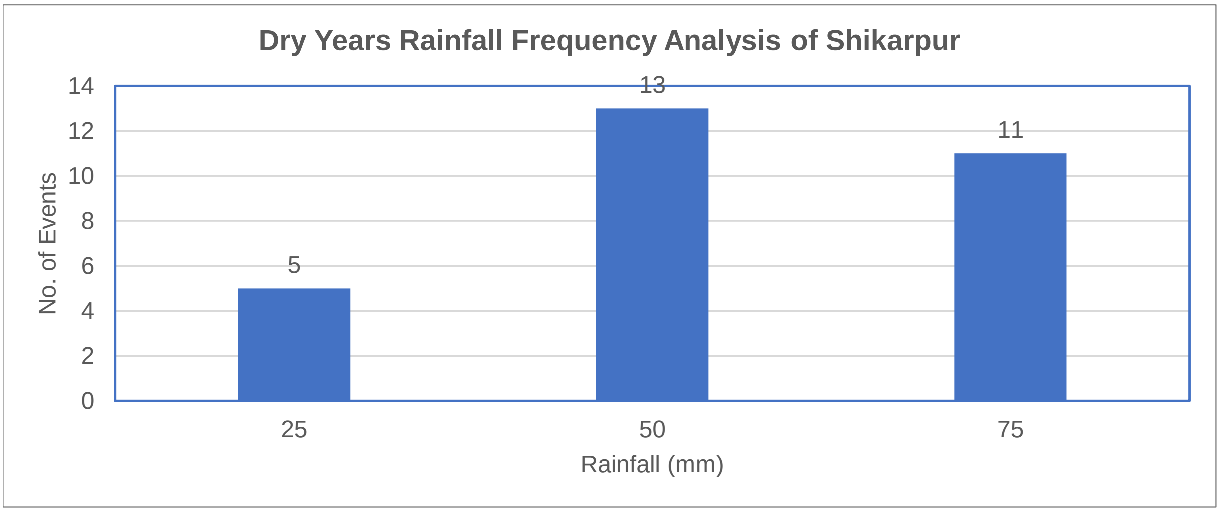
Annexure H Dry Years Rainfall Probabilties of Shaheed Benazirabad

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	64	0.30	0.83	0.97	1.00
1951	50	0.23	0.73	0.92	1.00
1952	75	0.35	0.89	0.99	1.00
1954	75	0.35	0.89	0.99	1.00
1957	41	0.19	0.65	0.88	0.99
1960	62	0.28	0.81	0.96	1.00
1963	25	0.12	0.48	0.73	0.96
1965	71	0.33	0.87	0.98	1.00
1966	45	0.20	0.68	0.90	1.00
1968	16	0.09	0.38	0.62	0.91
1969	17	0.09	0.39	0.63	0.92
1971	61	0.28	0.81	0.96	1.00
1972	24	0.12	0.47	0.72	0.96
1973	53	0.24	0.75	0.94	1.00
1974	19	0.10	0.41	0.66	0.93
1980	61	0.28	0.81	0.96	1.00
1982	76	0.36	0.89	0.99	1.00
1987	14	0.09	0.36	0.60	0.90
1990	70	0.33	0.86	0.98	1.00
1991	14	0.09	0.36	0.59	0.89
1993	54	0.25	0.76	0.94	1.00
1996	50	0.23	0.72	0.92	1.00
1998	43	0.20	0.66	0.89	1.00
1999	78	0.37	0.90	0.99	1.00
2000	40	0.18	0.63	0.86	0.99
2002	16	0.09	0.38	0.61	0.91
2004	28	0.13	0.51	0.76	0.97
2005	60	0.28	0.81	0.96	1.00
2012	69	0.32	0.86	0.98	1.00
2014	49	0.22	0.72	0.92	1.00
No.	30	30.00	30.00	30.00	30.00
Min	14	0.09	0.36	0.59	0.89
Max	78	0.37	0.90	0.99	1.00
Average	47	0.22	0.68	0.86	0.98
STD	22	0.10	0.19	0.14	0.04



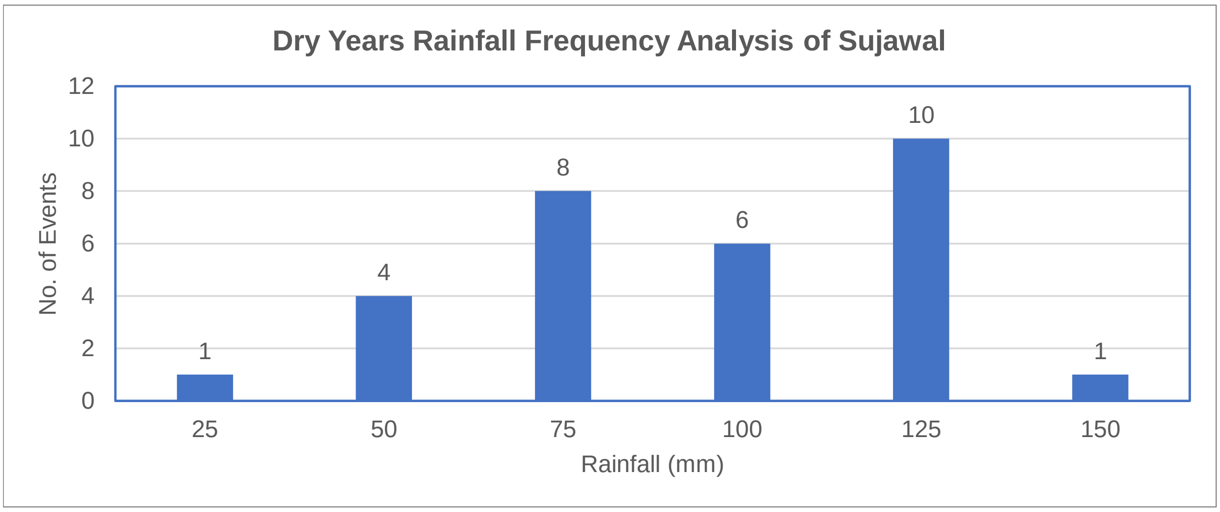
Annexure H Dry Years Rainfall Probabilties of Shikarpur

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1951	55	0.28	0.81	0.96	1.00
1952	54	0.28	0.80	0.96	1.00
1954	71	0.38	0.91	0.99	1.00
1957	48	0.24	0.75	0.94	1.00
1958	49	0.25	0.76	0.94	1.00
1960	56	0.29	0.82	0.97	1.00
1963	26	0.13	0.51	0.76	0.97
1964	63	0.33	0.86	0.98	1.00
1965	38	0.19	0.66	0.88	1.00
1966	31	0.16	0.57	0.82	0.99
1968	27	0.13	0.52	0.76	0.97
1969	19	0.10	0.42	0.66	0.93
1971	62	0.32	0.85	0.98	1.00
1972	31	0.16	0.57	0.82	0.99
1973	22	0.11	0.45	0.70	0.95
1974	17	0.10	0.39	0.63	0.92
1977	69	0.36	0.90	0.99	1.00
1980	23	0.12	0.48	0.73	0.96
1987	28	0.14	0.53	0.78	0.98
1991	31	0.15	0.56	0.81	0.98
1993	40	0.20	0.67	0.89	1.00
1998	59	0.30	0.84	0.97	1.00
2000	27	0.14	0.53	0.77	0.98
2002	16	0.09	0.38	0.62	0.91
2004	40	0.20	0.67	0.89	1.00
2005	52	0.26	0.78	0.95	1.00
2009	50	0.25	0.77	0.95	1.00
2012	53	0.27	0.79	0.96	1.00
2014	66	0.34	0.88	0.99	1.00
No.	29	29	29	29	29
Min	16	0.09	0.38	0.62	0.91
Max	71	0.38	0.91	0.99	1.00
Average	42	0.22	0.67	0.86	0.98
STD	17	0.09	0.17	0.12	0.03



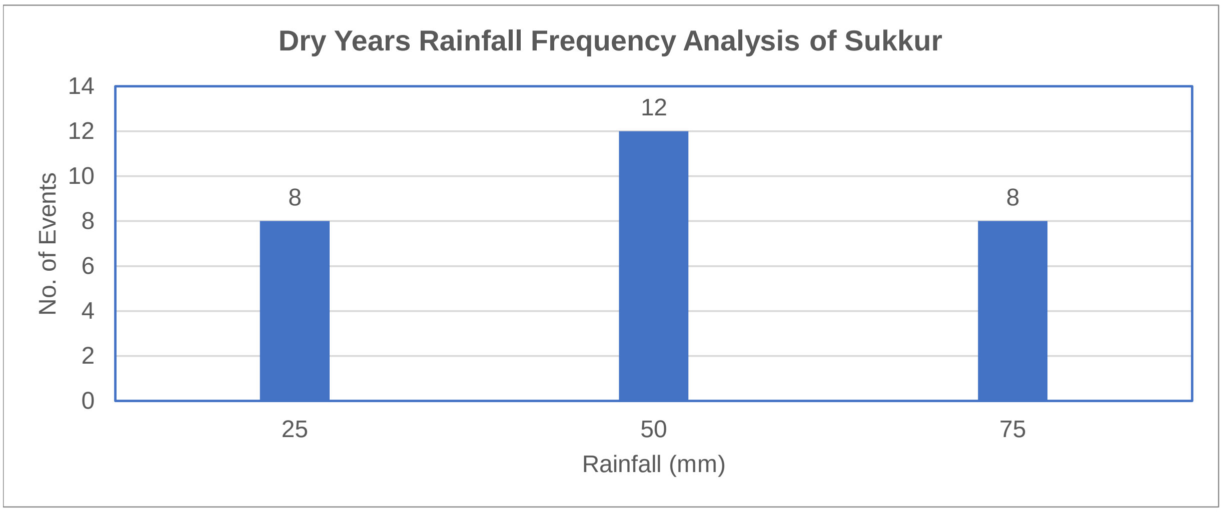
Annexure H Dry Years Rainfall Probabilties of Sujawal

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	121	0.35	0.88	0.99	1.00
1950	115	0.33	0.86	0.98	1.00
1951	66	0.17	0.61	0.85	0.99
1957	82	0.22	0.71	0.92	1.00
1960	83	0.22	0.71	0.92	1.00
1963	63	0.16	0.59	0.83	0.99
1966	81	0.22	0.70	0.91	1.00
1968	43	0.11	0.45	0.70	0.95
1969	41	0.11	0.44	0.69	0.94
1971	107	0.30	0.83	0.97	1.00
1972	62	0.16	0.58	0.83	0.99
1974	33	0.09	0.38	0.62	0.91
1981	95	0.26	0.78	0.95	1.00
1982	96	0.26	0.78	0.95	1.00
1986	123	0.35	0.89	0.99	1.00
1987	12	0.06	0.25	0.44	0.77
1989	117	0.33	0.87	0.98	1.00
1991	30	0.09	0.37	0.60	0.90
1993	72	0.19	0.65	0.88	0.99
1995	72	0.19	0.64	0.87	0.99
1996	79	0.21	0.69	0.90	1.00
1997	117	0.33	0.87	0.98	1.00
1998	129	0.37	0.90	0.99	1.00
1999	56	0.15	0.54	0.79	0.98
2000	114	0.32	0.86	0.98	1.00
2002	52	0.13	0.51	0.76	0.97
2004	74	0.20	0.66	0.89	1.00
2011	120	0.34	0.88	0.98	1.00
2012	118	0.34	0.87	0.98	1.00
2018	110	0.31	0.84	0.98	1.00
No.	30	30	30	30	30
Min	12	0.06	0.25	0.44	0.77
Max	129	0.37	0.90	0.99	1.00
Average	83	0.23	0.69	0.87	0.98
STD	32	0.09	0.18	0.14	0.05



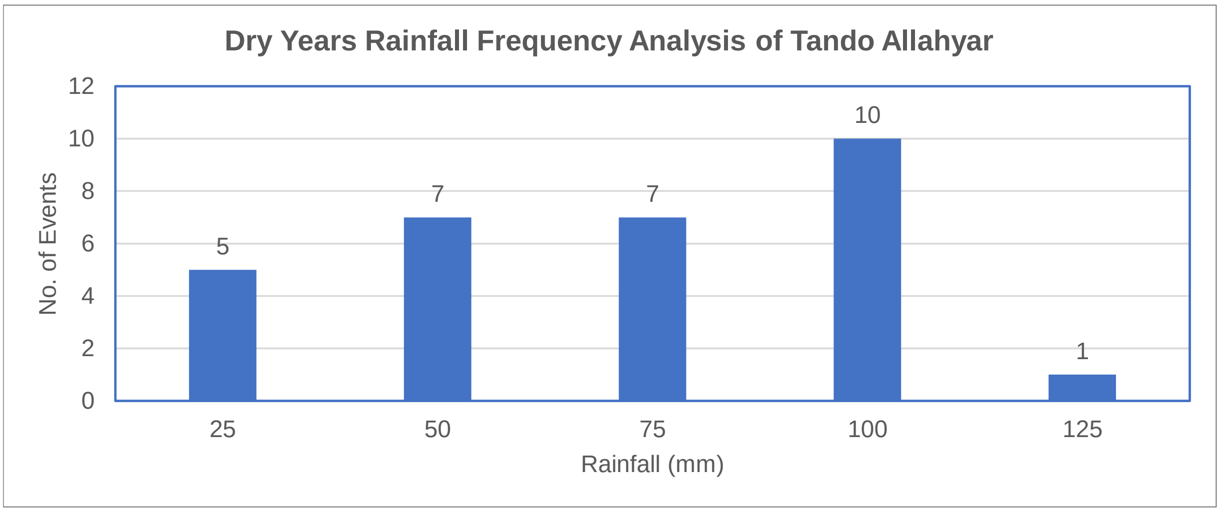
Annexure H   Dry Years Rainfall Probabilties of Sukkur

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1950	59	0.33	0.87	0.98	1.00
1951	24	0.14	0.54	0.79	0.98
1952	50	0.29	0.81	0.97	1.00
1954	65	0.37	0.90	0.99	1.00
1957	29	0.17	0.60	0.84	0.99
1958	40	0.22	0.72	0.92	1.00
1960	43	0.24	0.75	0.94	1.00
1963	30	0.17	0.61	0.85	0.99
1965	42	0.23	0.74	0.93	1.00
1966	37	0.21	0.68	0.90	1.00
1968	18	0.12	0.46	0.71	0.95
1969	15	0.10	0.42	0.67	0.94
1972	32	0.18	0.63	0.87	0.99
1973	29	0.17	0.60	0.84	0.99
1974	16	0.11	0.44	0.69	0.95
1980	23	0.14	0.53	0.78	0.98
1987	21	0.13	0.49	0.74	0.97
1990	66	0.37	0.90	0.99	1.00
1991	14	0.10	0.41	0.66	0.93
1993	39	0.22	0.71	0.91	1.00
1998	51	0.29	0.82	0.97	1.00
2000	32	0.18	0.63	0.86	0.99
2001	50	0.28	0.81	0.96	1.00
2002	12	0.09	0.38	0.62	0.91
2004	36	0.20	0.68	0.90	1.00
2005	38	0.21	0.70	0.91	1.00
2009	54	0.30	0.84	0.97	1.00
2014	67	0.38	0.91	0.99	1.00
No.	28	28	28	28	28
Min	12	0.09	0.38	0.62	0.91
Max	67	0.38	0.91	0.99	1.00
Average	37	0.21	0.66	0.86	0.98
STD	16	0.09	0.16	0.11	0.02



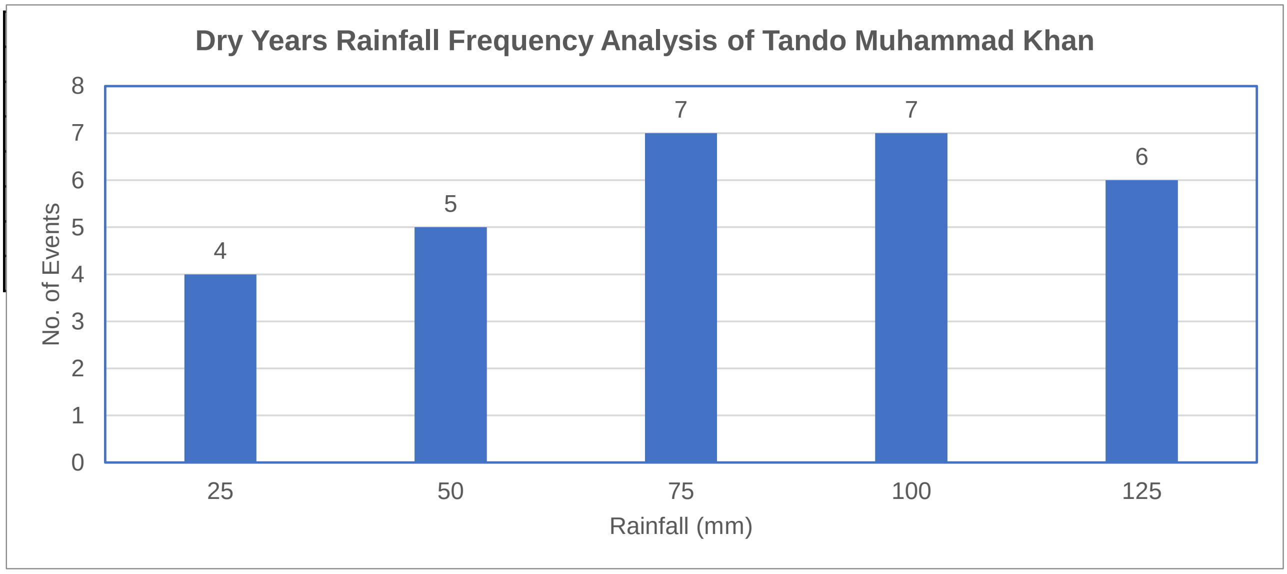
Annexure H   Dry Years Rainfall Probabilties of Tando Allahyar

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	28	0.11	0.44	0.69	0.95
1950	93	0.34	0.87	0.98	1.00
1951	55	0.19	0.66	0.88	1.00
1954	95	0.34	0.88	0.99	1.00
1957	73	0.26	0.78	0.95	1.00
1960	59	0.21	0.69	0.90	1.00
1963	42	0.15	0.56	0.80	0.98
1966	70	0.25	0.76	0.94	1.00
1968	34	0.13	0.49	0.74	0.97
1969	10	0.07	0.31	0.52	0.84
1971	91	0.33	0.86	0.98	1.00
1972	42	0.15	0.56	0.81	0.98
1973	90	0.32	0.86	0.98	1.00
1974	15	0.08	0.34	0.57	0.88
1980	70	0.25	0.76	0.94	1.00
1981	44	0.16	0.57	0.82	0.99
1982	94	0.34	0.87	0.98	1.00
1987	18	0.09	0.36	0.60	0.90
1991	11	0.07	0.32	0.53	0.85
1993	87	0.31	0.84	0.98	1.00
1996	48	0.17	0.61	0.85	0.99
1998	83	0.30	0.83	0.97	1.00
1999	65	0.23	0.73	0.93	1.00
2000	73	0.26	0.78	0.95	1.00
2001	102	0.37	0.90	0.99	1.00
2002	13	0.08	0.33	0.55	0.86
2004	44	0.16	0.57	0.82	0.99
2005	93	0.34	0.87	0.98	1.00
2008	95	0.34	0.88	0.99	1.00
2014	98	0.36	0.89	0.99	1.00
No.	30	30	30	30	30
Min	10	0.07	0.31	0.52	0.84
Max	102	0.37	0.90	0.99	1.00
Average	61	0.22	0.67	0.85	0.97
STD	30	0.10	0.20	0.16	0.05



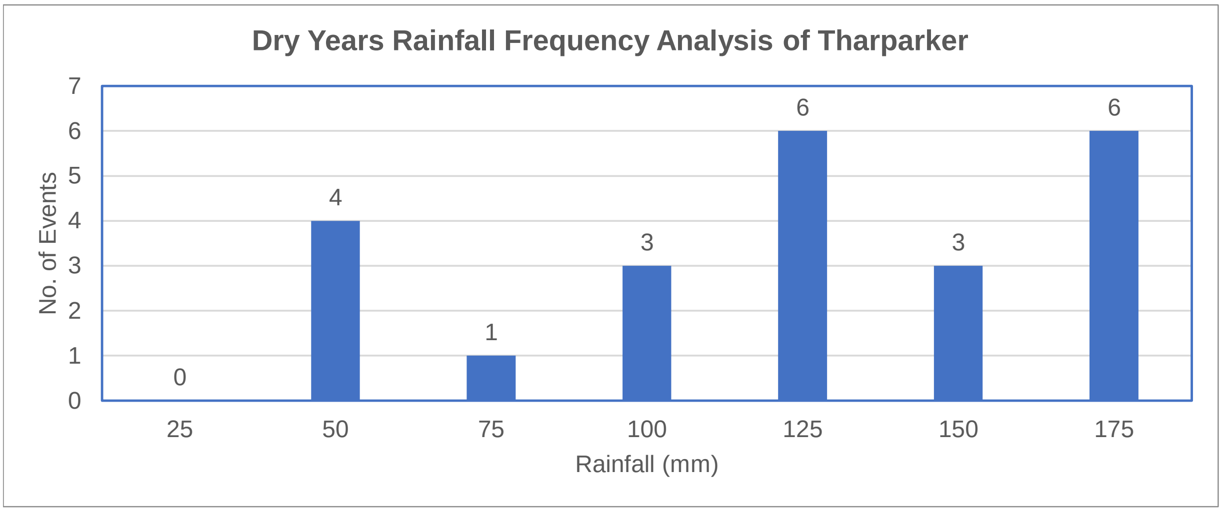
Annexure H   Dry Years Rainfall Probabilties of Tando Muhammad Khan

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	59	0.19	0.65	0.88	0.99
1950	102	0.33	0.87	0.98	1.00
1951	60	0.19	0.66	0.88	1.00
1957	79	0.25	0.77	0.95	1.00
1960	71	0.23	0.72	0.92	1.00
1963	49	0.16	0.58	0.82	0.99
1966	75	0.24	0.75	0.94	1.00
1968	33	0.12	0.46	0.71	0.95
1969	14	0.08	0.33	0.55	0.86
1971	95	0.31	0.84	0.97	1.00
1972	39	0.13	0.51	0.76	0.97
1973	104	0.34	0.88	0.98	1.00
1974	20	0.09	0.37	0.61	0.90
1980	99	0.32	0.86	0.98	1.00
1981	57	0.18	0.64	0.87	0.99
1982	79	0.25	0.77	0.95	1.00
1987	14	0.08	0.33	0.55	0.86
1991	18	0.08	0.36	0.58	0.89
1993	71	0.23	0.73	0.93	1.00
1995	103	0.34	0.87	0.98	1.00
1996	47	0.16	0.57	0.81	0.99
1997	108	0.35	0.89	0.99	1.00
1998	92	0.30	0.83	0.97	1.00
1999	62	0.20	0.67	0.89	1.00
2000	88	0.29	0.81	0.97	1.00
2002	29	0.11	0.43	0.68	0.94
2004	51	0.17	0.60	0.84	0.99
2008	114	0.37	0.90	0.99	1.00
2014	113	0.37	0.90	0.99	1.00
No.	29	29	29	29	29
Min	14	0.08	0.33	0.55	0.86
Max	114	0.37	0.90	0.99	1.00
Average	67	0.22	0.67	0.86	0.98
STD	32	0.10	0.19	0.14	0.04



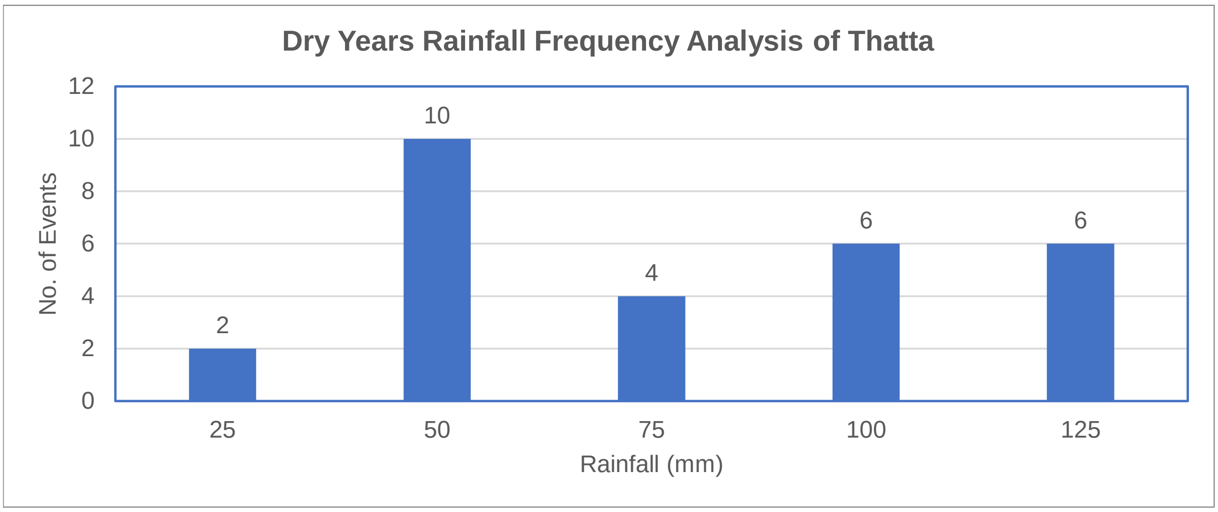
Annexure H Dry Years Rainfall Probabilties of Tharparker

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	120	0.18	0.64	0.87	0.99
1951	104	0.15	0.55	0.80	0.98
1957	148	0.25	0.76	0.94	1.00
1960	82	0.11	0.43	0.68	0.94
1963	167	0.30	0.83	0.97	1.00
1966	118	0.18	0.62	0.86	0.99
1968	96	0.13	0.51	0.76	0.97
1969	45	0.06	0.25	0.44	0.76
1972	100	0.14	0.53	0.78	0.98
1974	43	0.05	0.24	0.42	0.74
1980	112	0.17	0.60	0.84	0.99
1986	99	0.14	0.53	0.77	0.98
1987	39	0.05	0.22	0.39	0.72
1989	103	0.15	0.55	0.79	0.98
1991	61	0.08	0.33	0.55	0.86
1995	166	0.30	0.83	0.97	1.00
1996	182	0.34	0.88	0.99	1.00
1999	128	0.20	0.67	0.89	1.00
2000	166	0.30	0.83	0.97	1.00
2002	43	0.05	0.24	0.42	0.74
2004	143	0.24	0.74	0.93	1.00
2008	159	0.28	0.80	0.96	1.00
2018	156	0.27	0.79	0.96	1.00
No.	23	23	23	23	23
Min	39	0.05	0.22	0.39	0.72
Max	182	0.34	0.88	0.99	1.00
Average	112	0.18	0.58	0.78	0.94
STD	45	0.09	0.22	0.20	0.10



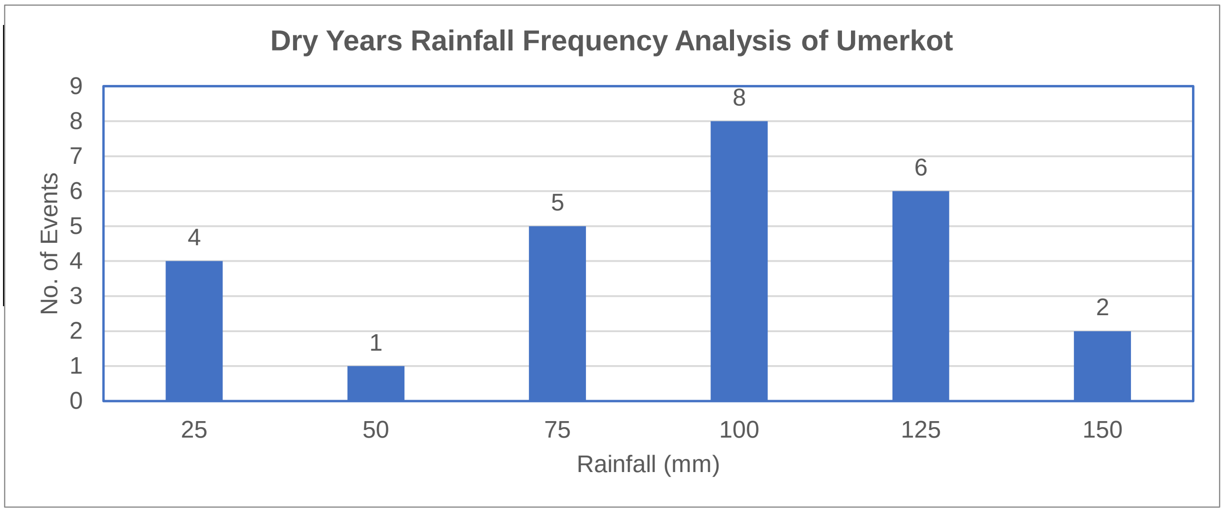
Annexure H   Dry Years Rainfall Probabilties of Thatta

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1951	48	0.16	0.59	0.83	0.99
1957	67	0.22	0.71	0.92	1.00
1960	87	0.29	0.81	0.97	1.00
1963	40	0.14	0.53	0.78	0.98
1966	69	0.23	0.72	0.92	1.00
1968	37	0.13	0.51	0.76	0.97
1969	35	0.13	0.49	0.74	0.97
1971	79	0.26	0.78	0.95	1.00
1972	47	0.16	0.58	0.82	0.99
1974	28	0.11	0.45	0.69	0.95
1981	107	0.35	0.89	0.99	1.00
1982	107	0.35	0.89	0.99	1.00
1987	9	0.07	0.31	0.53	0.85
1989	83	0.27	0.79	0.96	1.00
1991	25	0.10	0.42	0.67	0.94
1993	49	0.17	0.60	0.84	0.99
1995	52	0.17	0.61	0.85	0.99
1996	86	0.28	0.81	0.96	1.00
1997	109	0.36	0.89	0.99	1.00
1998	79	0.26	0.78	0.95	1.00
1999	40	0.14	0.53	0.78	0.98
2000	80	0.26	0.78	0.95	1.00
2002	48	0.16	0.59	0.83	0.99
2004	49	0.17	0.60	0.84	0.99
2008	112	0.37	0.90	0.99	1.00
2011	64	0.21	0.69	0.91	1.00
2014	111	0.37	0.90	0.99	1.00
2018	111	0.37	0.90	0.99	1.00
No.	28	28	28	28	28
Min	9	0.07	0.31	0.53	0.85
Max	112	0.37	0.90	0.99	1.00
Average	66	0.22	0.68	0.87	0.98
STD	30	0.09	0.17	0.12	0.03



Annexure H   Dry Years Rainfall Probabilties of Umerkot

Year	Threshold (mm/yr)	Probability of Excedence	5-years Risk	10-years Risk	25-years Risk
1948	65	0.15	0.56	0.81	0.98
1950	129	0.37	0.90	0.99	1.00
1951	67	0.16	0.58	0.82	0.99
1954	126	0.36	0.89	0.99	1.00
1957	102	0.27	0.79	0.96	1.00
1960	64	0.15	0.55	0.80	0.98
1963	86	0.22	0.70	0.91	1.00
1966	84	0.21	0.69	0.90	1.00
1968	70	0.17	0.60	0.84	0.99
1969	19	0.06	0.25	0.44	0.76
1972	88	0.22	0.72	0.92	1.00
1974	21	0.06	0.26	0.46	0.78
1980	56	0.13	0.49	0.74	0.97
1981	87	0.22	0.70	0.91	1.00
1986	84	0.21	0.69	0.90	1.00
1987	26	0.07	0.29	0.50	0.82
1989	82	0.20	0.67	0.89	1.00
1991	21	0.06	0.26	0.46	0.78
1996	114	0.31	0.85	0.98	1.00
1999	90	0.23	0.72	0.92	1.00
2000	102	0.27	0.79	0.96	1.00
2001	121	0.34	0.87	0.98	1.00
2002	15	0.05	0.23	0.41	0.73
2004	82	0.20	0.67	0.89	1.00
2005	121	0.34	0.87	0.98	1.00
2008	109	0.29	0.83	0.97	1.00
No.	26	26	26	26	26
Min	15.01	0.05	0.23	0.41	0.73
Max	129.5	0.37	0.90	0.99	1.00
Average	78.11	0.20	0.63	0.82	0.95
STD	34.77	0.10	0.21	0.19	0.09



ANNEXURE-I

SMALL DAMS ALREADY COMPLETED

LIST OF SMALL DAMS ALREADY CONSTRUCTED IN SINDH PROVINCE

Sr. Nr.	Name of Small Dam	Development Scheme	Latitude	Longitude	District	Type of Dam	Catchment Area (acre)	Crest Height (ft)	Annual Inflow (ac-ft)	Reservoir Capacity (ac-ft)
1	Lakhy-Jo-Wandio	ADP	24°22'36.4" N	70°41'13.4"E	Nagarparkar	Recharge	2,819	10		2506
2	Ranpur Bund	ADP	24°21'16.7" N	70°52'23.7"E	Nagarparkar	Storage	15,872	10	3129.0	800
3	Mulji	ADP	24°24'44.8"N	70°41'16.2"E	Nagarparkar	Recharge	6,144	8	1236.0	600
4	Bhodesar Tank	ADP	24°23'50.0"N	70°43'53.0"E	Nagarparkar	Storage	383	7	77.0	300
5	Khararo Bund	ADP	24°24'29.53"N	70°38'35.06"E	Nagarparkar	Delay Action	55,038	10	1107.0	600
6	Tobirio Tank	ADP	24°21'48.33"N	70°44'47.88"E	Nagarparkar	Storage	89	4	18.0	200
7	Miskeen Jahan Khan Khoso	ADP	24°22'49.5"N	70°44'45.0"E	Nagarparkar	Storage		6		1520
8	Bartlao Dam	ADP	24°22'51.1"N	71°00'45.8"E	Nagarparkar	Storage		6		2500
9	Kali Das	ADP	24°21'54.1"N	70°44'39.2"E	Nagarparkar	Recharge	1,977	15		1012
10	Vera Wah	ADP	24°30'57.8"N	70°47'19.3"E	Nagarparkar	Recharge		8		980
11	Ranasar	ADP	24°16'3.28"N	70°43'22.94"E	Nagarparkar	Recharge		6		382
12	Gotrawa	ADP	24°14'12.94"N	70°46'50.33"E	Nagarparkar	Recharge		8		399
13	Abasar	ADP	24°17'3.94"N	70°36'24.48"E	Nagarparkar	Recharge		-		1,179
14	Kanji-Jo-Wandio	ADP	24°29'16.11"N	70°50'43.25"E	Nagarparkar	Recharge		8		341
15	Naryasar Dam	PSDP	24°21'20.70"N	70°48'57.82"E	Nagarparkar	Tank	1,018	8	320.0	3,603
16	Ghartiari Dam	PSDP	24°19'41.33"N	70°47'15.29"E	Nagarparkar	Recharge	1,831	10	300.0	1,290
17	Gordhro Bhatiani	PSDP	24°23'45.1"N	70°47'27.6"E	Nagarparkar	Recharge	2,103	8	5307.0	7,476
18	Chanida Dam	PSDP	24°27'24.13"N	70°50'44.36"E	Nagarparkar	Storage		6		1,824
19	Lakar Khadio Dam	PSDP	24°15'57.59"N	70°43'5.44"E	Nagarparkar	Recharge		N/A		1,197
20	Koowara Dam	PSDP	24°20'42.21"N	70°54'25.11"E	Nagarparkar	Storage		6		326
21	Jhinjasar	PSDP	24°21'47.3"N	70°38'07.7"E	Nagarparkar	Storage		8		266
22	Adhigam	PSDP	24°18'6.48"N	70°39'18.68"E	Nagarparkar	Storage		6		361
23	Surachand	PSDP	24°18'12.3"N	70°49'59.7"E	Nagarparkar	Recharge	7,653		337.0	4,935
24	Rinmalsar Dam	PSDP	24°26'29.30"N	70°39'47.34"E	Nagarparkar	Recharge		8		809
25	Sabusan	SRP	24°16'17.8"N	70°41'33.1"E	Nagarparkar	Recharge	3,270	15		570

LIST OF SMALL DAMS ALREADY CONSTRUCTED IN SINDH PROVINCE

Sr. Nr.	Name of Small Dam	Development Scheme	Latitude	Longitude	District	Type of Dam	Catchment Area (acre)	Crest Height (ft)	Annual Inflow (ac-ft)	Reservoir Capacity (ac-ft)
26	Sankar	SRP	24°32'33.4"N	70°50'16.1"E	Nagarparkar	Recharge	2,573	15		1,003
27	Rathi	SRP	24°34'46.3"N	70°50'28.9"E	Nagarparkar	Recharge	5,414	15		2,416
28	Larha Nai Dam	PSDP	27°33'27.34"N	68°58'35.12"E	Khairpur	Recharge		13		151
29	Aikrso Nai Dam	PSDP	27°27'38.69"N	68°58'37.97"E	Khairpur	Recharge		5		236
30	Ukhari Nai Dam	PSDP	27°26'23.41"N	68°57'54.28"E	Khairpur	Recharge		10		487
31	Wariwaro Nai Dam	PSDP	27°22'58.13"N	68°55'24.86"E	Khairpur	Recharge		10		401
32	Kiniri Nai Dam	PSDP	27°25'31.29"N	68°56'32.48"E	Khairpur	Recharge		13		700
33	Salari	ADP	27°9'0.05"N	67°22'25.72"E	Dadu	Recharge	57,576	8	21,972	278
34	Makhi Nai Dam	ADP	27° 2'26.83"N	67°21'38.52"E	Dadu	Recharge	43,491	8	17,972	246
35	Taki Nai Dam	ADP	26°45'56.65"N	67°22'14.96"E	Dadu	Detention Weir	38,548	10	52,270	1,516
36	Angai-2 (Tunny)	ADP	27°19'45.81"N	67°26'20.84"E	Dadu	Recharge		15		1,102
37	Halelli	ADP	26°33'23.70"N	67°22'54.92"E	Dadu	Gravity Weir		7		178
38	Gamrach	ADP	26°20'25.88"N	67°36'43.30"E	Dadu	Recharge		10		176
39	Dillan	ADP	27°20'18.79"N	67°28'36.16"E	Dadu	Recharge	38,548	10	5,089	
40	Mazarani	ADP	27°22'46.66"N	67°32'33.83"E	Dadu	Recharge	83,027	12	10,960	
41	Shori Nai Dam	PSDP	26°41'52.33"N	67°20'2.12"E	Dadu	Gravity Weir	39,290	8	5,803	182
42	Kukrani	PSDP	26°35'56.2"N	67°21'14.2"E	Dadu	Gravity Weir	7,907	12	20,750	215
43	Khurbi	PSDP	27° 5'45.32"N	67°22'24.55"E	Dadu	Gravity Weir	12,859	8	7,539	210
44	Dhing Dhoro	PSDP	26°15'47.00"N	67°44'19.17"E	Dadu	Gravity Weir	34,101	10	19,357	367
45	Buri	PSDP	27°13'55.11"N	67°25'38.94"E	Dadu	Gravity Weir	63,506	13	19,560	964
46	Qasim Tok Dam	SRP	26°33'57.1"N	67°21'44.1"E	Dadu	Recharge	2,867	12		1,107
47	Nali Dam	SRP	26°36'59.57"N	67°23'27.76"E	Dadu	Recharge	62,758	7		113
48	Dhal Nai	ADP	26° 4'18.53"N	67°47'12.65"E	Jamshoro	Recharge		15		962
49	Dhadar Dam	ADP	27°30'46.77"N	67°32'15.82"E	Jamshoro	Gravity Weir		11		502
50	Maliriri	ADP	25°57'22.70"N	67°46'24.82"E	Jamshoro	Recharge		12		643

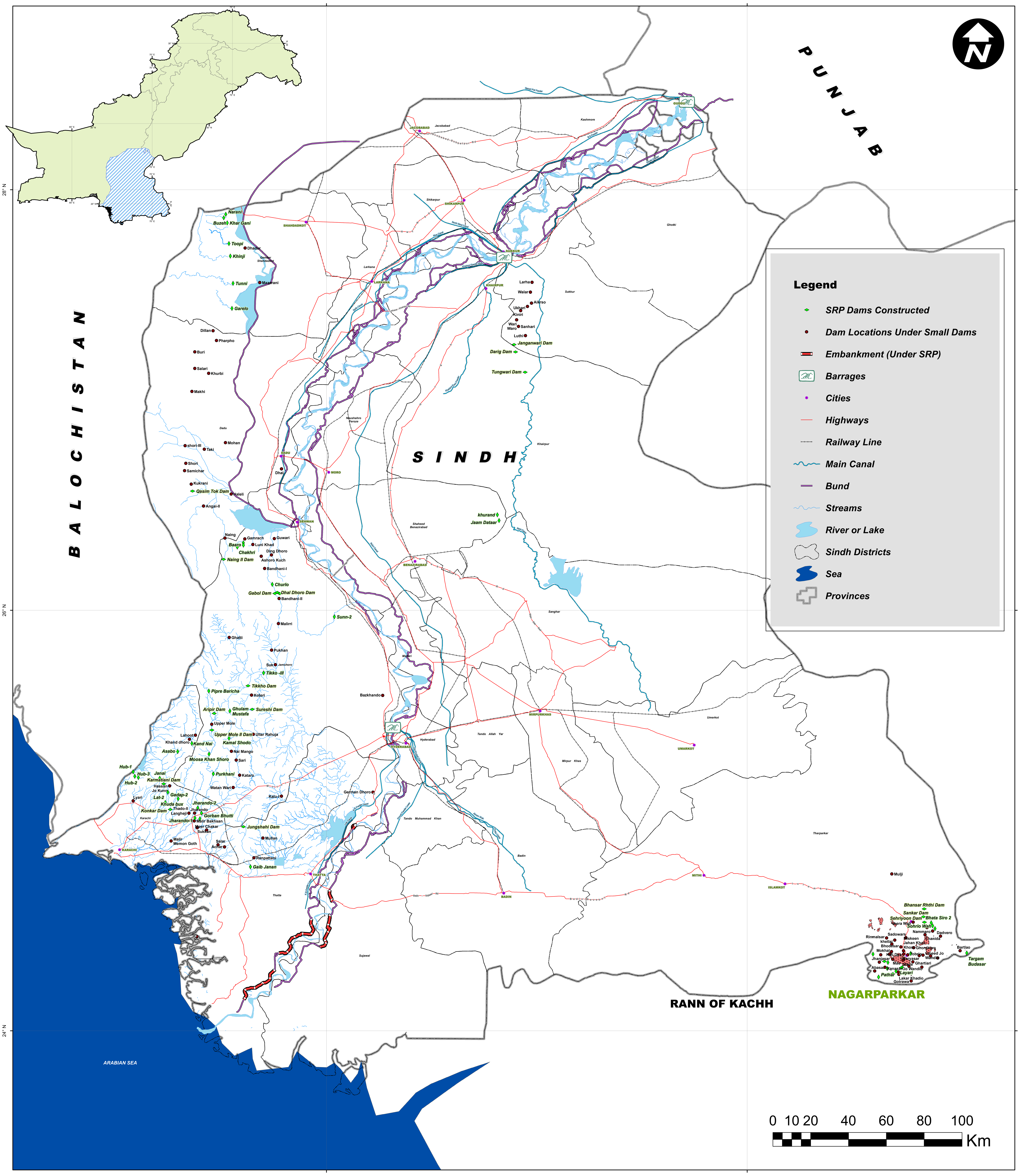
LIST OF SMALL DAMS ALREADY CONSTRUCTED IN SINDH PROVINCE

Sr. Nr.	Name of Small Dam	Development Scheme	Latitude	Longitude	District	Type of Dam	Catchment Area (acre)	Crest Height (ft)	Annual Inflow (ac-ft)	Reservoir Capacity (ac-ft)
51	Mohan (Rustamani) Dam	ADP	25°54'13.31"N	67°52'16.51"E	Jamshoro	Recharge		15		1,315
52	Ashoro Kuch	ADP	26°15'21.96"N	67°41'24.42"E	Jamshoro	Recharge		20		668
53	Guwari	ADP	26°20'26.30"N	67°45'7.72"E	Jamshoro	Recharge		10		612
54	Naing Nai Dam-1	ADP	26°20'39.43"N	67°31'3.35"E	Jamshoro	Recharge	170,058	8	12,615	
55	Bandhani-2	PSDP	26° 9'31.84"N	67°42'14.90"E	Jamshoro	Gravity Weir	21,763	8	28,117	158
56	Gabol Dam	SRP	26°04'47.7"N	67°45'17.8"E	Jamshoro	Recharge	44,717	15		110
57	Dhal Dhoro Dam	SRP	26°05'07.0"N	67°45'57.7"E	Jamshoro	Recharge	5,843	17		87
58	Naing-II Dam	SRP	26°14'33.4"N	67°30'35.5"E	Jamshoro	Recharge	152,858	14		226
59	Suk	ADP	25°44'27.85"N	67°45'49.84"E	Jamshoro	Recharge	80,799	6	35,001	327
60	Koteri	ADP	25°35'47.51"N	67°38'38.71"E	Jamshoro	Recharge	17,792	20.6	13,605	-
61	Nai-Mango	ADP	25°19'45.35"N	67°32'54.57"E	Jamshoro	Recharge	8,639	13	3,000	-
62	Kalu-1	ADP	25° 6'55.36"N	67°47'9.20"E	Jamshoro	Recharge	54,079	4	17,000	-
63	Rani Koti (Sann Nai) Dam	ADP	25°56'22.16"N	68° 1'29.19"E	Jamshoro	Detention Weir	48,186	5	62,240	1,775
64	Bandhani-1	ADP	26°11'50.22"N	67°43'19.41"E	Jamshoro	Detention Weir	83,769	8	61,222	804
65	Sari	ADP	25.2872007949N	67.5714536621E	Jamshoro	Recharge	48,126	6.25	16,000	-
66	Bazkhando	PSDP	25°35'41.50"N	68°16'03.10"E	Jamshoro	Recharge	59,058	15	26,235	681
67	Watan Wari	PSDP	25°09'25.50"N	67°33'23.50"E	Jamshoro	Recharge	63,336	12	12,085	256
68	Upper Mole -II	SRP	25°25'49.2"N	67°27'18.8"E	Jamshoro	Recharge	57,677	11		139
69	Aripir	SRP	25°30'34.1"N	67°27'58.0"E	Jamshoro	Recharge	23,392	15		218
70	Sureshi	SRP	25°31'45.7"N	67°38'50.8"E	Jamshoro	Recharge	4,640	12		126
71	Tikho-II	SRP	25°38'27.4"N	67°37'36.7"E	Jamshoro	Recharge	50,342	12		116
72	Malir Memon Goth Weir	ADP	24°54'01.5"N	67°15'29.9"E	Karachi	Detention Weir	127,506	13	-	-
73	Achar	ADP	24°52'22.31"N	67°30'52.89"E	Karachi	Recharge	6,104	10	16,219	
74	Salar	ADP	24°53'3.93"N	67°29'4.58"E	Karachi	Recharge	7,265	10	17,000	
75	Gaddap (Lat) Gravity Wier	PSDP	25°06'06.60"N	67°14'30.10"E	Karachi	Recharge	325,290	10	5,307	8,500

LIST OF SMALL DAMS ALREADY CONSTRUCTED IN SINDH PROVINCE

Sr. Nr.	Name of Small Dam	Development Scheme	Latitude	Longitude	District	Type of Dam	Catchment Area (acre)	Crest Height (ft)	Annual Inflow (ac-ft)	Reservoir Capacity (ac-ft)
76	Khand Dhoro	PSDP	25°23'58.73"N	67°21'57.49"E	Karachi	Recharge	58,600	20	4,570	280
77	Ullar-Rahuja	PSDP	25°24'37.70"N	67°39'09.40"E	Karachi	Recharge	46,923	15	6,546	10,395
78	Upper Mole Dam	PSDP	25°27'28.45"N	67°27'16.88"E	Karachi	Recharge	28,612	8	12,097	273
79	Liyari	PSDP	25°05'37.20"N	67°04'50.60"E	Karachi	Recharge	11,169	15	9,000	45
80	Thado-2	ADP	25° 4'54.59"N	67°16'21.84"E	Gaddap Karachi	Recharge	21,325	5	20,649	-
81	Meer Chakar	ADP	24°58'11.60"N	67°25'24.90"E	Gaddap Karachi	Gravity Weir	15,620	15	8,250	-
82	Mole Nadi	ADP	25° 4'0.40"N	67°24'12.04"E	Gaddap Karachi	Gravity Weir	43,644	10	6,373	-
83	Sukhan	PSDP	24°57'56.80"N	67°23'09.30"E	Gaddap Karachi	Recharge	43,644	10	17,000	177
84	Hassan Jo Kun	PSDP	25°09'53.90"N	67°15'16.10"E	Gaddap Karachi	Recharge	1,189	12	3,500	50
85	Konkar	SRP	25°03'09.4"N	67°15'28.6"E	Gaddap, Karachi	Recharge	2,272	12		32
86	Karmatiani	SRP	25°10'28.0"N	67°13'32.0"E	Gaddap, Karachi	Recharge	10,867	12		33
87	Langheji	ADP	25° 2'3.70"N	67°20'49.00"E	Kathor Karachi	Recharge	63,808	6	24,500	-
88	Jharando	ADP	25° 2'11.36"N	67°22'56.01"E	Kathor Karachi	Recharge	54,719	4.5	20,000	-
89	Malir Bakhshan	PSDP	24°59'54.55"N	67°22'18.66"E	Malir Karachi	Recharge	41,610	12	7,448	1,270
90	Kataro	ADP	25°11'51.73"N	67°54'46.97"E	Thatta	Gravity Weir	47,197	7	1,200	-
91	Mullan (Mulla)	PSDP	24°55'03.9"N	67°41'54.3E	Thatta	Recharge	266,380	15	-	146
92	German Dhoro	PSDP	25°07'51.20"N	68°12'54.80"E	Thatta	Recharge	2,016	10	7,500	80
93	Ranpathani	PSDP	24°49'21.40"N	67°39'20.50"E	Thatta	Recharge	41,514	12	56,166	160
94	Jungshahi	SRP	24°58'17.0"N	67°36'17.4"E	Thatta	Recharge	20,819	15		341

MAP OF SMALL DAMS ALREADY CONSTRUCTED SINDH PROVINCE



ANNEXURE-J

SMALL DAMS UNDER CONSTRUCTION

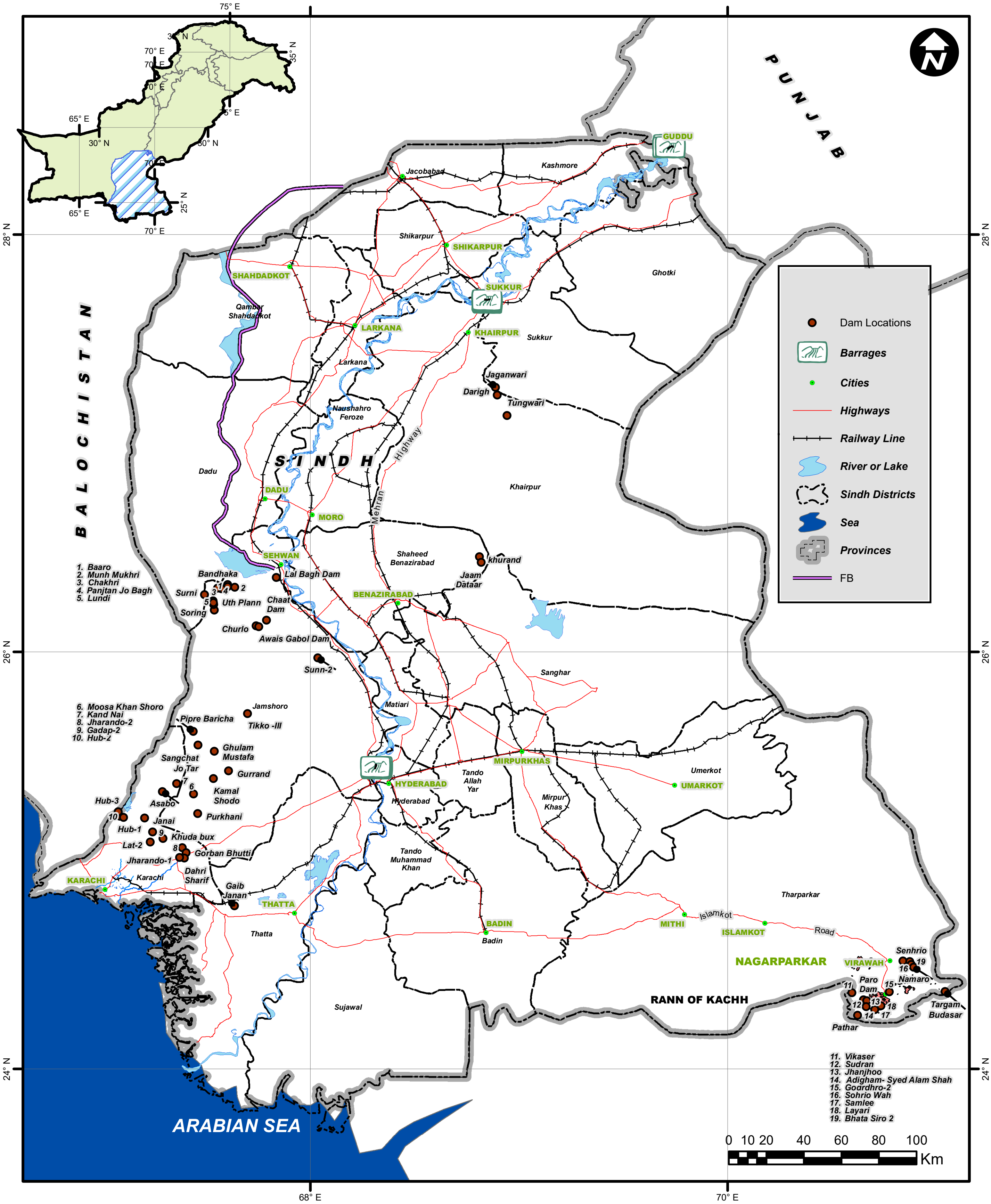
LIST OF SMALL DAMS UNDER CONSTRUCTION IN SINDH PROVINCE

Sr. Nr.	Name of Small Dam	Development Scheme	Latitude	Longitude	District	Type of Dam	Catchment Area (mi2)	Crest Height (ft)	Annual Inflow (ac-ft)	Reservoir Capacity (ac-ft)
1	Bhatta Siro-2	SRP	24° 30' 35.0" N	70° 52' 34.2" E	Tharparkar	Recharge	1.76	10	373.8	173
2	Sohrio Wah	SRP	24° 30' 01.2" N	70° 52' 55.7" E	Tharparkar	Recharge	1.32	12	270.0	69
3	Namaro	SRP	24° 28' 36.5" N	70° 53' 08.3" E	Tharparkar	Recharge	3.5	13	726.9	289
4	Viakasar	SRP	24° 21' 54.27" N	70° 36' 09.65" E	Tharparkar	Recharge	3.34	11	693.6	274
5	Gordhro-2	SRP	24° 21' 54.23" N	70° 46' 27.00" E	Tharparkar	Recharge	8.94	10	1856.6	278
6	Sudran	SRP	24° 19' 30.62" N	70° 40' 10.74" E	Tharparkar	Recharge	2.21	13	459.0	117
7	Adhigam- Syed Alam Shah	SRP	24° 17' 57.6" N	70° 40' 06.1" E	Tharparkar	Recharge	2.73	13	560.7	55
8	Layari-1	SRP	24° 18' 08.00" N	70° 44' 16.40" E	Tharparkar	Recharge	0.83	13	166.1	83
9	Jhanjhoo	SRP	24° 17' 22.3" N	70° 42' 24.8" E	Tharparkar	Recharge	3.18	13	647.9	40
10	Pathar	SRP	24° 15' 24.34" N	70° 37' 30.06" E	Tharparkar	Recharge	3.49	12	724.5	134
11	Targaam Budhesar	SRP	24° 22' 23.77"N	71° 02' 34.27" E	Tharparkar	Recharge	0.95	10	227.7	171
12	Paro Jo Wandio	SRP	8831395.461 N	2190358.896 E	Tharparkar	Recharge	0.95	10	-	20
13	Samlee	SRP	8820635.327 N	2217214.191 E	Tharparkar	Recharge	3.09	11	-	15
14	Sahriyou	SRP	8899747.403 N	2252863.002 E	Tharparkar	Recharge	1.62	14	-	15
15	Tangwari	SRP	9846088.15 N	1622210.714 E	Khairpur	Recharge	21.74	10	-	85.3
16	Jaganwari	SRP	9893857.97 N	1605221.809 E	Khairpur	Recharge	2.8	10	-	10.7
17	Darigh	SRP	9881205.6 N	1607387.8 E	Khairpur	Recharge	12.08	9	-	54
18	Khurand	SRP	26° 27' 28.03" N	68° 48' 42.35" E	Shaheed Benazeerabad	Recharge	8.26	9	209.0	156
19	Jaam Datar	SRP	26° 25' 39.62" N	68° 49' 12.61" E	Shaheed Benazeerabad	Recharge	54.82	9	1387.7	388
20	Garato	SRP	26° 14' 32.46" N	67° 32' 09.45" E	Jamshoro	Recharge	2.24	16	120.4	43
21	Soring	SRP	26° 11' 55.61" N	67° 32' 26.60" E	Jamshoro	Recharge	7.59	16	407.9	75
22	Lundi	SRP	26° 14' 03.11" N	67° 32' 12.25" E	Jamshoro	Recharge	0.91	10.5	48.4	37
23	Surni	SRP	26° 16' 18.36" N	67° 29' 39.36" E	Jamshoro	Recharge	2.46	16	132.2	28
24	Uth Plann	SRP	26° 13' 30.18" N	67° 32' 17.79" E	Jamshoro	Recharge	3.69	15	198.3	160
25	Munh Mukhri	SRP	26° 18' 27.97" N	67° 38' 23.86" E	Jamshoro	Recharge	36.12	14.5	1941.1	267
26	Panjtan Jo Bagh	SRP	26° 18' 10.85" N	67° 33' 22.05" E	Jamshoro	Recharge	1.11	14	53.7	45
27	Chaat Dam	SRP	26° 08' 59.71" N	67° 47' 29.88" E	Jamshoro	Recharge	34.58	16	1858.1	266
28	Awais Gabol	SRP	26° 07' 07.43" N	67° 45' 14.52" E	Jamshoro	Recharge	9.00	16	483.4	360

LIST OF SMALL DAMS UNDER CONSTRUCTION IN SINDH PROVINCE

Sr. Nr.	Name of Small Dam	Development Scheme	Latitude	Longitude	District	Type of Dam	Catchment Area (mi2)	Crest Height (ft)	Annual Inflow (ac-ft)	Reservoir Capacity (ac-ft)
29	Lal Bagh	SRP	26° 21' 14.39" N	67° 50' 15.80" E	Jamshoro	Recharge	1.47	10	79.1	65
30	Bandhaka	SRP	26° 19' 15.5576" N	67° 36' 17.1710" E	Jamshoro	Recharge	13.85	16	747.0	565
31	Baaro	SRP	26° 18' 36.8314" N	67° 36' 18.6983" E	Jamshoro	Recharge	5.54	16	297.9	93
32	Chakhri	SRP	26° 18' 02.7596" N	67° 34' 33.1078" E	Jamshoro	Recharge	2.59	16	139.7	29
33	Churlo	SRP	26° 07' 24.4044" N	67° 44' 32.0997" E	Jamshoro	Recharge	103.13	13.5	5553.4	96
34	Sunn-2	SRP	25° 58' 07.3488" N	68° 02' 15.4416" E	Jamshoro	Recharge	104.99	15	5642.1	407
35	Tikho-III	SRP	25°42'9.18"N	67°42'3.65"E	Jamshoro	Recharge	97.2	15	6934.5	295
36	Pipre Baricha	SRP	25°36'59.02"N	67°26'25.43"E	Jamshoro	Recharge	23.61	13	2014.3	49
37	Ghulam Mustafa	SRP	25°31'15.74"N	67°32'25.73"E	Jamshoro	Recharge	13.06	15	1114.2	173
38	Kamal Shodo	SRP	25°23'28.63"N	67°32'11.31"E	Jamshoro	Recharge	21.49	13	1834.3	66.9
39	Moosa Shoro	SRP	25°18'57.46"N	67°26'31.82"E	Jamshoro	Recharge	142.98	14	12199.8	380
40	Purkhani	SRP	25°13'20.33"N	67°27'42.46"E	Jamshoro	Recharge	193.34	11.5	16497.1	115
41	Sang chat Jo Tarr	SRP	25° 33' 06.09" N	67° 27' 48.3" E	Jamshoro	Recharge	33.78	12	-	140
42	Gurrand	SRP	25° 25' 48.9127" N	67° 36' 12.9752" E	Jamshoro	Recharge	16.57	10	-	41
43	Kand Nai	SRP	25°22'1.45"N	67°21'37.14"E	Karachi	Recharge	6.27	15	534.6	161.4
44	Asabo	SRP	25°19'42.93"N	67°17'33.59"E	Karachi	Recharge	13.69	15	1168.3	86
45	Janai	SRP	25°12'4.37"N	67°12'25.84"E	Karachi	Recharge	1.48	16	126.3	68.5
46	Hub-1	SRP	25°13'54.80"N	67° 4'51.16"E	Karachi	Recharge	3.85	15.5	328.7	28.8
47	Hub-2	SRP	25°12'37.96"N	67° 5'25.15"E	Karachi	Recharge	6.78	14	578.2	52
48	Hub-3	SRP	25°12'17.25"N	67° 6'20.31"E	Karachi	Recharge	11.63	13	992.4	33.3
49	Gadap-2	SRP	25° 08' 06.2798" N	67° 14' 48.4810" E	Karachi	Recharge	6.78	16	580.2	164
50	Khuda Bux	SRP	25° 06' 13.7537" N	67° 17' 30.8545" E	Karachi	Recharge	63.31	11	5401.1	345
51	Lat-2	SRP	25° 05' 10.3485" N	67° 14' 01.3249" E	Karachi	Recharge	29.47	12.5	2515.0	61
52	Jharando-2	SRP	25° 03' 36.5673" N	67° 23' 16.1906" E	Karachi	Recharge	27.77	15	2369.0	210
53	Ghorban Bhutti	SRP	25° 02' 09.3553" N	67° 24' 20.3033" E	Karachi	Recharge	238.41	12	20342.6	120
54	Dahri Sharif	SRP	25° 00' 32.9860" N	67° 23' 53.5540" E	Karachi	Recharge	457.72	10	39053.2	87
55	Jharando-1	SRP	25° 00' 44.7851" N	67° 22' 34.7871" E	Karachi	Recharge	30.7	15	2619.5	77
56	Gaib Janan	SRP	24° 46' 49.9612" N	67° 38' 18.4161" E	Thatta	Recharge	11.83	10	1009.6	607

MAP OF SMALL DAMS UNDER CONSTRUCTION SINDH PROVINCE



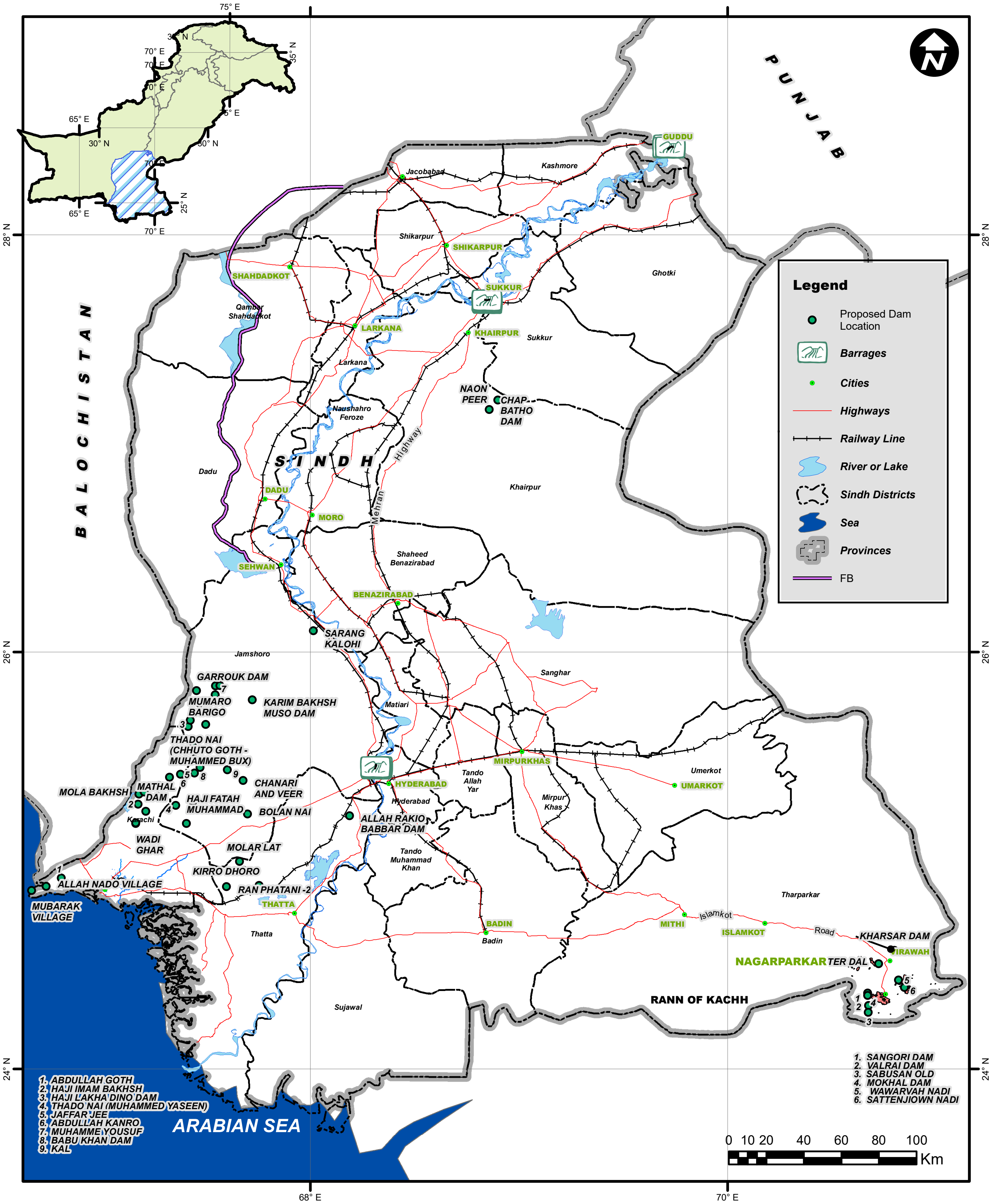
ANNEXURE-K

SMALL DAMS IN PIPELINE

Annex: K - Location of 50 Dams in Pipelinein Sindh Province

Sr. Nr.	Name	Coordinates			
		UTM - Ft		Geodetic	
		X	Y	LATITUDE	LONGITUDE
1	MUBARAK VILLAGE	866338.44	9025148.59	24° 51' 16.4251" N	66° 39' 54.1162" E
2	ALLAH NADO VILLAGE	889718.76	9032158.02	24° 52' 29.7406" N	66° 44' 06.5835" E
3	ABDULLAH GOTH	914095.95	9046299.43	24° 54' 53.7265" N	66° 48' 28.7173" E
4	WADI GHAR	1033634.74	9139273.73	25° 10' 32.1083" N	67° 09' 53.1956" E
5	MATHAL DAM	1049989.64	9160346.74	25° 14' 03.0047" N	67° 12' 48.1552" E
6	HAJI IMAM BAKHSH	1037744.91	9172957.71	25° 16' 06.2775" N	67° 10' 32.9546" E
7	MOLA BAKHSH	1039536.44	9190380.24	25° 18' 59.0751" N	67° 10' 49.8926" E
8	DHANI BAKHSH BHIGAT	1046767.34	9196192.47	25° 19' 57.6082" N	67° 12' 07.8340" E
9	NATIONAL PARK2	1048042.59	9194079.58	25° 19' 36.8510" N	67° 12' 22.0402" E
10	SANYASI DAM	1068952.3	9186012.61	25° 18' 19.6759" N	67° 16' 11.0448" E
11	AATHO DAM	1078666.3	9183956.72	25° 18' 00.5445" N	67° 17' 57.1738" E
12	SUNDI NAI (BAHI KHAN GOTH)	1070940.04	9205209.32	25° 21' 30.0670" N	67° 16' 30.0080" E
13	THADO NAI (CHHUTO GOTH - MUHAMMED B	1088183.07	9219578.37	25° 23' 54.5604" N	67° 19' 36.0119" E
14	ABDULLAH KANRO	1105627.03	9224406.99	25° 24' 44.5192" N	67° 22' 45.5961" E
15	KIRRO DHORO	1227896.99	9029364.63	24° 52' 45.2443" N	67° 45' 18.8749" E
16	RAN PHATANI -2	1176254.84	9027943.64	24° 52' 26.1971" N	67° 35' 58.1836" E
17	LAYAR BUND	1203833.42	9056101.04	24° 57' 07.8822" N	67° 40' 54.7171" E
18	MOLAR LAT	1197393.14	9071322.93	24° 59' 38.0608" N	67° 39' 43.1010" E
19	ALLAH RAKIO BABBAR DAM	1372362.81	9149636.08	25° 12' 47.7574" N	68° 11' 20.1813" E
20	BOLAN NAI	1211021.48	9153688.08	25° 13' 15.3593" N	67° 42' 02.6308" E
21	HAJI FATAH MUHAMMAD	1114050.63	9138421.52	25° 10' 33.8044" N	67° 24' 28.6028" E
22	THADO NAI (MUHAMMED YASEEN)	1097274.55	9169948.62	25° 15' 44.0922" N	67° 21' 21.7977" E
23	HAJI PANI LADO DAM	1124633.6	9176988.63	25° 16' 57.0632" N	67° 26' 18.9241" E
24	CHANARI AND VEER	1204234.37	9212400.96	25° 22' 56.3488" N	67° 40' 42.4110" E
25	KAL	1179716.75	9231341.86	25° 26' 01.5106" N	67° 36' 12.8919" E
26	JAFFAR JEE	1127419.31	9226323.48	25° 25' 06.0704" N	67° 26' 43.0279" E
27	BABU KHAN DAM	1136726.35	9236019.19	25° 26' 43.1757" N	67° 28' 23.3309" E
28	ZARO WAH	1127417.2	9263288.27	25° 31' 12.2189" N	67° 26' 38.2952" E
29	BAQAR NAI	1125899.09	9275558.94	25° 33' 13.5864" N	67° 26' 20.1495" E
30	MUMARO BARIGO	1118644.78	9307417.1	25° 38' 28.2919" N	67° 24' 56.7815" E
31	HAJI LAKHA DINO DAM	1121932.19	9318167.49	25° 40' 15.1629" N	67° 25' 31.3053" E
32	SUNDHARTI DAM	1146491.59	9310423	25° 39' 01.2795" N	67° 30' 00.7013" E
33	BELI THAP 2	1137219	9347900	25° 45' 11.4441" N	67° 28' 14.6259" E
34	GARROUK DAM	1132590.3	9369535.82	25° 48' 45.2120" N	67° 27' 21.2246" E
35	KOTAHARO NAI	1153111.7	9351521.85	25° 45' 49.1167" N	67° 31' 08.0112" E
36	KHAKHAR NAI (KHAKHAR DAM)	1162096.98	9362295.3	25° 47' 36.8230" N	67° 32' 44.9990" E
37	MUHAMME YOUSUF	1162434.65	9377862.72	25° 50' 11.0604" N	67° 32' 46.8114" E
38	BARAN NAI (LOHI DAM)-1	1169800.67	9378010	25° 50' 13.3200" N	67° 34' 07.4200" E
39	KARIM BAKHSH MUSO DAM	1220282.96	9352739.84	25° 46' 08.1450" N	67° 43' 22.6941" E
40	SARANG KALOHI	1317382.04	9472045.67	26° 05' 58.3423" N	68° 00' 55.2355" E
41	CHAP BATHO DAM	1594491.08	9856524.49	27° 09' 39.3760" N	68° 51' 31.3194" E
42	NAON PEER	1608216.54	9872773.77	27° 12' 20.4817" N	68° 54' 03.1919" E
43	KHARSAR DAM	2238715.31	8918204.63	24° 34' 03.5865" N	70° 48' 02.5861" E
44	DOTER DAL	2213943.77	8894855.42	24° 30' 15.4364" N	70° 43' 31.1184" E
45	WAWARVAH NADI	2246202.82	8866685.2	24° 25' 32.2972" N	70° 49' 16.3252" E
46	SATTENJIOWN NADI	2255624.11	8853726.08	24° 23' 22.6975" N	70° 50' 56.3793" E
47	MOKHAL DAM	2197366.6	8843145.41	24° 21' 45.2120" N	70° 40' 24.8870" E
48	SANGORI DAM	2197133.22	8838959.08	24° 21' 03.7692" N	70° 40' 21.8179" E
49	VALRAI DAM	2198779.54	8821426.26	24° 18' 09.8878" N	70° 40' 37.3332" E
50	SABUSAN OLD	2198348.58	8809699.36	24° 16' 13.7688" N	70° 40' 31.1501" E

MAP OF 50 SMALL DAMS IN PEPELINE SINDH PROVINCE



COMPLIANCE OF COMMENTS

COMPLIANCE OF

COMMENTS ON DROUGHT MANAGEMENT PLAN

Comments Set 1

COMMENTS (1)		REMARKS	COMPLIANCE
Kindly review the following documents for the plan; • Sindh Drought Needs Assessment Report 2019 • National Drought Plan 2021		• **Agreed** • **Agreed**	• **1.2.2** • **1.2.1**
Chapter-1	• A proper background of Drought in the province, mention the impacts of drought in the province, include the population affected due to the drought. • Also include the Losses to Agriculture, livestock, fishery, production yield, Health related Issues and Migration	• **Agreed** • **Agreed**	• **1.3 & 2.10** • **1.3 & 2.10**
Chapter 2	• Following the data and pattern evaluate the drought pattern • Occurrence frequency	• **Agreed** • **Agreed**	• Done
Chapter-3	• Rank the districts on the basis of drought characteristics. • Also rank the districts on the basis drought severity.	• **Agreed** • **Agreed**	• **3.9** • **3.9.1** • **3.9.2**
Chapter-4	• Provincial Task Force Committee to headed by, ----? • Role of departments should be identified • PMD, Rep of SUPARCO, should also be the members. • UNOCHA could be the part of committee. **District Drought Committee** • Headed by------- • Composition------ • They will be responsible for-----	• **Agreed** • **Agreed** • **Agreed** • **Agreed** • **Agreed** • **Agreed** • **Agreed**	• Done • Done • Done • done • Done • Done • done

Chapter-5	The operational measures mentioned;
	• **Early warning center for Drought**
	  ○ 5.1 -5.2 :Such system is already working under PMD
	  ○ The PDMA could be mobilized for the purpose and take the lead in province
	• **5.3;** kindly check with PDMA, they must have the plans of districts
	• **5.4;** This is again related to PDMA
	Consider adding some recommendation related to Water Management and Irrigational Purposes Including Research.
		• **Agreed**
		• **Agreed**
		• **Agreed**
		• **Agreed**
			• Incorporated in Chapter 5
			• Incorporated in Chapter 5
			• Incorporated in Chapter 5
			• Given in 6.5

<table>
<tr><th colspan="2">COMMENTS (1)</th><th>REMARKS</th><th>COMPLIANCE</th></tr>
<tr><td>Chapter-6</td><td>Technical Measure
• Include Action Plan with the activities, timelines and department responsible for the action.
• Also include the capacity building & institutional development in this or operational measures.</td><td>• Agreed
• Agreed</td><td>• Incorporated in Chapter-6
• Incorporated in Chapter-6</td></tr>
<tr><td>Chapter-7</td><td>• This chapter should start with a comprehensive details of small dams in the province, dams which are already constructed and under construction. Benefits they are yielding and how important they are in managing the drought.
• The run-off map should be the part of this chapter and include the estimated total run off, current reservoir capacity and measure to capture the remaining potential water through small, medium and large dams. Also mark the potential areas for the dams.</td><td>ACE may help</td><td>Already added in Annexure-I & Annexure-J</td></tr>
<tr><td>Chapter-8</td><td>Awareness and Education Plan:
As per ToRs the consultant has to Formulate Awareness and Education Plans.
• Therefore, go through this chapter again, consult the PDMA, if they have the Drought Awareness Content, and where needed for specific awareness or educational material, relevant department should be assigned this task to develop the material.</td><td>• Agreed
• Agreed</td><td>• 8.1
• 8.1</td></tr>
<tr><td>Include</td><td>• Add an Action plan for <u>Short, Medium & Long Term</u>
• Add a Cost plan as well, or a draft which could be discussed with Stakeholders & can be presided at different forums for funding purposes.</td><td>Beyond the Scope</td><td></td></tr>
</table>

Response to Comments on Drought Management Plan

By Nasir Ali Panhwar, Social Safeguard Consultant, SRP

14 September 2022

Comments Set 2

Comments (2)	Remarks	Compliance
General Comments • The Drought Management Plan is expected to be based on drought policy and the document is silent in this regard. It only refers to draft National Drought Management Plan as Annex-V but it is not included in this report. • The Drought Management Plan seems to be more focused to only one sector i.e. water. • It also appears that plan is Thararkar centered leaving other regions aside. • References may be provided as an Annexure • It is important to define the key components of drought management plan, its objectives, and steps in the implementation process • Please discuss national and international obligations such as Hyogo Framework for Action and others. • The section on socio-economic factors, consideration of vulnerable groups and gender may be added. • Since the plan has to provide specific actions with clear roles and responsibilities but as such this plan is devoid of such action plan.	• Policy is yet to be made. Annex -V has been referred and expanded • Drought is primarily lack of water • Data for all districts is provided and analyzed in Annexes • All are explained • Agreed • Agreed Beyond the Scope	• **1.2.3 & 1.2.4** • **2.10**
• **Chapter-1: Introduction** In the context section it has been stated that 60% of area of Sindh province has arid climate. This may be revised as "65 % of land is classified as arid zone".	• Agreed	• done
It is mentioned that Thar zone comprises of 22000 km, in fact it comprises on 23000 km, while Nara Region comprises on 22000 km and it also includes parts of Shaheed Benazirabad District.	• Agreed	• done
Please mention districts located in Kohistan region.	• Agreed	• done
Climate change and its possible impacts on Sindh may also be discussed in this section.	• Agreed	• done
• **Chapter -2** **2.2 Causes of Drought in Sindh Province** **This section may be revised and also add following**		

causes of drought El-Nino & La Nina Phenomena Increase of atmospheric Co2 & other greenhouse gases etc. Please provide description of typology of drought i.e. in terms of typologies, droughts are classified as meteorological, agricultural, hydrological, and socio-economic **2.3 Drought Mitigation** This section may elaborate as to how drought is managed currently in Sindh i.e. what is institutional structure and what are the gaps? In this section mitigation is discussed only related to water sector, whereas other sectors may also be discussed. **2.8 Drought Management Plan of Sindh Province.** In this section guiding principles followed for DMP are very vague, which may be revisited. **2.9 Drought Impact on eco-system** Leaf Area Index is provided only for Thar. I wonder, if this Index may also be provided for other districts.	• Agreed • Agreed • Agreed • Data for other districts is available in Annexes	• done • done • done • done
Chapter -4 This chapter is unable to provide clear road map for institutional arrangements. For instance, proposed compositions of provincial and district drought task forces are not provided.	Composition can be added	• done

COMMENTS ON THE FEASIBILITY STUDY OF 50 NOS OF SMALL DAMS AND LINING OF 50 NOS OF PONDS IN SINDH PROVINCE

Comments Set 3

General Comments	Response	Compliance
1. Overall document is well written 2. Grammar & Spelling mistakes need to be rechecked in overall document. 3. The DMP shall be prepared under the legal cover of Provincial Drought management policy, preparing just DMP will have no legal support in our opinion. 4. This DMP shall be an overarching document, whereas district-wise drought management plans also need to be prepared. 5. It is suggested that, role of PDMA, along with allied departments need to be clearly mentioned in this plan along with timeline. 6. The DMP has no timelines, it is suggested that action plan need to be developed for the effective implementation	1. Thanks 2. Will be checked 3. Beyond the Scope 4. Beyond the Scope 5. Agreed 6. Beyond the Scope	• 4.1 Done

Specific Comments

S.No	PAGE	SECTION	COMMENT	Response	Compliance
1.	ES-1 of 3	Executive Summary	DPP Steps VII, please include technology as well. Consultant will develop Provincial Policy of Sindh for Drought Management??	• Agreed • Beyond the Scope	• added
2.	1/2 of 3	1.3.2 TORs of Drought Management Plan of Sindh	Please clarify that which department / authority will be implementing the DMP?	• Provincial Drought Task Force jointly with Irrigation Department	• added
3.	2/2 of 11	2.1.2 Categories of Droughts	Which category does Pakistan comes in?	• Agreed	• Added
4.	2/2 of 11	2.2 Causes of Droughts in Sindh Province	The section is very generic. Please incorporate some data on de-forestation in Sindh. Include green cover required as per international standard and available?? The causes mentioned	• Agreed	• Added

S.No	PAGE	SECTION	COMMENT	Response	Compliance
			this section lack real time data such as what is the increased population in Sindh, or what is the deforestation rate, or the significant climate change impacts that are faced by Sindh in recent times as compared to the past? Elaborate how the anthropogenic activities have made an impact on the surroundings and how they are linked to droughts. Please mention some data related to Sindh for causes of droughts.		
5.	2/4 of 11	2.4 Drought Mitigation Approaches	Please recommend the suitable approach	• Will be done	•
6.	2/7 of 11	2.7 Drought Preparedness Planning	How are these steps furnished and on what basis?	• These are internationally recognized & used	•
7.	4/1 of 7	CHAPTER 4 INSTITUTIONAL / ORGANIZATIONAL MEASURES	This chapter includes information about the appointment of task force for the plan. Apparently the task force has to consist of professionals from various departments within the government and also non-profit organizations. It further includes establishment of sub-committees such as awareness and education, water resource, livestock, and public participation.	• Right • Right	
8.		Domestic Water Supply	Domestic Water supply in urban center is also major problem, especially from groundwater this plan shall also address to the urban areas, such as Karachi, Hyderabad, Sanghar etc.	• Beyond ToRs	Domestic water supply in Rural areas is covered already
9.		Rain Water	The DMP is silent on	• Can be	• added

S.No	PAGE	SECTION	COMMENT	Response	Compliance
		Harvesting in Field	urban rain water harvesting techniques, as per ToR, underground water storage and recharge wells may be recommended in drought plan. Rain water harvesting such as roof top harvesting, this may help to conserve water in urban center this will also reduce the damage to infrastructures of city and ensure the availability of ground water in dry years. Sindh Building control authority role may be defined and taken on board in this task.	added • Can be added • Beyond ToRs	as 8.4 • added as 8.4