Pakistan Meteorological Department
The Islamic Republic of Pakistan

PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR THE INSTALLATION OF WEATHER SURVEILLANCE RADAR AT SUKKUR
IN
THE ISLAMIC REPUBLIC OF PAKISTAN

July 2020

JAPAN INTERNATIONAL COOPERATION AGENCY

INTERNATIONAL METEOROLOGICAL CONSULTANT INC.

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Summary

Summary

1. Outline of the Country

The Islamic Republic of Pakistan (hereinafter referred to as “Pakistan”) has a population of 207 million (Pakistan Bureau of Statistics, 2017 Census) with an annual growth rate of 2.4%, and it is expected to become the country with the world’s fourth largest population following India, China and the United States by 2050. The national GDP is about 305 billion US dollars (2017 World Bank) and the real economic growth rate is 5.97% (Pakistan Economic Survey 2017).

2. Background of the Project

The Government of Pakistan adopted a national approach toward the strengthening of disaster prevention systems focusing on disaster prevention and damage mitigation. It has promulgated the National Disaster Management Ordinance (NDMO), established the National Disaster Management Authority (NDMA) as well as formulated the National Disaster Management Plan with the Japanese assistance. In the National Disaster Management Plan, a Multi-Hazard Early Warning System Plan aiming for the establishment and maintenance of the appropriate forecasting/warning system was proposed. For the successful implementation of the Plan, the enhancement of the PMD’s observation and forecasting capabilities will be a key point. Parallel improvement of the following areas is also equally vital, namely; the development of human resources in the field of disaster prevention, dissemination of disaster prevention knowledge to the people, the establishment of flood control facilities, and etc. Therefore, it is highly necessary that the PMD improve its capability of meteorological observation and forecast/warning accuracy as well as to disseminate more promptly and timely the weather information (forecast/warning) to the proper channels.

Currently, the PMD is unable to accurately observe the rain clouds and the thunderstorm accompanied by heavy rain in the Sindh Province during the Monsoon season invading Pakistan from India. As a result, it is actually difficult for the PMD to appropriately reflect heavy rain information in its flood forecasting and warnings. Therefore, in order to address the current situation whereby it is difficult to issue weather and flood forecasts and warnings in a timely manner due to the lack of observation data on the Indian side, it is urgently necessary to install a new meteorological radar system in Sukkur situated near the country border with India.

Once the Project is fully implemented, which is designed to enable the PMD to be capable in providing accurate meteorological observations on the wide area of the Sindh and Punjab Provinces including the Indian side, and to ensure the stable and sustained supply of weather and flood forecasts/warnings to the general public through the establishment of a new meteorological radar system in Sukkur, the accuracy of weather and flood information and warnings in Pakistan will be improved, thereby contributing to the reduction of damages caused by natural disasters.

3. Outline Design of the Study and Contents of the Project

In 2019, the Government of Pakistan made a request to the Government of Japan for Grant Aid for "The Project for Installation of Weather Surveillance Radar at Sukkur in the Islamic Republic of Pakistan" (hereinafter referred to as "the Project"). In response to this request, the Government of Japan decided to conduct a Preparatory Survey for the Installation of a Weather Surveillance Radar at Sukkur (hereinafter referred to as the "Preparatory Survey"). The Japan International Cooperation Agency (hereinafter referred to as "JICA") sent the Preparatory Survey Team to Pakistan in order to conduct the Preparatory Survey from June 11 to July 17, 2019. The Team had a series of discussions with the officials concerned from the Government of Pakistan, conducted surveys and collected necessary and pertinent information and data for the Project. In addition, the Team conducted further studies, including a feasibility study focusing on the justification and scope of the Project paying particular attention to the present situation in Pakistan from various perspectives such as the operation & maintenance capabilities of the PMD, best equipment arrangement plan, etc.

JICA sent the Preparatory Survey Team again to Pakistan from January 20 to February 06, 2020 in order to explain and discuss the outline design & draft survey report. During the course of discussions and field surveys, it was confirmed that the requested items are indeed required for the Project in consideration of the Project's objectives and effects.

As a consequence of the further study on the requested items in Japan, it has been decided that the following components indicated in the table attached hereunder are object items of the Preparatory Survey for the Project.

Table 1: Object Items of the Preparatory Survey

Component	Proposed Sukkur Meteorological Radar Observation Station	PMD Islamabad Head Office National Weather Forecasting Center	PMD Tropical Cyclone Warning Center	PMD Flood Forecasting Division, Lahore	PMD Meteorological Office in the International Airports, Karachi, Islamabad and Lahore
Procurement and Installation of Equipment					
S-Band Pulse Compression Solid State Dual Polarization (Polarimetric) Meteorological Doppler Radar System including Surge Protector, Power Back-up System, Lightning System Measuring Equipment and Spare Parts	1	-	-	-	-
Meteorological Radar Central Processing System	-	1	-	-	-
Meteorological Radar Data Display System	1	1	1	1	1 at each office
Construction of Radar Tower Building					
Radar Tower Building	1	-	-	-	-
Technical Training	Initial operation guidance included in the contract of the manufacturer				
Soft Component					

4. Project Implementation Period and Cost Estimation

The required implementation period of the Project is approximately 35.8 months. The required capital costs for the Project to be borne by Pakistan/PMD, as estimated in the Preparatory Survey, is 70,000,000 PKR (approx. 63 Million JP Yen).

5. Project Evaluation

5-1 Relevance

1) Development Plan of Pakistan

The enhancement and modernization of the meteorological services in Pakistan are urgent issues to alleviate the negative impact of severe weather and to ensure the people's safety as well as to significantly contribute to the sustainable development of the country. From the viewpoint of the PMD, in order to contribute to the achievement of the government goals indicated in "Vision 2025", which is the long-term national development policy of Pakistan, and the National Disaster Management Plan (NDMP), the Ten Year Development Plan of the PMD (a step towards modernization) has been formulated in 2016 by the PMD.

"Vision 2025" is a national development policy for the whole country published in August 2014 by the Ministry of Planning, Development & Reform. "Vision 2025" declares that Pakistan will enter the upper middle income country group by 2025 and sets numerical targets of 25. The numerical targets include increasing the per capita national income from US$1,299 to US$ 4,200 and reducing the population's poverty ratio from the current 49% to 20%. In addition, the declaration statement in "Vision 2025" that it will become one of the world's top ten economic nations by total GDP by 2047, when it celebrates the 100th anniversary of independence of the country, is included as a long-term goal.

The National Disaster Management Plan (NDMP) is a guideline for strengthening and modernizing the disaster-prevention sector in Pakistan and is one of the major achievements in support of disaster management measures of Pakistan by the Government of Japan. The NDMP is also a base of support by donor organizations in the area of disaster prevention.

In the document, "Reducing Vulnerability and Exposure to Disasters," published by the United Nations ESCAP/UNISDR, the disasters that occurred every year between 2004 and 2010 have pushed down Pakistan's GDP by US$ 20 billion compared with no disasters in 2011. In view of such reports, the significance of promoting disaster reduction is considered to be very high for the sustainable development of the country.

Since the modernization of a meteorological radar observation network in Pakistan is mentioned in the first chapter (Chapter 1) of the Ten Year Development Plan of the PMD as one of the top priority

implementation items, this Project agrees with the national development plan and disaster prevention plan, and in the first five years of the National Flood Protection Plan IV (Ten Year Plan) approved by the Government of Pakistan in May 2017, the upgrade and expansion of the PMD's existing meteorological radar observation network and the flood forecasting & warnings are indicated. Based on the above, this project is consistent with the national development plan and disaster prevention plan of the country.

2) Aid Policy of Japan

Japan and Pakistan have long since developed congenial bilateral relations and have commemorated the sixtieth anniversary of the establishment of diplomatic ties between the two countries in 2012. Japan's major aid policy for Pakistan issued on February 2018 is the "building of a stable and sustainable society through middle class expansion." In addition to supporting the self-sustaining growth of Pakistan through development cooperation, Japan intends to make good use of Japan's strengths, including high technological capabilities, to further develop favorable bilateral relations. Furthermore, the aim of development cooperation is to promote peace and stability and economic development in Pakistan and in the region. The Government of Japan focuses on the following three priority areas for the realization of the aid policy indicated above.

1. Development of an economic foundation
2. Ensuring human security and improvement of social foundation
3. Establishment of peace and stability

Under the second priority area, the provision of aid for the "strengthening of disaster prevention capability against frequent natural disasters" is stated as one of Japan's important roles. Since both Pakistan and Japan are frequent victims to natural disasters, the Sendai Framework for Disaster Risk Reduction 2015-2030 adopted at the Third UN World Conference on Disaster Risk Reduction in view of climate change risk supports the strengthening of disaster prevention systems centered on disaster prevention (preparedness) and disaster mitigation that utilize Japan's knowledge and technology and aims at building a strong society that is not inferior to disasters. It is truly significant to strengthen the meteorological monitoring system of Pakistan and improve disaster prevention capabilities nationwide through the Grant Aid from Japan as it is consistent with Japanese priorities in terms of international cooperation.

3) Utilization of Meteorological Radar Observation Data

The flood forecasting system of the PMD Flood Forecasting Division at Lahore currently collects satellite rainfall data and other global data, such as actual rainfall, forecasting rainfall topography, elevation and land use, which are provided by various organizations to cover lack of temporal and spatial data. Based on these data as inputs, rainfall runoff and inundation calculation are implemented for the Indus River and its tributaries. Under these circumstances, the PMD aims to improve the accuracy of its flood forecast &

warning by expanding their observation data of ground stations and meteorological radars as input data. Therefore, the establishment of a nationwide meteorological radar network is the top priority and highly expected as an essential factor to improve forecast & warning accuracy.

According to the National Flood Protection Plan-IV (2017-2026), there are still blind areas in rainfall observation in spite of advancing new observatory installation. More accurate flood forecast & warning would increase the lead time for evacuation or preparation in response to any incoming flooding. Therefore, the establishment of a meteorological radar network is recognized as a vital factor to quantitatively detect heavy rain and torrential rain over the entire basin.

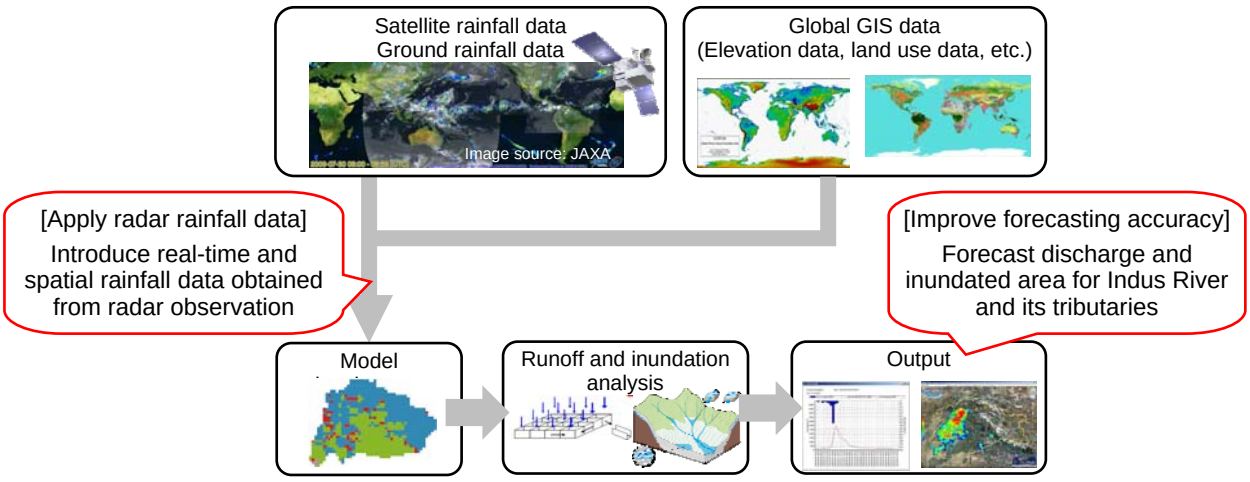

Figure 1: Outline of Flood Forecasting System of PMD

Image source: ICHARM

Some urban rivers in Pakistan have standard operation procedures in terms of early warning to flash flood. In case an excess in actual rainfall of 50mm/3hrs is observed as the criteria for early warning pre-alert is issued. Applying real-time and spatial rainfall data obtained from meteorological radar observation, very short-term forecasting for the next 3 hours or more will be enabled to issue timely early warning to the region where there is an anticipated occurrence of a flash flood. This would be an enabler for various groups to prepare and implement measures to protect human life and properties of residents and administrative organization.

4) Expected improvements following the implementation of the Project

It will be expected that the following points related to the management of flood caused by heavy rain and torrential rain in Pakistan will improve:

1. Timely issuance of forecasting and early warning to the hilly area responding to the flash flood;
2. Timely issuance of forecasting and early warning to urban flooding;

3. The accuracy of flood forecasting system for the Indus River and its tributaries by providing spatial rainfall data with higher resolution; and,

4. The accuracy of inflow discharge to the Indus River in the downstream basin.

These improvements will have a great effect on ensuring the appropriate lead time for coming floods. It would lead to secure valuable time for residents, administration and private companies, to evacuate from dangerous areas, to develop protection measures and to move materials and machineries respectively.

Therefore, the installation of the Sukkur radar is essentially effective and valuable.

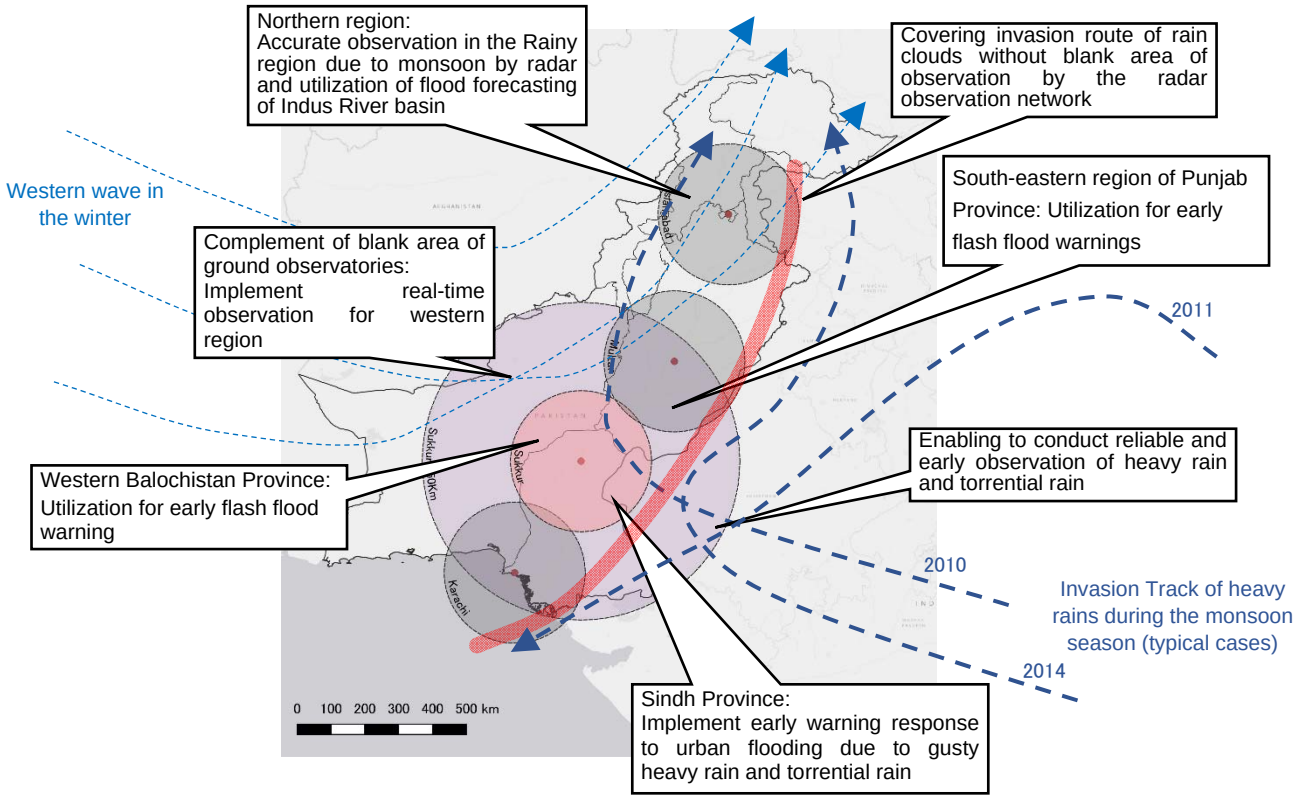

Figure 2: Importance of Sukkur Radar

5-2 Effectiveness

1) Quantitative indicators

Table 2: Achievement Indicators

Indicators	Present (Baseline in 2020)	Target (2026) (3 years after the Project Completion)
Improvement in the observation density of meteorological information (rainfall, wind direction & speed) provided to organizations related to Disaster Risk Reduction (DRR)	Spatial resolution of the latest 45 automatic observation systems in Punjab and Sindh Provinces: 88km mesh on average	・ Spatial resolution for precipitation data calibrated with Synoptic Meteorological Observation data within the maximum radar detection range between 450km: approx. 1km mesh. ・ Spatial resolution for wind speed & direction data calibrated with Synoptic Meteorological Observation data within the maximum radar detection range within 200km: approx. 1km mesh.
Improvement in the temporal observation ability of meteorological information (rainfall, wind direction & speed) provided to organizations related to Disaster Risk Reduction (DRR)	Time interval of meteorological information (rainfall, wind direction & speed) obtained in the area • Meteorological Satellite: 30-minute. • Synoptic Meteorological Observation: 1 hour.	Time intervals of radar observation data calibrated with Synoptic Meteorological Observation data: 10-minute.

2) Qualitative indicators

a) To enable DRR-related organizations (NDMA and its allied DRR authorities in provinces and districts) and mass-media to timely response and commence necessary countermeasures against disasters in order to reduce the number of potential disaster victims.

b) To ensure aviation safety connecting to contribute to the improvement of social infrastructures through the provision of timely and accurate information to the international airports in Pakistan.

c) To promote the implementation of DRR measures in order to reduce economic losses, through the provision of accurate weather information to users engaged in industries such as transportation, tourism and agriculture.

Since the improvement of PMD's capacity is expected to directly contribute to the reduction of human and economic losses due to natural disasters based on a careful and comprehensive evaluation of the project effects, this Project will greatly contribute to the reduction of the adverse effects of natural disasters and effectively protect the people of Pakistan. In conclusion, the implementation of the Project is considered to be an appropriate, suitable, viable and worthwhile endeavor.

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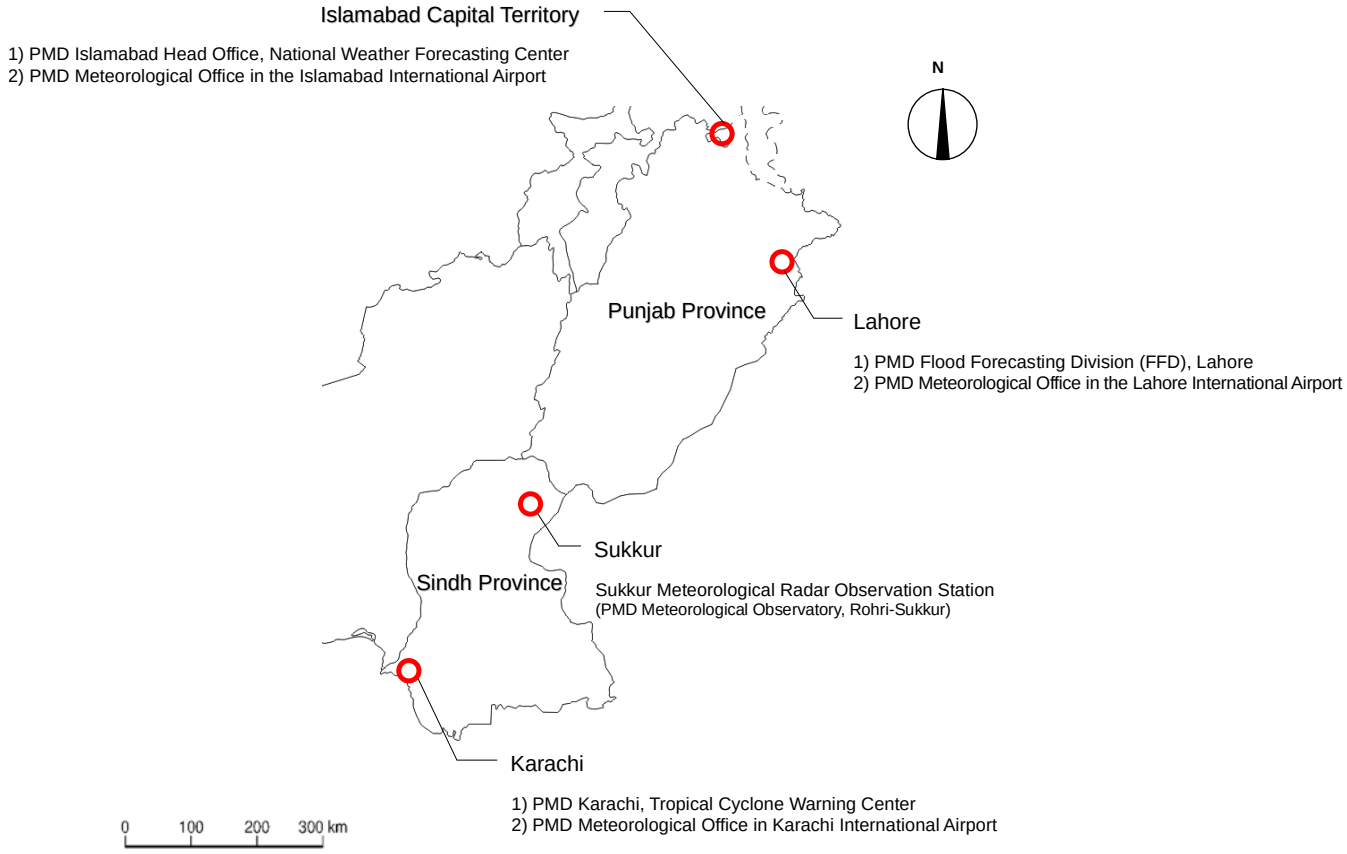
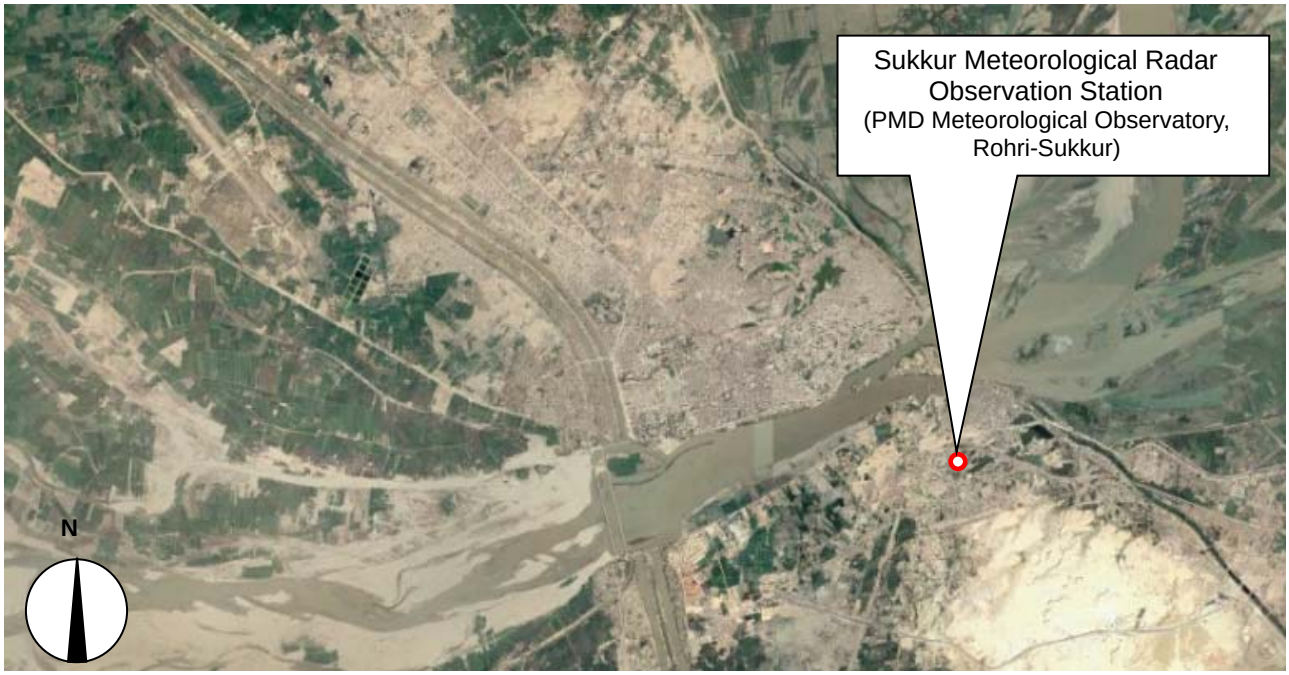
■ Islamic Republic of Pakistan





Sukkur Meteorological Radar Tower Building

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ABBREVIATIONS

ADB : Asia Development Bank
AIJ : Architectural Institute of Japan
ASEAN : Association of Southeast Asian Nations
ASF : Airport Security Force
ASTM : American Society for Testing and Materials
AWS : Automatic Weather Stations
CAA : Civil Aviation Authority
CAD : Computer-Aided Design
CAPPI : Constant Altitude Plan Position Indicator
DRR : Disaster Risk Reduction
EAD : Economic Affairs Division
ECNEC : Executive Committee of National Economic Council
EEC : Enterprise Electronics Corporation
EM-DAT : Emergency Events Database
EPA : Environmental Protection Agency
ESCAP : Economic and Social Commission for Asia and the Pacific
FAB : Frequency Allocation Board
FBR : Federal Board of Revenue
FFD : Flood Forecasting Division
G/A : Grant Agreement
GDP : Gross Domestic Product
GIS : Geographic Information System
GST : General Sales Tax
GTS : Global Telecommunication System
IEE : Initial Environmental Examination
IP-VPN : Internet Protocol - Virtual Private Network
JGS : Japanese Geotechnical Society
JICA : Japan International Cooperation Agency
JRC : Japan Radio Co., Ltd.
KML : Keyhole Markup Language
LED : Light Emitting Diode
MTBF : Mean Time between Failure
MTTR : Mean Time to Repair
NASA : National Aeronautics and Space Administration
NDMA : National Disaster Management Authority
NDMO : National Disaster Management Ordinance
NDMP : National Disaster Management Plan
NetCDF : Network Common Data Form
NOAA : National Oceanic and Atmospheric Administration
NOC : No Objection Certificate

NTC : National Technology Council
NTU : Network Terminating Unit
OJT : On-the-Job Training
PKR : Pakistani Rupee
PMD : Pakistan Meteorological Department
PoE : Power over Ethernet
POL : Port of Loading
PPI : Plan Position Indicator
PTCL : Pakistan Telecommunication Company Limited
PVC : Polyvinyl Chloride
PVT Ltd. : Private Limited
R&D Division : Research and Development Division
RHI : Range Height Indicator
SEPCO : Sukkur Electric Power Company
SMRFC : Specialized Medium Range Forecasting Center
SRTM : Shuttle Radar Topography Mission
STALO : Stabilized Local Oscillator
TCWC : Tropical Cyclone Warning Center
UBC : Uniform Building Code
UNISDR : United Nations International Strategy for Disaster Reduction
UPS : Uninterruptible Power Supply
VoIP : Voice over Internet Protocol
VPN : Virtual Private Network
WGS : World Geodetic System
WIS : World Information System
WMO : World Meteorological Organization

Chapter 1
Background of the Project

Chapter 1 Background of the Project

1-1 Background of the Project

The Islamic Republic of Pakistan (hereinafter referred to as "Pakistan") is hit by various natural disasters such as heavy rain, torrential rain, flooding, sediment disaster, tropical cyclones and drought because the land extends north and south for 1,500km and has a large difference in the altitude and shape causing meteorological phenomena to vary. It is an urgent necessity to prepare the management system for disasters including early warning system against natural disasters because global climate change can increase the frequency and magnitude of natural disasters in the mid to long term and it is expected to affect Pakistan remarkably in the region where many natural disasters have occurred.

According to the Annual Flood Report 2018 issued by the Federal Flood Commission (FFC) of Pakistan, massive flooding occurred consecutively in the recent years of 2010, 2011, and 2012. The Indus River Floods in 2010 (approximately 2,000 killed and lost, over 20 million people affected (by EM-DAT), 100 million USD total direct losses) and the floods in the province of Sindh and its neighbors in 2011 (over 500 killed and lost, approximately 5 million people affected (by EM-DAT), 37 million USD total direct losses) caused serious damages.

Approximately half of the total damage (18,986 million USD) caused by the floods in Pakistan since 1950 (38,171 million USD) are caused by the floods which occurred in 2010 and the years after, which were triggered by heavy rain and torrential rain during monsoon seasons.

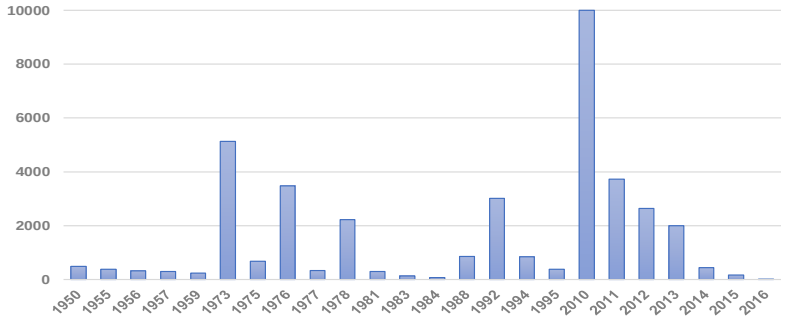


Figure 1: Amount of Direct Losses (Million USD)
Source: Annual Flood Report 2018 of Federal Flood Commission (FFC)

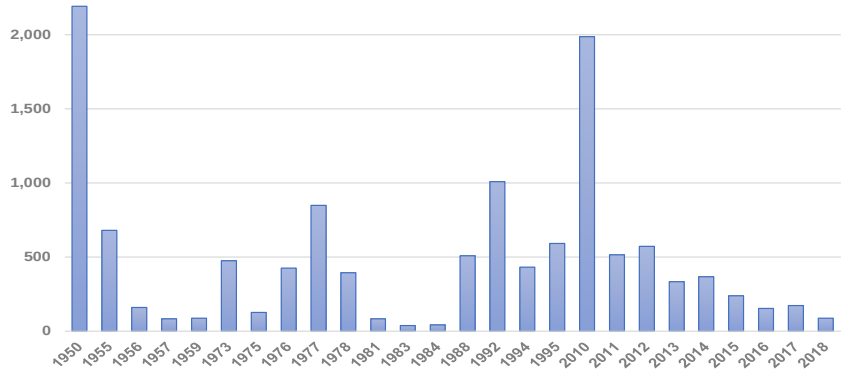


Figure 2: Number of Deaths
Source: Annual Flood Report 2018 of Federal Flood Commission (FFC)

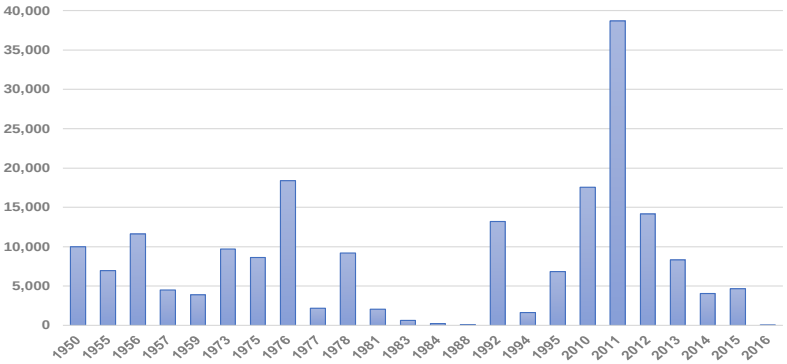


Figure 3: Number of Damaged Villages
Source: Annual Flood Report 2018 of Federal Flood Commission (FFC)

Most of the rain clouds bringing heavy rain and torrential rain during monsoon seasons intrude Pakistan from India, and around 80% of them move up to the north and bring heavy rainfalls causing floods. Floods are responsible for about 60% of the number of disasters in Pakistan, about 70% of the number of deaths, and over 90% of the number of victims. It not only causes loss of lives and properties and stagnation of economic activities but also significantly affects the poor, and, thus, it causes a negative influence to poverty reduction which is one of the development strategies of the Government of Pakistan.

Therefore, in order to further reduce the damages caused by flooding, it is strongly required to improve the PMD's meteorological observation capability by developing the observation network of its meteorological radars to accurately observe the entire area facing the country border between India and the provinces of Punjab and Sindh which are the entrance gates for the rain clouds bringing heavy rain and torrential rain during monsoon seasons, and also to promptly and quickly deliver forecasts and warnings to appropriate organizations so that the risks of natural disasters are predicted in advance and appropriate measures are taken to cope with the situation.

1-2 Natural Disasters in Pakistan

The figure below shows the proportion of the number of disasters and killed & affected people by natural disasters between 1982 and 2018 in Pakistan. Since floods account for about 60% of the number of disasters, about 70% of the killed people and more than 90% of the affected people, the reduction of damage by the floods caused by the concentrated heavy rain and torrential rain during the monsoon season is a very urgent issue for Pakistan.

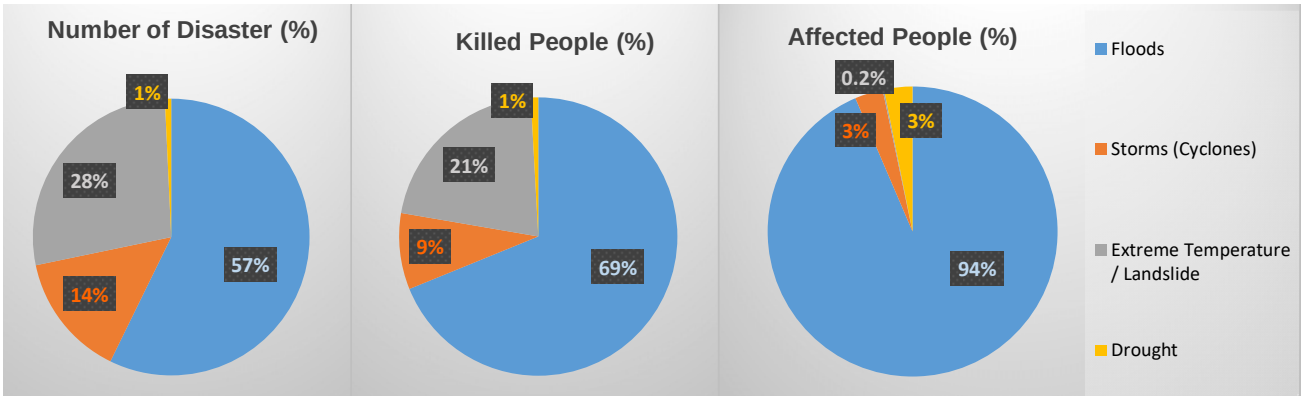


Figure 4: Percentage of Number of Disaster, Killed People and Affected People in Pakistan between 1982 and 2018

Data Source: Emergency Events Database (EM-DAT)

Floods occur everywhere; particularly the Khyber Pakhtunkhwa state in the northern area, the Punjab state in the central area, the Sindh and Balochistan states are more vulnerable. Most of the rain clouds that bring about torrential rain in the Monsoon season invade Pakistan from India, about 80% of which rise northward, bringing heavy rains to the north causing floods. The precipitation in the northern area is obviously much greater than any other area. This means that heavy rains in the northern area cause flash floods or landslides in the upper river basin with rainwater gradually flowing into the river which, in turn, causes flooding in the middle and lower river basins. In addition to this, heavy rainfall flows into the Indus river, Sutlej river, Ravi river, Chenab river, Jhelum river, etc. which further increase the scale of floods in the central and southern areas of Pakistan.

1-3 The Existing Meteorological Radar Systems in Pakistan

The central region of Pakistan, southern Punjab and northern Sindh, is the gateway of the rain clouds that bring about torrential rain from India during the monsoon season (summer season). In addition, the Balochistan Province is in the pathway of a westerly depression wave (mid latitude weather system) during winter. These depressions migrate toward the north, and then they cause the frequent torrential downpours in the northern area of Pakistan. Annual rainfall is more than 1500mm in the northern area while, on the other hand, there are dry areas with annual rainfall of less than 150mm, such as northern Sindh including Sukkur, southern Punjab and western Balochistan. However, even in the dry areas, there are extremely localized downpours during the monsoon season, or during the winter season under special weather conditions.

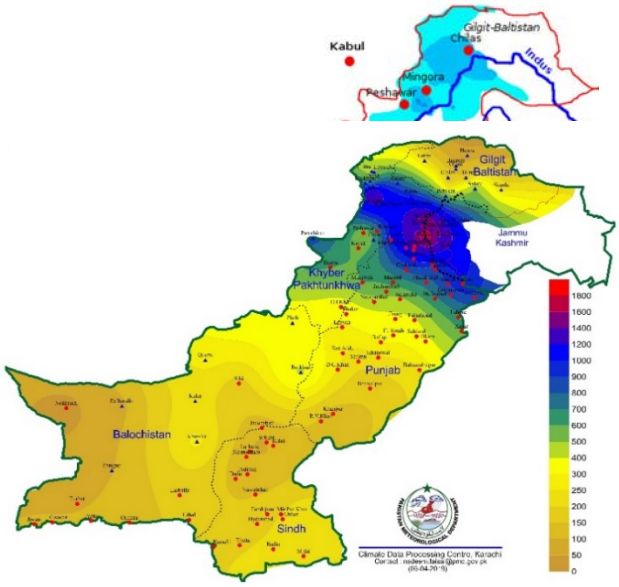


Figure 5: Annual Normal Rainfall Pattern of Pakistan Source: PMD

There are two prominent types of flood, riverine flood and flash flood including urban flooding in Pakistan. Riverine flood mainly occurs in the region along the Indus River and its major tributaries (Jhelum, Chenab, Ravi and Sutlej Rivers). Flood water leads to the inundation of adjacent areas. Once a low-lying area is inundated, it tends to continue for longer periods and heavily influences the growth of economic activity and/or the daily lives of local residents. On the other hand, a flash flood is the phenomena which involves a rapid increase in river flow due to local short term torrential downpour caused by the monsoon or westerly depression during winter and medium- or small-sized torrent river flowing through the hilly area. Finally, urban flooding is the short term flooding of water beyond the drainage capacity of a drainage channel during or after torrential downpours in the urbanized areas.

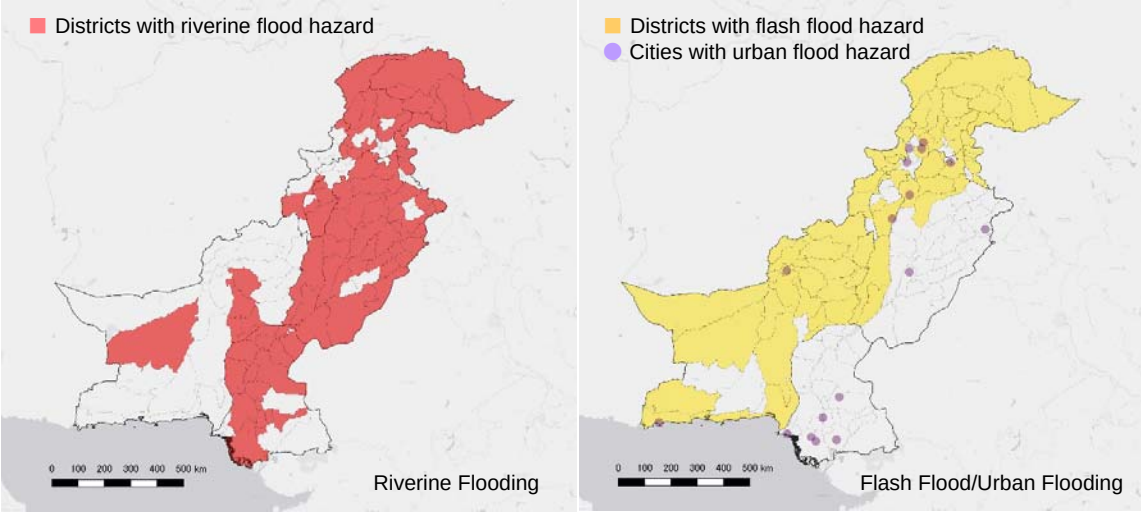


Figure 6: Flood Hazard of Districts

Created based on National Monsoon Contingency Directive 2018, NDMA

1-4 Flood Mechanism in Pakistan

The Indus River, flowing through the nation from north to south, and four tributaries (Jhelum, Chenab, Ravi, Sutlej Rivers) in the northeast region are regarded as the major rivers of Pakistan. Major historical floods which occurred in the rivers and districts exposed to flood hazard are as illustrated by the figure above. Flood hazard in the downstream basin of the Indus River from the confluence point with the Chenab River increases due to the addition of flow discharge when it joins together with the tributary at southern Punjab. Furthermore, there is a potential for an occurrence of flooding in the downstream basin or an extension of flood damage by additional inflow from small tributaries due to torrential downpour in the downstream basin. Since the Indus River flood plain in the downstream basin from southern region of Punjab to southern region of Sindh has extremely flat and low-lying land, it is difficult for the flood water to return back to the river channel. This would lead to spreading of the damage due to the prolonged duration of inundation and delay in the recovery of social functions in that region.

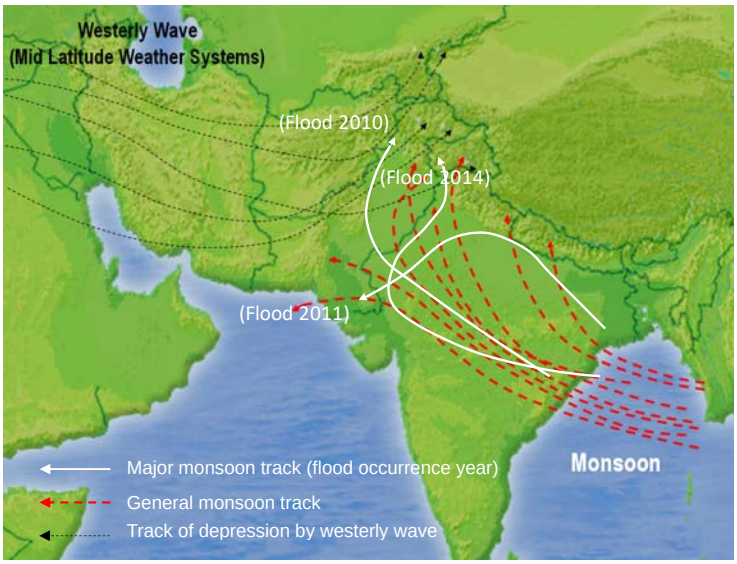


Figure 7: Track of Monsoon and Westerly Depressions

Source: PMD

Flood mechanism is marshalled about the 2010, 2011 and 2014 flood as typical examples.

Flood Pattern-1: 2010 flood caused the greatest inundation area, damage on human life and economic loss in Pakistan history. Discharge exceeding high flood level was recorded at Sukkur Barrage and inundation was spreading across a wide area. This flood was characterized by a flooded area quite far away from torrential rainfall area. Since both of the Indus River and its tributaries (Jhelum and Chenab Rivers) reached a state where its discharge was more than flood level, it resulted in the largest inundated area in the downstream area.

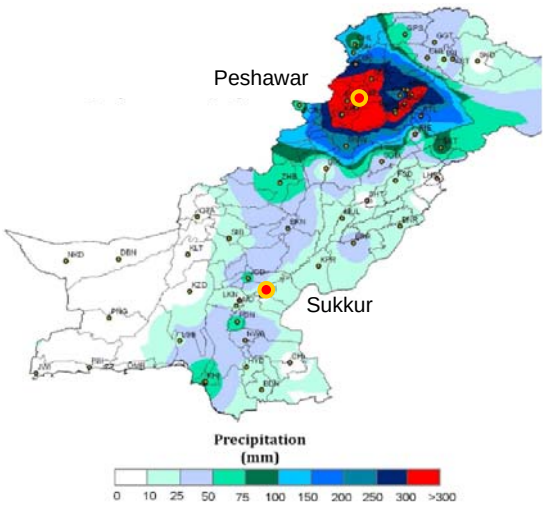


Figure 8: Rainfall Pattern from 26 to 29 July 2010

Source: PMD

- Flood mechanism (Pattern occurring a flood in the Indus flood plain due to torrential rainfall in the northern basin)
- 2010 flood (flooding and inundation occurred in the wide area of Pakistan, including mid- and downstream basin of Indus

Rain Cloud in Monsoon season approaches	Torrential rainfall in the northern region	Flooding in the midstream basin of Indus River Flooding in the upstream basin of tributaries	Flooding in the downstream of Indus River
Invade from the middle east and go north	Peshawar: 333mm Rawalakot: 297mm	Indus River Chashma: approx. 1,000,000 Cusecs Jhelum River Rasul: approx. 260,000 Cusecs More than flood level	Sukkur barrage: Exceed flood level discharge Huge inundation on the western side of Indus River basin

Figure 9: Flood Pattern-1

Source : PMD

Flood Pattern-2: The 2011 flood caused damages due to inundation in the southern region of Pakistan with two spells of monsoon rainfall; however, the discharge of the Indus River was less than the flood level. Drainage capacity of the channels within that area was not enough to drain rainfall completely.

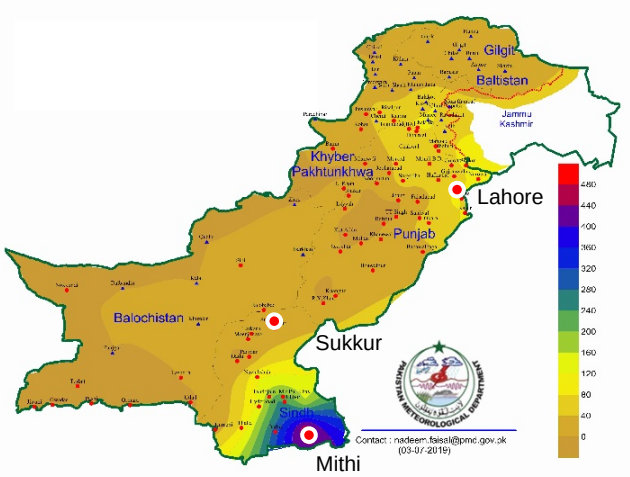


Figure 10: Rainfall Pattern from 10 to 17 Aug 2011

Source: PMD

- Flood mechanism (Pattern occurring flood only within Indus flood plain due to torrential rainfall in that region)
- 2011 flood (flood and inundation occurred due to overflow of small rivers and drainage channels in the southern Sindh.)

Rain Cloud in Monsoon season approaches	Torrential rainfall in the southern region	Overflowing due to low drainage capacity to Indus River	Inundation in the downstream basin of Indus River
Southern Region	1st spell (August 10-17): more than 300mm 2nd spell (Sep 29 – 12): Average 200mm, partly more than 400mm	Amount of rainfall was 8–10 times more than the design drainage capacity In order to reach the flood level of Indus River discharge	Damage due to inundation on the eastern side of Indus River basin in southern Sindh Province

Figure 11: Flood Pattern-2

Source : PMD

Flood Pattern-3: The 2014 flood caused inundation in some tributary basins after torrential rainfall in the northern Punjab as its upstream basin. Flooding water also led to inundation in the downstream basin of the Indus River from the confluence point up to Sukkur Barrage.

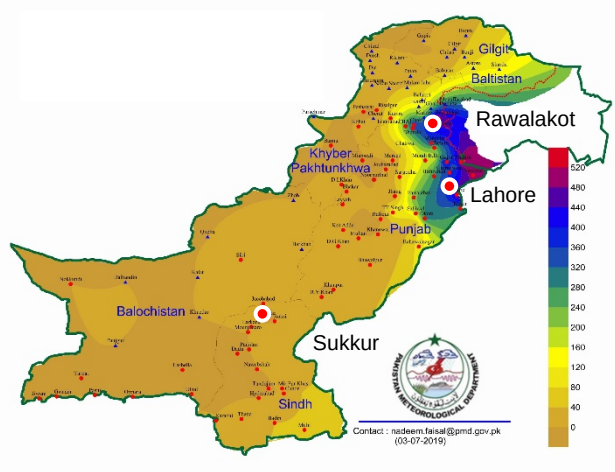


Figure 12: Rainfall Pattern from 2 to 7 Sept. 2014

Source: PMD

- Flood mechanism (Pattern occurring a flood in the downstream of the Indus River due to rainfall in the tributary basins) :
- 2014 flood (Flood occurred in the tributaries in Punjab and in the downstream from confluence point of Indus River.)

Rain Cloud in Monsoon season approaches	Torrential rainfall in the southern region	Flooding in the tributary basins	Flooding in the downstream of Indus River (from confluence point)
Migrate toward north along border	Sialkot: more than 550mm Rawalakot: more than 540mm	Jhelum River Trimmu: 605,000 Cusecs Panjnad: 410,000 Cusecs	Inundation in the area along Indus River in Punjab Province Indus River Guddu: 367,000 Cusecs

Figure 13: Flood Pattern-3

Source : PMD

Characteristics of flood mechanism and the inundated area mainly depend on the difference in monsoon track and subsequent rainfall area. Especially in the flooding of the Indus River, in case there is a period of long delay between torrential rainfall and the occurrence of flooding and inundation, there is enough lead time for the evacuation of human and materials for the downstream for which flooding was predicted. Meanwhile, in the case of the 2011 flood, there was not enough lead time to evacuate or prepare against

flooding following the drainage capacity causing overflow from drainage channels or small rivers since flooding occurs at almost within the same area of torrential rainfall.

1-5 The importance of the Sukkur Meteorological Radar from the Meteorological Observation perspective

After the completion of the S-band Meteorological Doppler Radars in Islamabad, Karachi, and Multan, established through the support of the Government of Japan, the high resolution observation data of rain intensity and wind speed and direction could be obtained in approximately every 1km by using the Doppler Mode Observation (observation range: 200km radius), which was a remarkable improvement in the meteorological observation capability of Pakistan. However, there is a gap area not covered by the observation ranges in the middle and south region between Karachi and Multan as it is depicted in the figure on the right. In order to certainly grasp the movement of heavy rain and torrential rain from India to the middle region of Pakistan during monsoon seasons, it is necessary to establish a new Meteorological Doppler Radar in Sukkur in the middle of Karachi and Multan. As depicted in the figure on the right, the blank area of the observation will be completely covered once the Meteorological Radar is established in Sukkur, and the network of the Meteorological Radars can then cover all the approach paths of the rain clouds bringing heavy rain and torrential rain from India to Pakistan within the observation ranges.

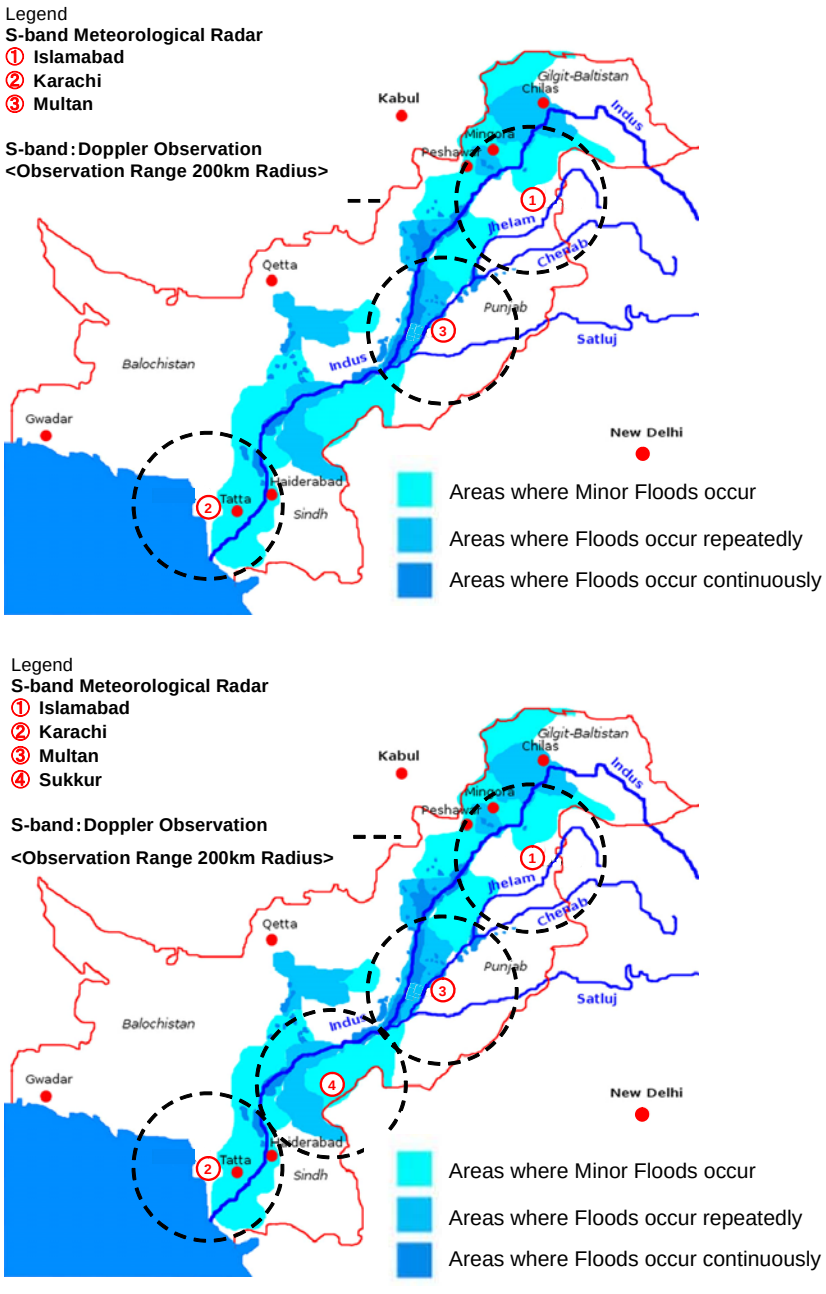


Figure 14: Comparison of Doppler Observation Range of S-Band Meteorological Doppler Radars with or without the Sukkur Meteorological Radar

1-6 The need for the dual polarization meteorological doppler radar system

Meteorological radars transmit radio waves and estimate precipitation from the received radio waves scattered by raindrops. However, the accuracy of the estimated amount of rainfall depends on the type of weather radar. Since the accuracy of the observed amount of precipitation by a conventional single polarization radar is insufficient, the accuracy of the estimation of the amount of rainfall is to be improved by comparing the observed radio wave intensity with the amount of precipitation observed by ground rain gauges, processing them statistically and obtaining appropriate rainfall transformation coefficients. However, there are about 40 rain gauges within the observation range (450km radius) of the Sukkur Meteorological Radar among the rain gauges owned by the PMD even if we count in the automatic weather stations (AWS) planned to be newly installed through the Economic and Social Development Program supported by Japan. The resulting ground observation density is only approximately 25% of the JMA's (Japan Meteorological Agency). By taking the operation and maintenance situation into account, the current ground observation density is not enough to correct the amount of rainfalls estimated from the observation done by a single polarization meteorological radar.

In contrast, a dual polarization meteorological radar can estimate the amount of rainfall with higher accuracy than a single polarization radar because a dual polarization meteorological radar transmits horizontally and vertically polarized radio waves and uses the difference in reflection intensity and phase information between two horizontal and vertical polarizations of scattered waves caused by the flatness of rainfall particles to grasp the situation of precipitation particles more accurately, while a single polarization radar estimates the amount of rainfall only by using the reflection intensity. Therefore, the dual polarization meteorological radar can estimate the amount of rainfalls even in case the number of ground observation stations is not sufficient as in the observation range of the Sukkur meteorological radar, after making appropriate adjustments through verification of the polarization parameters by zenith and plane observations, optimization of the elevation angle setting for clutter eliminations, identification of cluttering areas, calculation and verification of the coefficients to estimate the amount of rainfall (B, β and α) and comparison and verification with the observations by the rain gauges etc.

By considering the aforementioned deployment situation of automated ground rain gauges within the observation range of the Sukkur meteorological radar, establishing a dual polarization meteorological radar, not a single polarization one, will improve the accuracy of the precipitation estimation and contribute to yielding successful outcomes from the grant aid cooperation project.

1-7 The Existing Meteorological Radar Systems in Pakistan

Information on the existing Meteorological Radar Systems in Pakistan is indicated in the table shown in the next page.

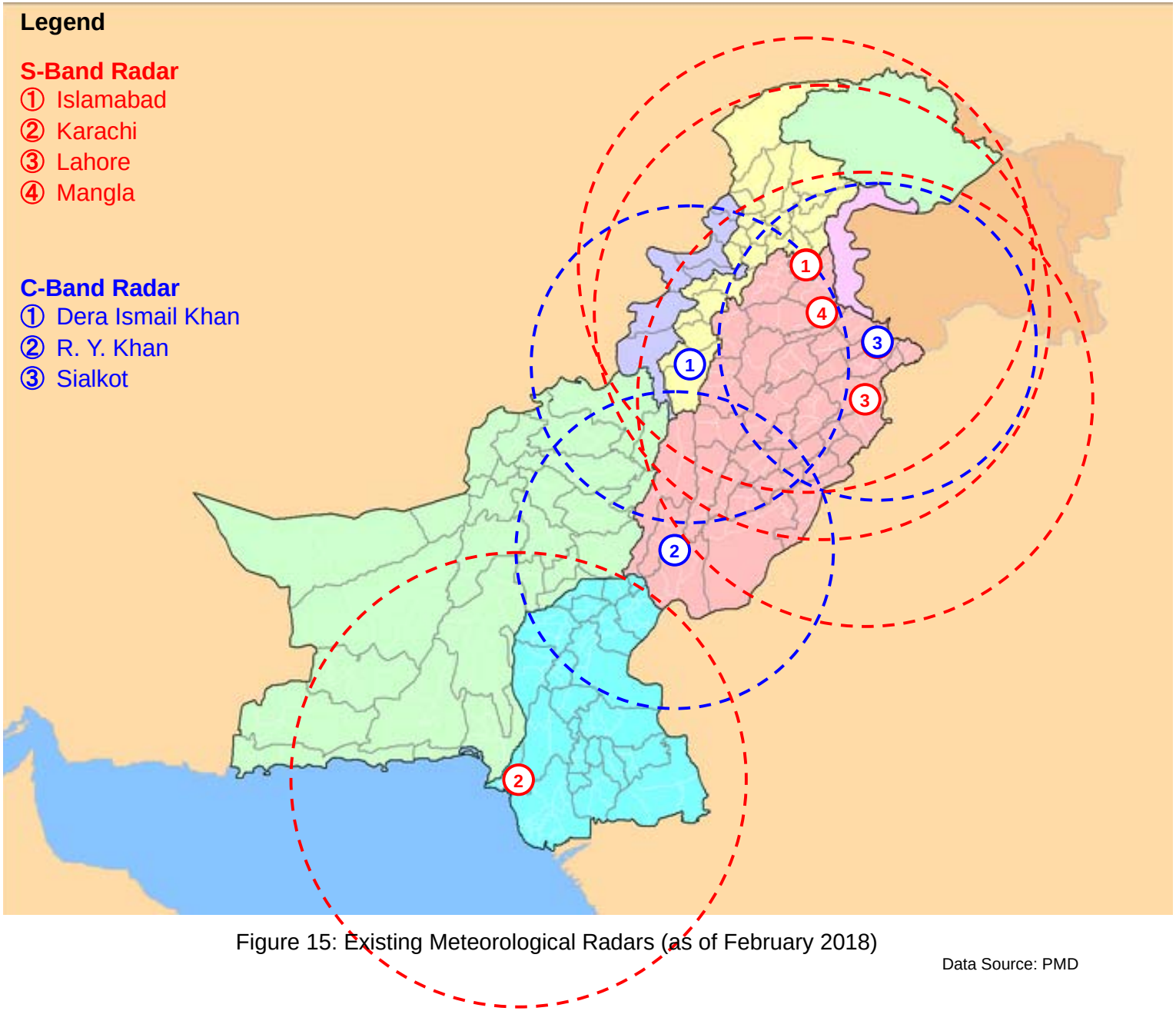


Figure 15: Existing Meteorological Radars (as of February 2018)

Data Source: PMD

Table 1: The Existing Meteorological Radar Systems (as of March 2020)

Existing Radar Observation Station	Location Latitude Longitude	Financial Support	Frequency Band	Type (Conventional/ Doppler/ Multi Parameter)	Antenna Diameter	Transmission Type (Magnetron/ Klystron/ Solid State)	Country of Origin Manufacturer	Installation Month & Year	Method of Observation Data Transmission to the Islamabad National Forecasting Center	Observation Data Processing System	Working Condition (as of March 2020)
Islamabad	N 33º 40' 57.52" E 73º 03' 51.08"	Government of Japan (Grant Aid)	S-Band	Doppler	5m	Pulse Compression Solid State	Japan Japan Radio Company (JRC)	May 2019	Direct Web Site Automaticaly Uploading	J-BIRDS Software	In operation
Karachi	N 24º 55' 44.71" E 67º 08' 36.31"	Government of Japan (Grant Aid)	S-Band	Doppler	5m	Pulse Compression Solid State	Japan Japan Radio Company (JRC)	2020	Direct Web Site Automaticaly Uploading	J-BIRDS Software	In operation
Lahore	N 31º 32' 33.16" E 74º 19' 28.61"	Asia Development Bank (ADB)	S-Band	Doppler	8m	Magnetron (Remaining Spare: 0)	USA Enterprise Electronics Corporation (EEC)	1997	Direct Web Site Manually Uploading	Edge Software	Needs to be replaced as soon as possible since rain intensity observation capability of 450km radius has currently reduced to 120km radius due to deterioration of the transmitter.
Mangla	N 33º 03' 58.66" E 73º 37' 58.98"	Asia Development Bank (ADB)	S-Band	Doppler	8m	Magnetron (Remaining Spare: 0)	USA Enterprise Electronics Corporation (EEC)	2004	Direct Web Site Manually Uploading	Edge Software	Partially in operation (needs to be replaced)
Dera Ismail Khan	N 31º 50' 10.19" E 70º 55' 01.51"	Government of Japan (Grant Aid)	C-Band	Conventional	4m	Magnetron (Remaining Spare: 1)	Japan Japan Radio Company (JRC)	March 1999	Direct Web Site Manually Uploading	JRC Software	Under suspension (It would be made functional by placing the parts from the Islamabad Radar)
Rahimyar Khan	N 28º 23' 34.88" E 70º 17' 15.84"	Government of Japan (Grant Aid)	C-Band	Conventional	4m	Magnetron (Remaining Spare: 1)	Japan Japan Radio Company (JRC)	March 1999	Direct Web Site Manually Uploading	JRC Software	In operation (It was extended functionally by placing the parts from the Islamabad & Karachi Radars)
Sialkot	N 32º 31' 28.98" E 74º 32' 33.28"	Asia Development Bank (ADB)	C-Band	Doppler	4m	Magnetron (Remaining Spare: 0)	USA Enterprise Electronics Corporation (EEC)	2005	Direct Web Site Manually Uploading	Edge Software	Partially in operation (needs to be replaced)

1-8 Ten Year Development Plan of the PMD

The enhancement and modernization of the meteorological services in Pakistan are urgent issues to alleviate the negative impact of severe weather and to ensure the people's safety as well as to significantly contribute to the sustainable development of the country. From the viewpoint of the PMD, in order to contribute to the achievement of the government goals indicated in "Vision 2025", which is the long-term national development policy of Pakistan, and the National Disaster Management Plan (NDMP), the Ten Year Development Plan of the PMD (a step towards modernization) has been formulated in 2016 by the PMD. The modernization of a meteorological radar observation network in Pakistan is mentioned in the first chapter (Chapter 1) of the Ten Year Development Plan of the PMD as one of the top priority implementation items. The detailed information on the latest modernization plan (modification version) currently made by the PMD is indicated in the next page.

Legend

[S-Band Meteorological Radar]
❶ Islamabad
② Mangla
③ Lahore
❹ Multan
❺ Sukkur
❻ Karachi
⑦ Gwadar

[C-Band Meteorological Radar]
❶ Rahim Yar Khan
❷ Dera Ismail Khan
❸ Sialkot

[X-Band Meteorological Radar]
① Gilgit
② Chitral
③ Mardan
④ Queta

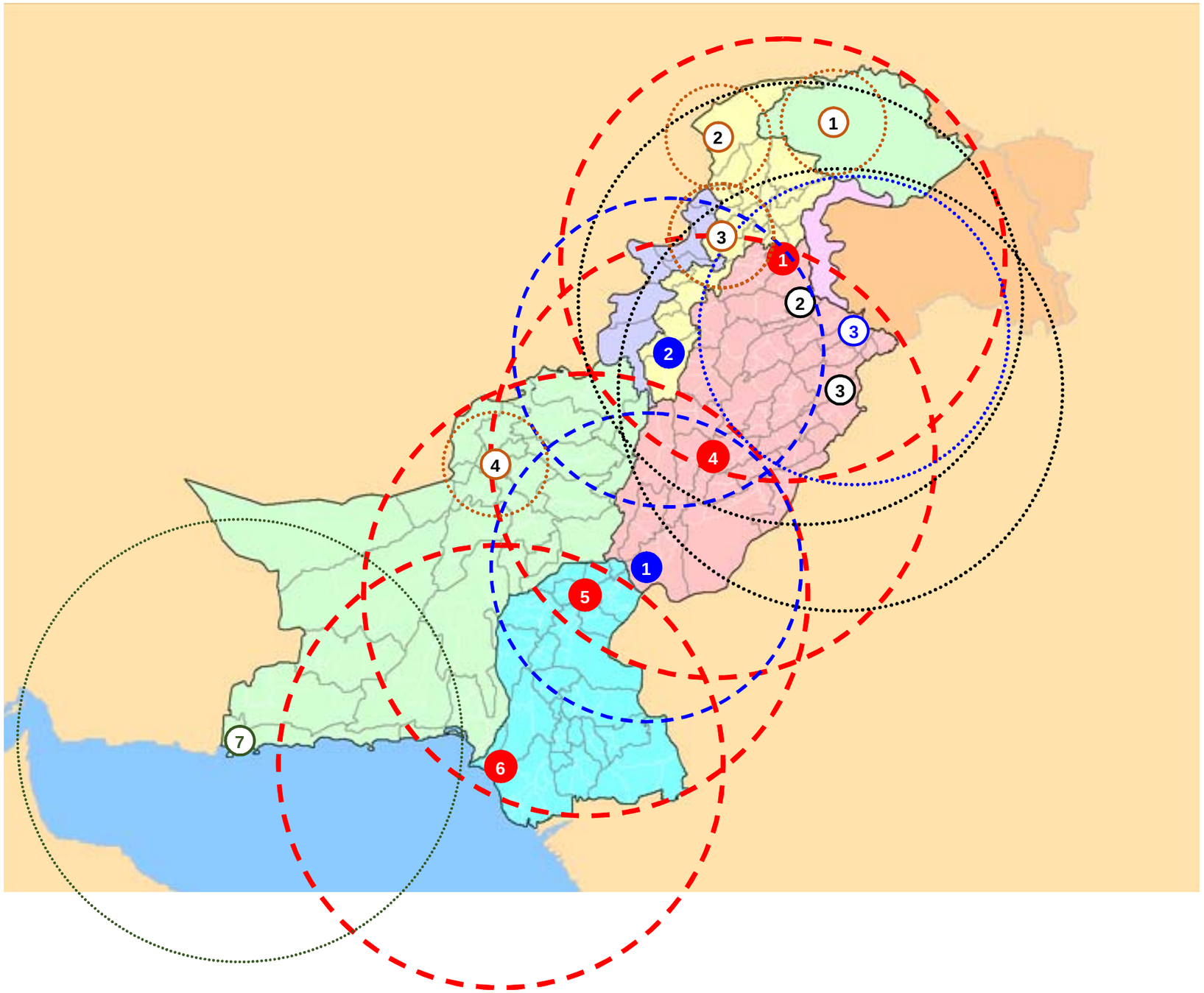


Figure 16: Establishment (including some proposed Replacement/s) of Meteorological Radars Comprising the Meteorological Radar Observation Network in Pakistan (as of March 2020)
Data Source: PMD

Table 2: Establishment (including some proposed Replacement/s) of Meteorological Radars Comprising the Meteorological Radar Observation Network in Pakistan (as of March 2020)

Map No.	Radar Station Name	Financial Support	Radar Type (Conventional/Doppler)	Antenna Diameter	Installation Month & Year	Remarks/Necessity of Replacement	Working Condition (as of March 2020)/Other Information
S-Band Meteorological Radar							
❶	Islamabad	Government of Japan (Grant Aid)	Doppler (Pulse Compression Solid State) made in Japan	5m	May 2019	New/Not Necessary	• Existing C-Band Ordinary Radar has been replaced with an S-Band Pulse Compression Solid State Doppler Radar provided under the Japan's Grant Aid • In operation
②	Mangla	Asian Development Bank (ADB)	Doppler (Magnetron) made in USA	8m	2004	Necessary	It is functional. However, EL antenna motor is defective and no spare Magnetron remains.
③	Lahore	Asian Development Bank (ADB)	Doppler (Magnetron) made in USA	8m	1997	Needs to be replaced as soon as possible	• The original rain intensity observation capability of 450km radius has currently been reduced to 120km radius (approx. 75% is lost) due to the deterioration of the transmitter. The radar is expected to soon shut down completely as it further deteriorates. Certainly, it will have a serious impact to Pakistan's flood forecasting and warning capability. • No spare Magnetron remains.
❹	Multan	Government of Japan (Grant Aid)	Dual Polarization (Polarimetric) Doppler (Pulse Compression Solid State) made in Japan	8m	2023 (Plan)	-	Project under the Japan's Grant Aid will start soon.
❺	Sukkur	Government of Japan (Grant Aid)	Dual Polarization (Polarimetric) Doppler (Pulse Compression Solid State) made in Japan	8m	2024 (Plan)	-	Project under the Japan's Grant Aid is currently at the initial stages.
❻	Karachi	Government of Japan (Grant Aid)	Doppler (Pulse Compression Solid State) made in Japan	5m	March 2020	New/Not Necessary	• Existing C-Band Ordinary Radar has been replaced with an S-Band Pulse Compression Solid State Doppler Radar provided under the Japan's Grant Aid
⑦	Gwadar	-	Doppler (Pulse Compression Solid State)	5m	-	-	A plan is available (Prospect of funding is not yet confirmed).
C-Band Meteorological Radar							
❶	Rahimyar Khan	Government of Japan (Grant Aid)	Ordinary (Magnetron) made in Japan	4m	1999	No plan for replacement	It is functional and operational by utilizing the useful parts from the old Islamabad & Karachi Radars and to be operated until the end of the equipment lifetime.
❷	Dera Ismail Khan	Government of Japan (Grant Aid)	Ordinary (Magnetron) made in Japan	4m	1999	Necessary	To be replaced with an S-Band Doppler Radar financed by the Government of Pakistan.
③	Sialkot	Asian Development Bank (ADB)	Doppler (Magnetron) made in USA	4m	2005	Necessary	• It is functional. However, no spare Magnetron remains. • A replacement plan is available (Prospect of funding is not yet confirmed).
X-Band Meteorological Radar							
①	Gilgit	-	Dual Polarization (Polarimetric) Doppler (Pulse Compression Solid State)	-	-	-	A plan is available (Prospect of funding is not yet confirmed).
②	Chitral	-	Dual Polarization (Polarimetric) Doppler (Pulse Compression Solid State)	-	-	-	A plan is available (Prospect of funding is not yet confirmed).
③	Mardan	Government of Pakistan	Dual Polarization (Polarimetric) Doppler: made in China	1.2m	2018	Not Necessary	In operation
④	Queeta	-	Dual Polarization (Polarimetric) Doppler (Pulse Compression Solid State)	-	-	-	A plan is available (Prospect of funding is not yet confirmed).

Source: PMD

1-9 Negative Impact on the Development of the Pakistani Economy

Pakistan has a population of 207 million (Pakistan Bureau of Statistics, 2017 Census) with an annual growth rate of 2.4%, and it is expected to become the country with the world's fourth largest population following India, China and the United States by 2050. The national GDP is about 305 billion US dollars (2017 World Bank) and the real economic growth rate is 5.97% (Pakistan Economic Survey 2017).

The following two figures show the relationship between the GDP growth rate (annual change) of Pakistan and the damage caused by floods in Pakistan. Since the Indus River Flood in 2010, which is one of the most devastating catastrophes in Pakistani history, occurred and caused unimaginable damages to almost the entire nation, the GDP growth rate also dropped to 1.6% in that same year. Furthermore, it has been observed that there is a tendency for the GDP growth rate to drop in inverse proportion to the number of the major flood disaster and the affected people (including killed and missing). These dips on the rate of the country's economic growth clearly demonstrate that the damages caused by flood disasters interfere with the socio-economic development of Pakistan. In addition, flood damages in Punjab and Sindh Provinces, where agricultural production is active and more than 70% of the population of Pakistan is concentrated, is considered to have a major negative impact on the economic development of the entire country.

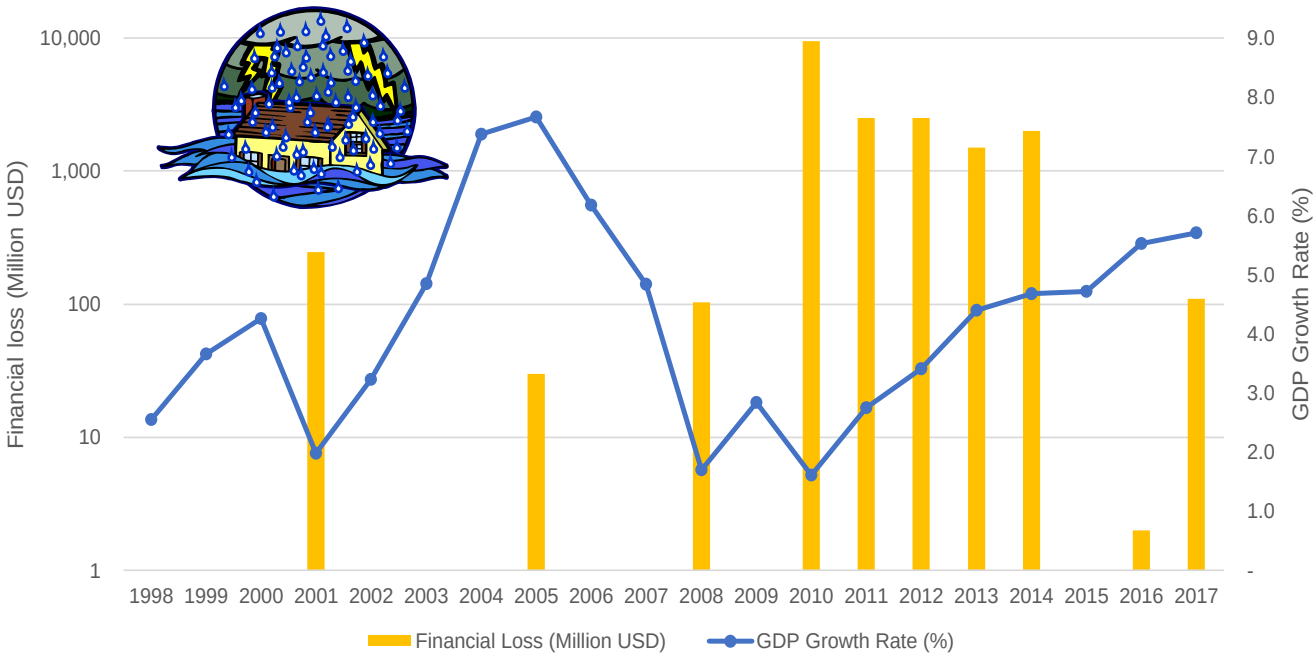


Figure 17: GDP Growth Rate of Pakistan and Financial Loss by Flood Disaster

Figure 18: GDP Growth Rate of Pakistan and Human Losses by Flood Disaster

1-10 Brief Summary on the Request for the Project by Pakistan

The Government of Pakistan adopted a national approach toward the strengthening of disaster prevention systems focusing on disaster prevention and damage mitigation. It has promulgated the National Disaster Management Ordinance (NDMO), established the National Disaster Management Authority (NDMA) as well as formulated the National Disaster Management Plan with the Japanese assistance. In the National Disaster Management Plan, a Multi-Hazard Early Warning System Plan aiming for the establishment and maintenance of the appropriate forecasting/warning system was proposed. For the successful implementation of the Plan, the enhancement of the PMD's observation and forecasting capabilities will be a key point. Parallel improvement of the following areas are also equally vital, namely; the development of human resources in the field of disaster prevention, dissemination of disaster prevention knowledge to the people, the establishment of flood control facilities, and etc. Therefore, it is highly necessary that the PMD improve its capability of meteorological observation and forecast/warning accuracy as well as to disseminate more promptly and timely the weather information (forecast/warning) to the proper channels.

Currently, the PMD is unable to accurately observe the rain clouds and the thunderstorm accompanied by heavy rain in the Sindh Province during the Monsoon season invading Pakistan from India. As a result, it is actually difficult for the PMD to appropriately reflect heavy rain information in its flood forecasting and

warnings. Therefore, in order to address the current situation whereby it is difficult to issue weather and flood forecasts and warnings in a timely manner due to the lack of observation data on the Indian side, it is urgently necessary to install a new meteorological radar system in Sukkur situated near the country border with India.

In 2019, the Government of Pakistan made a request to the Government of Japan for Grant Aid for "The Project for Installation of Weather Surveillance Radar at Sukkur in the Islamic Republic of Pakistan" (hereinafter referred to as "the Project"). In response to this request, the Government of Japan decided to conduct a Preparatory Survey for the Installation of a Weather Surveillance Radar at Sukkur (hereinafter referred to as the "Preparatory Survey"). The Japan International Cooperation Agency (hereinafter referred to as "JICA") sent the Preparatory Survey Team to Pakistan in order to conduct the Preparatory Survey from June 11 to July 17, 2019. The Team had a series of discussions with the officials concerned from the Government of Pakistan, conducted surveys and collected necessary and pertinent information and data for the Project. In addition, the Team conducted further studies, including a feasibility study focusing on the justification and scope of the Project paying particular attention to the present situation in Pakistan from various perspectives such as the operation & maintenance capabilities of the PMD, best equipment arrangement plan, etc.

JICA sent the Preparatory Survey Team again to Pakistan from January 20 to February 06, 2020 in order to explain and discuss the outline design & draft survey report. During the course of discussions and field surveys, it was confirmed that the requested items are indeed required for the Project in consideration of the Project's objectives and effects.

As a consequence of the further study on the requested items in Japan, it has been decided that the following components indicated in the table attached hereunder are object items of the Preparatory Survey for the Project.

Table 3: Object Items of the Preparatory Survey

Component	Proposed Sukkur Meteorological Radar Observation Station	PMD Islamabad Head Office National Weather Forecasting Center	PMD Tropical Cyclone Warning Center	PMD Flood Forecasting Division, Lahore	PMD Meteorological Office in the International Airports, Karachi, Islamabad and Lahore
Procurement and Installation of Equipment					
S-Band Pulse Compression Solid State Dual Polarization (Polarimetric) Meteorological Doppler Radar System including Surge Protector, Power Back-up System, Lightning System Measuring Equipment and Spare Parts	1	-	-	-	-
Meteorological Radar Central Processing System	-	1	-	-	-

Meteorological Radar Data Display System	1	1	1	1	1 at each office
Construction of Radar Tower Building					
Radar Tower Building	1	-	-	-	-
Technical Training	Initial operation guidance included in the contract of the manufacturer				
Soft Component					

During the study period indicated above, a comparison between a steel structure and a reinforced concrete structure for a radar tower building was conducted since steel structure radar tower buildings (Japan: for a C-Band radar system) are available in Japan and other overseas countries. Key points considered were construction cost, undertakings to be borne by the Pakistan side, possible technical issues during construction works, construction period and etc.

As a consequence of the comparison, it was decided that a reinforced concrete structure will be the best option to be used for the construction of the Sukkur Radar Tower Building due to the following reasons: (1) a concrete structure building will be cheaper; (2) total construction duration for a concrete structure building is shorter than a steel structure building; (3) a steel structure building is uncommon in Pakistan, taking into account the Pakistani side expression of their strong demand to use a reinforced concrete structure; (4) scope of works (tax exemption, etc.) to be undertaken by the Pakistani side will be smaller; (5) all the construction materials for concrete structure building can be procured in Pakistan and maintenance for a concrete structure building by the PMD is easier than a steel structure building; and finally, (6) no space for keeping steel structural frames in the project site, since the carrying in of a larger size truck for the steel structures and a 100-ton class sized crane into the project sites are quite challenging due to narrow main roads and lower overhead high voltage cables set along the main roads of the project site and special engineers of the steel frames factory and steel frame workers are required for erection of steel structural frames.

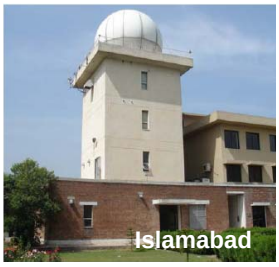
Table 4: Comparison between a Steel Structure and a Reinforced Concrete Structure for Radar Tower Building

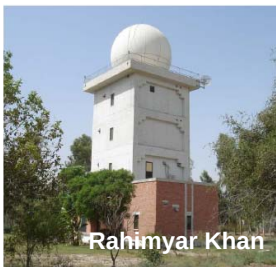
Items of Comparison	Steel Structure Radar Tower Building	Reinforced Concrete Structure Radar Tower Building
Structure	Steel pipe truss structure is required (Total Weight: 250 Tons).	Reinforced concrete structure which is commonly used in Pakistan.
Procurement of the Main Structural Materials	Import of main structural materials from Japan or Third Countries (south-eastern Asia) is required.	100% local procurement.
Utilization of a Local Construction Company for the Radar Tower Building Construction	■ No possibility to utilize a local construction company as a sub-construction company under a Japanese prime contractor for the construction of the main structure of the Radar Tower Building. ■ Specialized steel workers of Japan or a third country are necessary for the steel structures erection.	Since the reinforced concrete structure is commonly used in Pakistan, the utilization of a local construction company as a sub-construction company under a Japanese prime contractor for the construction of all of the Radar Tower Building is highly possible.
Necessity of Marine Transportation of the Main Structural Materials	Marine transportation of the main structural materials from overseas is indispensable and marine transport cost is quite high.	Not required.
Custom Clearance & Duty	Custom clearance and duty exemption or paying tax by the recipient country is	Not required.

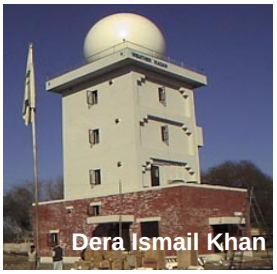
	required	
Inland Transport in Pakistan for Construction Materials	Since inland transport of the steel pipe truss structure (Total Weight: 250 Tons) from the Karachi Seaport is required, inland transportation cost is quite high.	Since aggregate (sand and gravel) can be procured near the project site, inland transport cost is not high.
Total Construction Period after signing of the contract	18-19 months (20-21 months, if piling work is available)	18 months (20 months, if piling work is available)
Corrosion on the Main Structures including Stairs Structures	Due to the provision of high corrosion treatment to the steel materials and appropriate supervision, salt corrosion on the main structures is less likely.	Due to appropriate supervision, salt corrosion is less likely.
Construction of Main Structures	For erection of steel structural frames, 2 blacksmith engineers of the steel frames factory and 8 steel frame workers are required.	Any special skilled workers or engineers are required.
Construction Work Duration at the Site	Shorter	Longer
Fire Resistance and Thermal Conductivity	Since steel structures are not fireproof and high in thermal conductivity, fireproof and thermal insulation materials for the main structures are required when used in areas where the outside temperature is very high as the outside air temperature is likely to affect the room temperature due to high heat conductivity.	Since concrete structures are generally fireproof and low in thermal conductivity, fireproof and thermal insulation materials for the main structures are not required.
Periodic Painting	Periodic painting to the construction materials (bolts, nuts, connection parts, etc.) which are not provided with high corrosion treatment is required.	Periodic painting is not indispensable.
Material Storage Space and Crane Vehicle	Since there is no space to temporarily store steel frames on the proposed Project Site in Sukkur, it is required to secure a provisional space located near the site, a 20-ton sized crane for unloading/loading and a 100-ton sized crane for the steel structure erection.	A compact/middle size crane vehicle and a tower crane are widely utilized for the construction of reinforced concrete structure buildings.

*Assuming the height of a meteorological radar tower building is approximately 50m

1-11 The trend of Aids by the Government of Japan in the Meteorological Field







The Government of Japan has provided various cooperation in the meteorological field for nearly 30 years in order to reduce the damages caused by natural disasters in Pakistan. Since 1990, "The Project for Establishment of Meteorological Radar Network (Phase I)" has been executed and completed in March 1991, and C-band Meteorological Radars were established in Islamabad, the capital in the north, and in Karachi in the south. Since 1998, "The Project for Improvement of the Meteorological Radar Network (Phase II)" has been executed and completed in March 1999. In this project C-band Meteorological Radars have been established in Dera Ismail Khan and Rahim Yar Khan in the middle of Pakistan, which is the first observation network of Meteorological Radars in Pakistan. However, as the Islamabad and Karachi Radars are 29 years old and the Dera Ismail Khan and Rahim Yar Khan Radars are more than 20 years old, a number of troubles have occurred recently due to equipment deterioration over the last 20 years. In addition, the radar makers find it difficult to supply the spare parts of these Meteorological Radars as they are analog components, and, thus, it is expected that they will completely stop the operation in the near future.

Currently the PMD owns three Meteorological Radars in Lahore, Sialkot, and Mangula established with the support of the Asian Development Bank other than the aforementioned four analog Meteorological Radars. However, those three Meteorological Radars have also deteriorated. Especially the S-band Meteorological Radar in Lahore (completed in 1997), one of the most important Radars to make the flood forecasting and warning, has degraded its observation range from 450km to approximately 120km radius due to significant reduction in its transmission capacity. It is a concern that the Lahore Meteorological Radar will stop its operation in the near future because there is no spare magnetron transmitter tube. Under such circumstances, the grant aid project by the government of Japan conducted an upgrade of Meteorological Radars in Islamabad (completed in May 2019) and in Karachi (planned completion in 2020). However, these two S-band Meteorological Doppler Radars are not sufficient to accurately observe the rain clouds moving from India to the middle area of Pakistan and causing heavy rain and torrential rain during monsoon seasons and thunderstorms

associated with cumulonimbus clouds and the heavy rainfalls around the Sulaiman Mountains.

It is under schedule from 2020 to establish a new S-band Solid State Power Amplifier Dual-Polarization Meteorological Doppler Radar in Multan through the Grant Aid project of the Government of Japan because it is necessary to compensate the observation range of the existing Dera Ismail Khan Meteorological Radar which has deteriorated and expected to stop in the near future (The Rahimyar Khan Meteorological Radar has already stopped due to lack of spare parts needed for the repair).

1-12 Project Site Location Information

Table 5: Project Site Location Information

Name of Site	Proposed Radar Observation Station (PMD Meteorological Observatory, Rohri-Sukkur)	PMD Islamabad Headquarters, National Weather Forecasting Center	PMD Karachi, Tropical Cyclone Warning Center (TCWC)	PMD Lahore, Flood Forecasting Division (FFD)
Latitude	N 27º 41' 06.48"	N 24º 55' 58.9"	N 24º 55' 58.9"	N 31º 32' 33.1"
Longitude	E 68º 53' 25.15"	E 67º 08' 32.8"	E 67º 08' 32.8"	E 74º 19' 29.5"
Altitude	69m	39m	39m	163m
Name of Site	PMD Meteorological Office in the Islamabad International Airport	PMD Meteorological Office in the Karachi International Airport	PMD Meteorological Office in the Lahore International Airport	
Latitude	N 33º 32' 36.43"	N 24º 54' 01.7"	N 31º 31' 14.02"	
Longitude	E 72º 49' 40.22"	E 67º 10' 05.6"	E 74º 24' 37.81"	
Altitude	530m	37m	238m	

1-13 Stability of Commercial Power

Stability tests measuring commercial power through a power quality analyzer were conducted at the proposed Radar Observation Station (PMD Meteorological Observatory, Rohri-Sukkur) for 3 weeks with the results indicated in the following table. Since an ordinary power supply (Ordinary Line), which is a target of planned electric outage, is laid at the PMD Meteorological Observatory, Rohri-Sukkur, electric outage for about 8 hours a day occurs.

Table 6: Stability of Commercial Power (Measured by a Power Quality Analyzer)

Name of Site		Proposed Project Site for construction of the Sukkur Meteorological Radar Tower Building
Commercial Power (Voltage: Nominal)		230V, 50Hz, Single-phase 2-wire
Voltage (V)	Max.	224.2
	Min.	170.0
	Average	201.0
Frequency (Hz)	Max.	50.6
	Min.	49.5
Frequency of Electric Outage (Scheduled Electric Outage)		4 times/day (Total: Approx. 8 hours/day)

1-14 Internet Connection used by the PMD

The current status of the internet connection used by the PMD and the future plan for internet connection expansion according to implementation of the Projects financed by the Japan's Grant Aid are as follows.

Table 7: Improvement Plan Chart of PMD Internet Connection

Japan's Grant Aid Projects for the PMD				
Major Project Components	Establishment of Specialized Medium Range Weather Forecasting Center, Islamabad Radar and Wind Profiler (Islamabad & Multan)	Establishment of Karachi Radar	Establishment of Multan Radar	Establishment of Sukkur Radar
Completion Time	May 2019 ➡	Mar 2020 ➡	2023 (Plan) ➡	2025 (Plan)
Specialized Medium Range Weather Forecasting Center, PMD Islamabad Headquarters For Global Telecommunication System (GTS), World Information System (WIS), and Karachi Radar				
Service Provider	NTC	NTC	NTC	NTC
Connection Type	Shared Line	Shared Line	Shared Line	Shared Line
Public IP Address	○	○	○	○
Contract Speed (bps)	100M	100M	100M	100M
Specialized Medium Range Weather Forecasting Center, PMD Islamabad Headquarters For Multan Radar, Sukkur Radar				
Service Provider	-	-	PTCL	PTCL
Connection Type	-	-	IP-VPN	IP-VPN
Public IP Address	-	-	○	○
Contract Speed (bps)	-	-	4M	8M
Specialized Medium Range Weather Forecasting Center, PMD Islamabad Headquarters For Flood Forecasting Center Lahore				
Service Provider	-	-	NTC / PTCL	NTC / PTCL
Connection Type	-	-	IP-VPN	IP-VPN
Public IP Address	-	-	○	○
Contract Speed (bps)	-	-	6M	10M
PMD Meteorological Office Islamabad International Airport (New Benazir Bhutto International Airport (NBBIA))				
Service Provider	NTC	NTC	NTC	NTC
Connection Type	Shared Line	Shared Line	Shared Line	Shared Line
Public IP Address	×	×	×	×
Contract Speed (bps)	2M	4M	4M	100M
PMD Karachi Tropical Cyclone Warning Center				
Service Provider	NTC	NTC	NTC	NTC
Connection Type	Shared Line	Shared Line	Shared Line	Shared Line
Public IP Address	○	○	○	○
Contract Speed (bps)	100M	100M	100M	100M
PMD Meteorological Office Karachi International Airport				
Service Provider	NTC	NTC	NTC	NTC
Connection Type	Shared Line	Shared Line	Shared Line	Shared Line
Public IP Address	×	×	×	×
Contract Speed (bps)	2M	4M	4M	100M
Karachi Meteorological Radar Observation Station: Radar Tower Building				
Service Provider	-	N/A	N/A	N/A
Connection Type	-	LAN	LAN	LAN
Public IP Address	-	×	×	×
Contract Speed (bps)	-	100M	100M	100M

PMD Flood Forecasting Division, Lahore				
Service Provider	NTC	NTC	NTC/PTCL	NTC/PTCL
Connection Type	Shared Line	Shared Line	IP-VPN	IP-VPN
Public IP Address	○	○	○	○
Contract Speed (bps)	4M	6M	6M	10M
PMD Lahore Regional Meteorological Center				
Service Provider	NTC	NTC	NTC	NTC
Connection Type	Shared Line	Shared Line	Shared Line	Shared Line
Public IP Address	○	○	○	○
Contract Speed (bps)	2M	2M	2M	2M
PMD Multan Regional Meteorological Center (Multan Meteorological Radar Observation Station: Radar Tower Building)				
Service Provider	-	-	N/A	N/A
Connection Type	-	-	Long Distance Wireless LAN	Long Distance Wireless LAN
Public IP Address	-	-	×	×
Contract Speed (bps)	-	-	54M	54M
PMD Meteorological Office Multan International Airport				
Service Provider	NTC	NTC	PTCL	PTCL
Connection Type	Shared Line	Shared Line	IP-VPN	IP-VPN
Public IP Address	×	×	×	×
Contract Speed (bps)	1M	1M	4M	4M
PMD Gilgit Regional Meteorological Center				
Service Provider	NTC	NTC	NTC	NTC
Connection Type	Shared Line	Shared Line	Shared Line	Shared Line
Public IP Address	×	×	×	×
Contract Speed (bps)	1M	1M	1M	1M
Sukkur Meteorological Radar Observation Station: Radar Tower Building				
Service Provider	-	-	-	PTCL
Connection Type	-	-	-	IP-VPN
Public IP Address	-	-	-	×
Contract Speed (bps)	-	-	-	4M

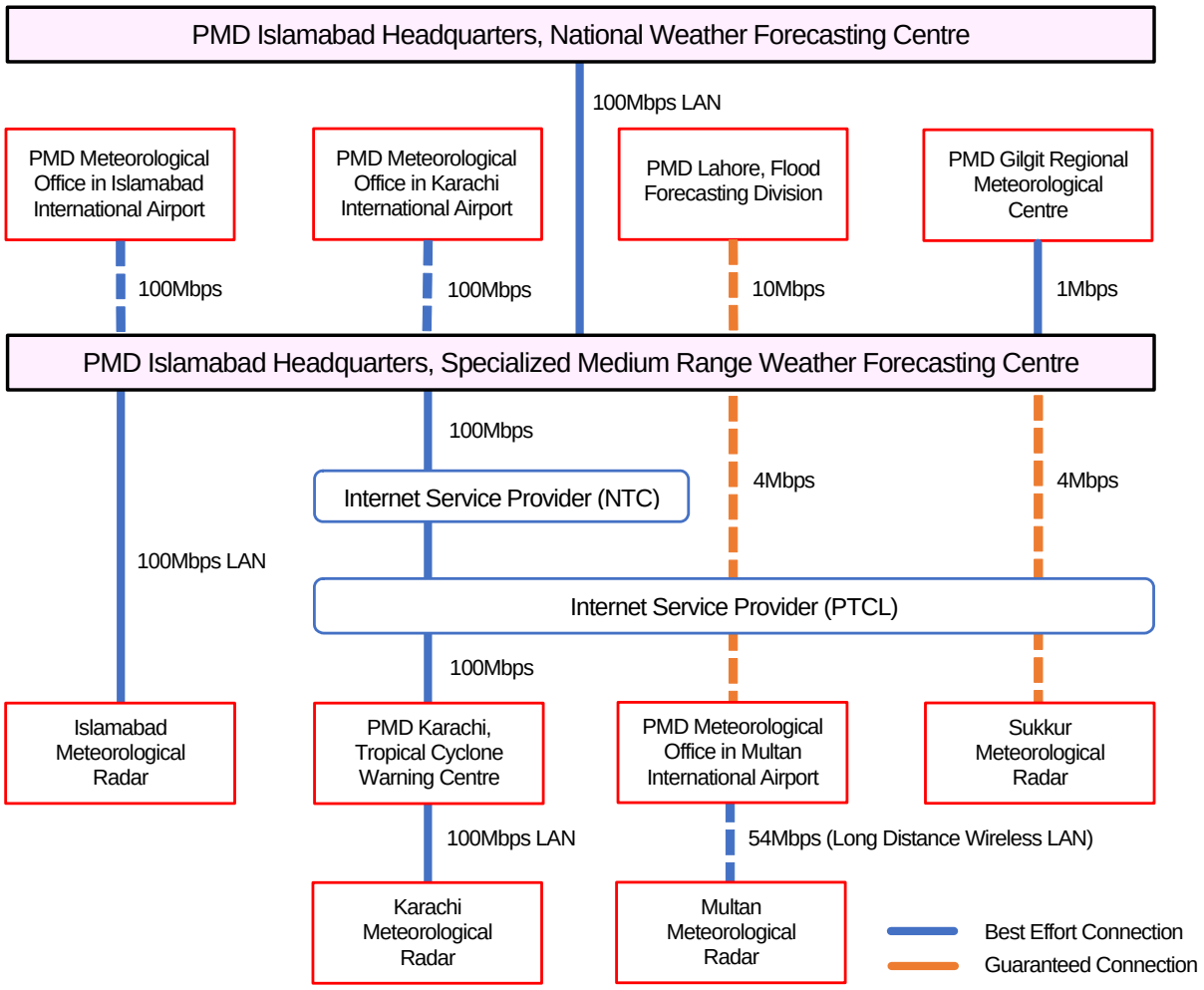


Figure 19: PMD Internet Network between PMD Islamabad Headquarters and PMD Meteorological Radars Established under the Japan's Grant Aid

1-15 Meteorological Radar Images published by the PMD

As shown in the figure below, three types of images of the Meteorological Radars of Islamabad and Karachi newly established by the Japan's Grant Aid are published to the general public through the PMD Web site. Also, in the future, when Multan and Sukkur Meteorological Radars are completed, the PMD has a plan to add these images and a composite image to its Web site.

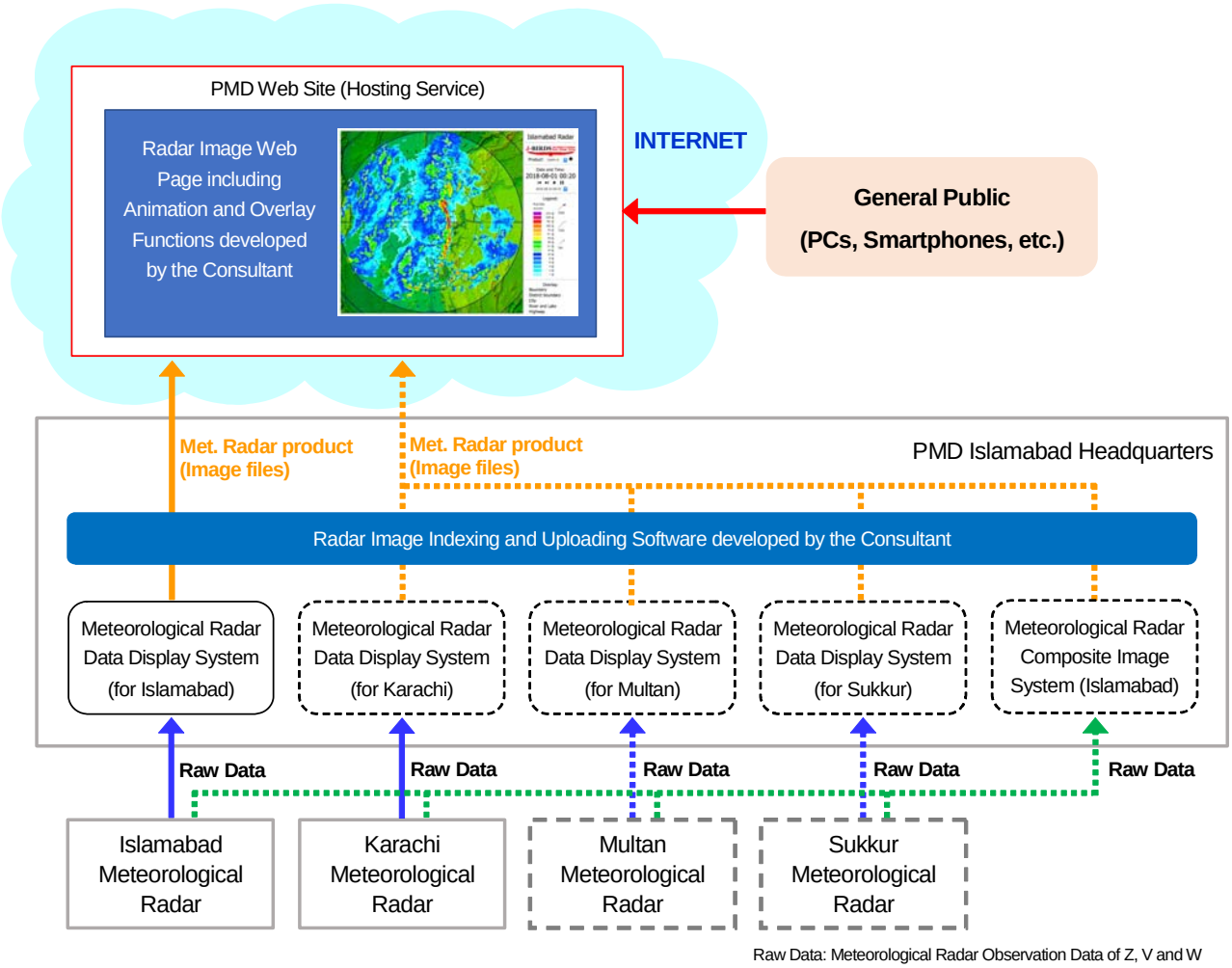


Figure 20: Mechanism of Meteorological Radar Images Published by the PMD Web Site for the General Public

1-16 Natural Conditions of Sukkur

Rohri, where the PMD Meteorological Observatory, Rohri-Sukkur resides, is situated in the Rohri sub-division of Sukkur district in the Sukkur Division within the province of Sindh. Sukkur district is the city with the 14th largest population in Pakistan. On the west side of the Indus River is the Sukkur sub-division and on the east side is the Rohri sub-division. It is extremely hot during summer. The PMD Meteorological Observatory, Rohri-Sukkur has conducted weather observation since 1925. The maximum temperature recorded for the last 95 years is 51.0 degrees Celsius (June 01, 1996) while the minimum temperature is -1.5 degrees Celsius (December 15, 1986). The annual average precipitation for the 5 years between 2014 and 2018 is 22.56mm. On the other hand, the amount of precipitation is extremely smaller than in the northern part of Pakistan. The maximum temperature reaches almost 50 degrees Celsius in April, May and June.

The attached figures below show the past 5-year averages of the monthly maximum, mean, and minimum temperatures and the monthly total precipitation at the PMD Meteorological Observatory, Rohri-Sukkur.

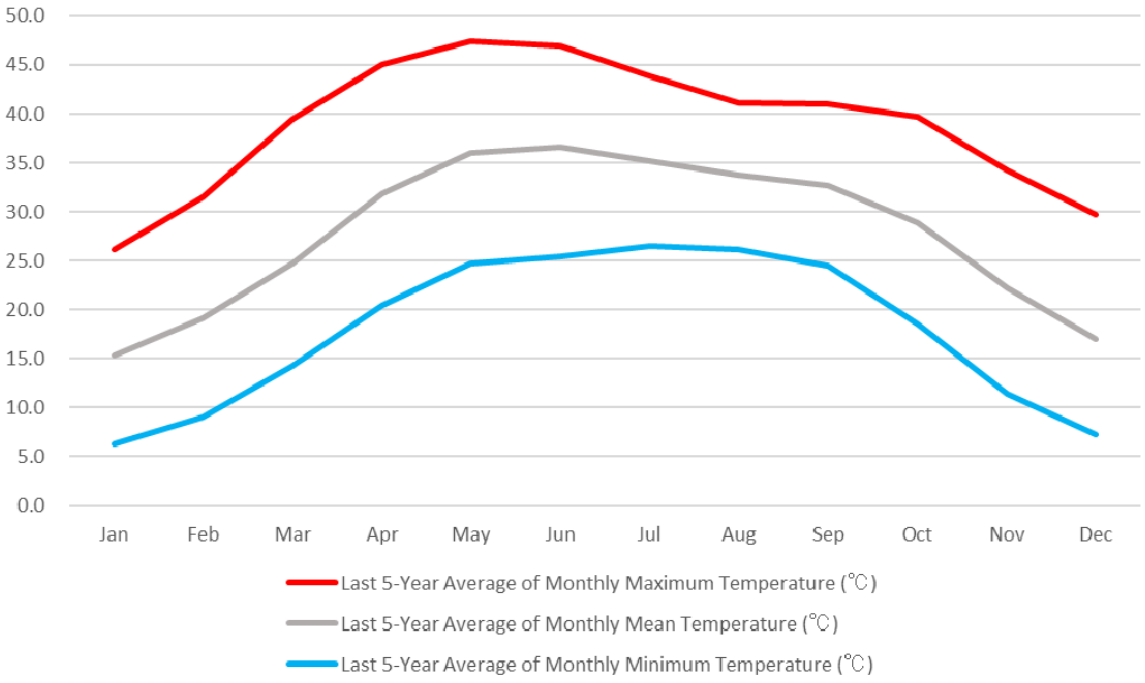


Figure 21: Last 5-year Average of Monthly Temperatures at PMD Meteorological Observatory, Rohri-Sukkur (2014 - 2018)

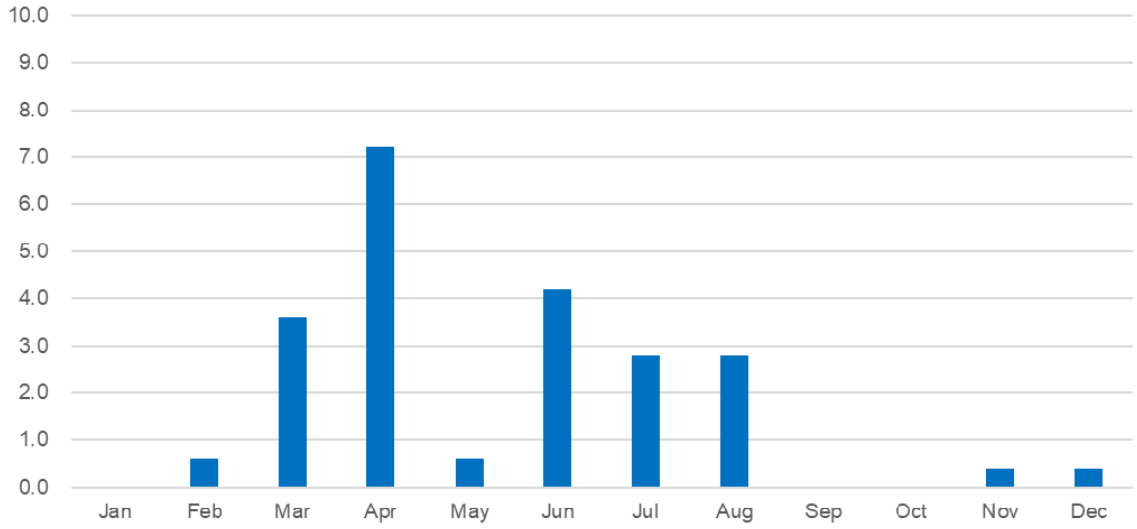


Figure 22: Last 5-Year Average of Monthly Total Precipitation at PMD Meteorological Observatory, Rohri-Sukkur (2014 - 2018)

1-17 Topographic and Geotechnical Surveys

The topographic and geotechnical surveys indicated in the following tables were implemented by a local contractor consigned by the Preparatory Survey Team.

Table 8: Topographic Survey

Required Works	• Position of the existing building, observation facility, observation field • Bearing survey of the magnetic north • Calculation of the area planned
	• Plane surveying (0.5m contour line) - Position of the existing facilities (electrical lines, water lines, telephone lines, public roads, sidewalks, existing buildings, fences/wall, trees: more than 4m height, streetlights, manholes, sewage and other features)
	• Longitudinal profile and cross section - Indication of ground level at intervals of 10m - Public roads, ponds, river and each water level - Setting bench marks
Required Products	• Plane surveying map • Longitudinal profile and cross section • AutoCAD data file in CD-ROM

Table 9: Geotechnical Survey

Boring (All core boring)	Required number of borings: 3 Maximum depth of borings: 40m (Borings shall be extended to a more suitable bearing layer for a building construction even if borings have reached more than a depth of 40m. After reaching the bearing layer, borings shall be continued to a depth of at least 5m.)
Collecting soil samples	• Undisturbed soil sampling: 3 samples (at different levels) × 3 holes • Disturbed soil sampling: 3 samples (at different levels) × 3 holes • Adoption of standard: ASTM or JGS-Japanese geotechnical society
Standard Penetration Test	At intervals of every 1 m till the bottom of each borehole
Laboratory Testing	• Density Test of Soil Particle, Particle Size Distribution, Specific Gravity, Water Content, Liquid Limits, Plastic Limits • Unconfined Compression Test and Consolidation Test
Required Products	Geotechnical Survey Report: expected soil bearing capacity and calculation of consolidation coefficient

Table 10: Geotechnical Survey Result of the Proposed Project Site for Sukkur Meteorological Radar Observation Station

Boring No.	Depth (m)	Soil Type	N-value
BH-1	0.0-0.3	Silty sand	-
	0.3-15.0	Limestone	>50
	15.0-31.5	Limestone	>50
	31.5-40.0	Limestone	>50
BH-2	0.0-0.3	Silty sand	-
	0.3-7.5	Limestone	>50
	7.5-30.0	Limestone	>50
	30.0-45.0	Limestone	>50
BH-3	0.0-0.3	Silty sand	-
	0.3-7.5	Limestone	>50
	7.5-30.0	Limestone	>50
	30.0-40.0	Limestone	>50

1-18 Consideration for Environmental Conservation

The Project would be assessed as category C in the environmental and social consideration guidelines of JICA.

Since it was confirmed by the PMD with the Environmental Protection Agency (EPA) in the Sindh Province that an Environmental Impact Assessment (EIA) permit is not required for implementation of the Project, the PMD has prepared Initial Environmental Examination (IEE) on the Project "Installation of Weather Surveillance Radar at Sukkur in the Islamic Republic of Pakistan" and submitted it to the EPA to obtain the No Objection Certificate (NOC).

Chapter 2
Contents of the Project

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

The establishment under the Project (Input) of an S-Band Pulse Compression Solid State Dual Polarization Doppler Meteorological Radar System at Sukkur in the Sindh Province, together with the associated Meteorological Radar Central Processing System and Meteorological Radar Data Display Systems will strengthen the PMD's monitoring capability of hazardous weather phenomena. The implementation and completion of the Project will particularly enable the PMD to be capable in providing highly accurate meteorological observations on the wide area of the Sindh and Punjab Provinces including the Indian side, and ensure the quick and timely dissemination of weather and flood forecasts/warnings to the general public (Outcome). Hence, the Project will certainly contribute to the reduction of damages caused by natural disasters (especially flood damages caused by heavy and torrential rains) in Pakistan (Impact).

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

(1) Basic Design Policy of the Project

a) To design a meteorological observation system that will improve the ability to monitor meteorological phenomena that cause disasters in order to reduce the human and economic losses arising from these natural disasters (mainly flood damage due to heavy rain or torrential rain).
b) To enable the PMD to provide weather information, forecasts, advisories and warnings necessary for the protection of people's lives and properties from natural disasters and the improvement of social infrastructure in Pakistan.
c) To enable the PMD to monitor weather conditions around-the-clock on a real time basis.
d) To enable the PMD to promptly issue a weather information and/or a warning to the public.
e) To design the equipment so that the meteorological radar system assumes a significant role in the severe weather detecting network of Pakistan.
f) To determine and set up the size and components of the Project to match with the technical, operational and maintenance capabilities of the PMD.

[1] Design Policy of the Equipment

a) To ensure that the equipment is compatible with and meets the technical requirements of the

World Meteorological Organization (WMO).

b) To ensure that the equipment is suitable for the routine observation and forecasting work of the PMD.
c) To design the Sukkur Meteorological Radar System with functions relevant to quantitative rainfall observation and air-turbulence observation capabilities that enhances and upgrades the accuracy of the weather forecasts made by the PMD.
d) To design the Sukkur Meteorological Radar System to acquire constant altitude rainfall information from 3-dimensional observation raw data obtained by scans of the radar system at multiple elevations to ensure wider coverage and detection of rainfall distribution at each altitude.
e) To design the system in such a way that all the data produced by the Sukkur Meteorological Radar System are delivered to the National Weather Forecasting Center, PMD Islamabad Head Office every 10 minutes.
f) To design the system considering the PMD's capability to operate, maintain and repair.
g) To select equipment for which spare parts and consumables can be easily procured and replaced.
h) To select reliable and durable equipment suitable for the local environment.
i) To minimize the recurrent costs of the PMD for the operation, maintenance and repair of the equipment.
j) To ensure the accuracy of radar data through meticulous adjustment and proper calibration (optimization of radar ZR relation parameter for rainfall calculation).
k) To design the equipment so as to minimize lightning damage.
l) To have the necessary power supply back-up equipment (diesel generator, radar power backup unit, auto voltage regulator, etc.) for performing around-the-clock meteorological services 24 hours a day, 365 days a year.
m) To design the equipment to operate using 230V Single Phase 2-Wire/400V 3-Phase 4-Wire ±20%, 50Hz power.

[2] Design Policy of the Radar Tower Building

The aim is to construct a meteorological radar tower building that will ensure the appropriate and effective operation of the system as well as accommodate the required systems, equipment and personnel. It is basic policy that the designed Radar Tower Building satisfies the following requirements:

a) To ensure, as much as possible, that the height of the radar tower building is free of obstructions (e.g. surrounding mountains, existing facilities) to avoid blind areas during radar observations.

b) To select the most suitable foundation structures to ensure that the permissible horizontal deflection of the radar tower buildings by the design wind pressure is not more than 1/1000 of the height of radar tower building.
c) To adopt the design wind pressure: 6kN/m^2 and the seismic zone factor: Z=0.15 of the Building Code of Pakistan-Seismic Provisions-2007.
d) To ensure that the working environment within the office spaces for all the PMD personnel performing 24-hour/day work schedule of observations is conducive towards effective and efficient performance.
e) To be sufficiently robust enough to withstand extreme weather and ensure uninterrupted radar observation and continuous provision of weather forecasts & warnings to the public, even during the occurrence of a natural disaster.
f) To make use of local building materials for the easy maintenance of the radar tower building by the PMD.
g) To design the equipment so as to minimize lightning damage.
h) To adapt to the routine work system and implementation method of the PMD.

(2) Design Policy on Environmental Conditions

1) Temperature/Humidity

In order to ensure the smooth operation of the equipment under the appropriate environment at a controlled temperature/humidity, air-conditioning systems are required for the rooms (e.g. radar equipment room, radar observation room, spare parts room, electricity room, surface observation room, etc.) where the equipment to be procured under the Project (radar transmitter, operation terminals, display monitors, spare parts, test instruments and power back-up system) are to be installed in.

2) Rainfall

Meteorological data should be transmitted and received even during the occurrence of very heavy rains. A maintenance staircase is located at the center of the building, covered by an upper concrete slab, to enable the PMD personnel to easily reach each room for the regular maintenance of the radar equipment without getting wet during the rainy season.

3) Flood

The ground floor of the radar tower building will be built 2m high to minimize any possible damage due to flooding.

4) Lightning

Frequent lightning occurs especially during the rainy season. A lightning protection and grounding system (see the drawing of Lightning Protection & Grounding System) are, therefore, indispensable to

prevent damage to the building and to the equipment.

- Installation of lightning rod(s) at the top of the Radome
- Installation of roof-ridge lightning conductors at the Radome Roof and the Observation Deck
- Installation of a down grounding conductor at the center of the Radar Tower Building
- Installation of a down lightning conductor at each of the 4 major columns of the Radar Tower Building
- Adoption of a Ring Earth Electrode Method

5) Wind

For calculation of the design wind pressure: 6kN/m^2 of the Building Code of Pakistan-Seismic Provisions-2007 will be utilized.

6) Earthquake

For calculation of the seismic zone factor: Z=0.15 and the importance factor (I) = 1.25 of the Building Code of Pakistan-Seismic Provisions-2007 will be applied.

7) Load Bearing Layer

The structural design of the radar tower building is to be implemented according to the results of the geotechnical survey done by a local contractor consigned by the Preparatory Survey Team. Foundation type of the radar tower building is as follows:

Table 11: Foundation Type of the Proposed Sukkur Meteorological Radar Tower Building

	Sukkur Meteorological Radar Tower Building
Foundation type	Spread foundation

(3) Socio-economic Conditions

Since floods not only cause loss of lives and properties and stagnation of economic activities but also significantly affect the poor, the Project will be designed in order for the PMD to acquire the capability to be able to implement accurate observation and monitoring in the entire area facing the country border between India and the provinces of Punjab and Sindh as well as to be able to promptly and quickly disseminate and deliver vital weather & flood forecasts and warnings to the general public.

(4) Design Policy for Construction Work

1) Environmental Regulation

Waste water discharged from the radar tower building must undergo initial treatment before filtering the

treatment into the soil at the site.

2) Use of Locally Procurable Materials

Most of the construction materials can be procured from the local market. For the Project, maintenance materials not containing asbestos will be selected from locally available materials.

3) Use of Local Construction Methods and Local Workers

Laborers are classified according to their skills (e.g. as carpenters, plasterers, steel fitters, etc.) and skill level is variable in Pakistan. In order to be able to utilize local laborers as often as possible, reinforced concrete structures, which local workers are familiar with, will be used.

(5) Policy for Use of Local Construction Companies

1) Construction Work of the Radar Tower Building

Generally, in Pakistan, the technical skills and competence of the major local construction companies are adequate enough. Thus, they will be used for the construction of the radar tower building.

2) Equipment Installation Work

Under the supervision of a Japanese engineer, a local electrical work contractor will be used in the installation work of the equipment.

(6) Active Utilization of Japanese Companies

The planned Pulse Compression Solid State Dual Polarization (Polarimetric) Meteorological Doppler Radar System will primarily be a state-of-the-art Japanese system in this field. Hence, it is positively expected that many small-to-medium-sized Japanese companies will be involved and render valuable support directly under the system manufacturer. In addition, most of the companies engaged in the construction for associated facilities as well as the vital equipment installation works are similarly small-to-medium-sized Japanese firms. Therefore, the plan is made to exhibit or showcase the high quality and well-trusted Japanese skills through those Japanese companies.

(7) Design Considerations to Simplify Operation and Maintenance for the PMD

1) User-friendly equipment

The equipment to be supplied under the Project will be used to support the PMD’s routine work as the national meteorological agency for natural disaster prevention. As such, a variety of data processing, analysis, display and communications capabilities must be readily available for the PMD using simple operational procedures.

2) Easy maintenance of the equipment

The equipment must be designed in such a way so as to minimize the spare parts and consumables required and to simplify regular maintenance. Replacement parts must be quickly and readily available.

3) Consideration of minimizing operational & maintenance costs

The biggest recurrent cost of the Project is expected to be electricity; therefore, the equipment and facility should be designed to minimize power consumption. In order for the PMD to meet the operational and maintenance costs, the following measures have been included in the plan for the equipment and the radar tower building:

- The ability to restrict the operation of the air-conditioning systems and the electricity supply in the operational rooms within the radar tower building only.
- The utilization of natural light to reduce energy requirements by minimizing the hours of artificial lightening required.
- Usage of LED for artificial lightening.
- Incorporation of solid-state parts into the radar system to reduce the cost and frequency of parts replacement.

(8) Design Policy for Equipment & Building Grade

To ensure the uninterrupted dissemination of forecasts and warnings to the public, the equipment and the radar tower building must be sufficiently robust enough to withstand very heavy rains, local severe storms and lightning strikes to enable the provision of meteorological services 24 hours per day.

(9) Design Policy regarding Construction/Procurement Method and Schedule

The equipment for the Project must be durable, reliable, of high technical level and cost effective. Though the equipment to be installed in the radar tower building, such as the specialized power backup systems and meteorological equipment are not available in the local market, locally procurable materials and local construction methods must be used in the building design. The S-Band Pulse Compression Solid State Dual Polarization (Polarimetric) Meteorological Doppler Radar System, which has already been put into practical use for meteorological observation and has confirmed its reliability, durability, accuracy and performance, is made in Japan. Since outside temperature in Sukkur reaches near 50 degrees in April, May and June, it is necessary to consider the influence of outside high temperature in the course of the implementation schedule in the construction and equipment installation stages.

(10) Project Supervision Policy

The Project components consist of the procurement and installation of meteorological observation & communication equipment as well as the associated construction work (a radar tower building). Ensuring the overall consistency and synergy is the main policy for the Project Supervision.

(11) Safety Measures Policy

The results of discussions among the Sindh Central Police, Sukkur Police and the JICA security advisor and as stipulated in the JICA Safety Measures Guidance will all be accurately reflected to the Project.

2-2-2 Basic Plan

(1) Overall Plan

The finalized components in the basic design for the Project are as follows.

Table 12: Equipment and Facilities Determined from the Preparatory Survey

Component	Proposed Sukkur Meteorological Radar Observation Station	PMD Islamabad Head Office National Weather Forecasting Center	PMD Tropical Cyclone Warning Center	PMD Flood Forecasting Division, Lahore	PMD Meteorological Office in the International Airports, Karachi, Islamabad and Lahore
Procurement and Installation of Equipment					
S-Band Pulse Compression Solid State Dual Polarization (Polarimetric) Meteorological Doppler Radar System including Surge Protector, Power Back-up System, Lightning System Measuring Equipment and Spare Parts	1	-	-	-	-
Meteorological Radar Central Processing System	-	1	-	-	-
Meteorological Radar Data Display System	1	1	1	1	1 at each office
Construction of Radar Tower Building					
Radar Tower Building	1	-	-	-	-

The outline and current situation of the infrastructures of the proposed Project Site for Sukkur Meteorological Radar Tower Building are as follows.

Table 13: Outline and Current Situation of the Infrastructures of the Proposed Project Site for the Sukkur Meteorological Radar Tower Building

Study Items	The Proposed Project Site for Sukkur Meteorological Radar Tower Building
Picture of Proposed Site	
Latitude (N) Longitude (E)	N 27° 41' 06.48" E 68° 53' 25.15"
Altitude	67m
Area of the Proposed Project Site	4,518m^2
Enough Space for Radar Tower Construction	Enough space available
Access Road	Available (No problem)
Description Outline of the Premises	2m lower than the frontal road
Infrastructures	
Commercial Power Supply	400V, 3-phase 4-wire, 50Hz
Public Water Supply System	Not available
Public Sewerage System	Not available
Telephone Line	Available
Internet Access	Available (by tethering of the mobile telephone network)
Mobile Phone Service	Available

(2) Equipment Plan

1) S-Band Pulse Compression Solid State Dual Polarization Meteorological Doppler Radar System

A meteorological radar system is a very effective system which is able to observe in real time the meteorological phenomena related to rainfall such as, among others, the occurrence, movement, distribution and intensity as well as to provide quantitative measurements over a large area in real time. In order to ensure its stable operation and almost maintenance free, there is a strong demand that a meteorological radar uses solid state components instead of klystrons and magnetrons which are currently being used and which requires periodic replacement, maintenance and inspections due to their shorter operational life.

A meteorological doppler radar system transmits a single phase radio wave to estimate the rain intensity. On the other hand, dual polarization meteorological doppler radar system enables the transmission of two phases of radio waves which are vertical and horizontal in polarization and obtains various

parameters from the signals that are reflected from the raindrops for accurate rainfall estimates, as polarization parameters are closely related with raindrops' shape and their drop-size distribution. In addition, a meteorological doppler radar system can estimate the wind speed and direction by measuring doppler velocity of rain drops.

The S-band radar system has several important characteristics, including lower attenuation by rain and the atmosphere than other types of radar. It has the ability to transmit at high power providing a "long range", "real time" system.

The frequency of the S-Band Pulse Compression Solid State Dual Polarization Meteorological Doppler Radar System (wave length: approx. 10cm) is designed to be able to observe a rain cloud in the theoretical observation range with 450km radius. The radio frequency band planned to be used is of the Center Frequency (S-Band), ±5 MHz band width. It is planned that the PMD will apply for this frequency band, and it will be allocated by the Frequency Allocation Board (FAB) exclusively for the PMD. Technical features of the proposed S-Band Pulse Compression Solid State Dual Polarization Meteorological Doppler Radar System (Antenna: approx. 8.5m diameter, Beam width: not wider than 1.0 degree at -3dB point without Radome) are as follows.

Table 14: Major Features of the Proposed S-Band Pulse Compression Solid State Dual Polarization Meteorological Doppler Radar System

Frequency	S-Band (2.7GHz-2.9GHz)
Frequency Band Width	10 MHz (Center Frequency ±5 MHz)
Wavelength	Approx. 10cm
Detectable Maximum Range of Precipitation Intensity 1 mm/h	450km radius or more
Detectable Maximum Range of Wind Velocity	200km radius
Observable Maximum Wind Speed	More than 70m/s
Transmission Peak Power	10 kW + 10 kW
Dual-polarization Function	Available
Doppler Function	Available
Accumulated Rainfall	Available
Rainfall Data by using Dual-polarization Function	0 - 250mm/h rainfall intensity quantitative data

In order to accomplish the project targets, the proposed radar system is planned an S-Band Pulse Compression Solid State Dual Polarization Meteorological Doppler Radar System with approximately 8.5m diameter antenna (antenna beam angle: not wider than 1 degree) and meet the following requirements.

[1] Doppler Mode

Through the Doppler mode function of the meteorological radar, the observation of the components of the wind approaching and moving away from the meteorological radar via the Doppler effect of radio waves reflected from precipitation particles shifted by the wind can be possible. In general, the Doppler effect can be described using an example similar to the sound of an ambulance siren which gets louder when approaching and decreases when moving away. The same applies to radio waves. Since the

frequency of the received radio wave increases as the precipitation particles approach the meteorological radar and decreases when the precipitation particles are moving away, the meteorological radar can observe the movement speed of the precipitation particles by detecting the difference between the transmission frequency and the reflected reception frequency of the precipitation particles shifted by the wind. The meteorological radar system to be supplied under the Project is designed to work in Doppler mode, which detects wind velocity within approximately a 200km radius.

[2] CAPPI (Constant Altitude PPI (Plan Position Indicator)) Mode

In order to obtain accurate observation rainfall data during meteorological radar observation, it is recommended to conduct radar observations at lower antenna angles closer to the ground surface. The continuous automatic observation done in multiple elevations during a CAPPI enabling the collection of echo intensity data in three different dimensions. It is possible to eliminate the disadvantages described above by converting the data observed from a constant altitude surface and the data obtained from CAPPI into rainfall data.

Figures of the Conceptional PMD Radar Observation Network consisting of Islamabad, Karachi, Multan and Sukkur Radars established/to be established by the Japan's Grant Aid and the existing Lahore Radar are attached hereunder.

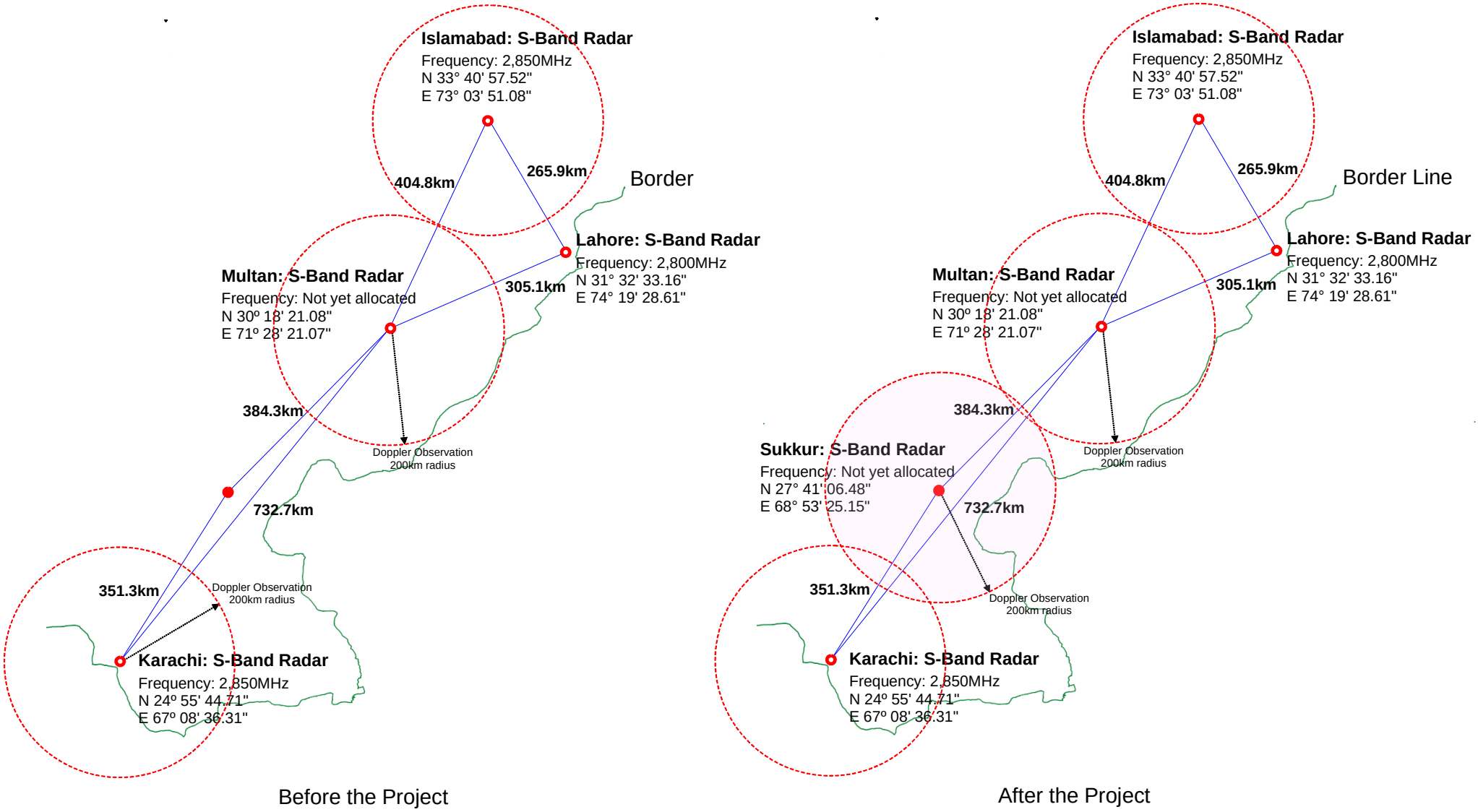


Figure 23: Comparison of Doppler Observation Range of S-Band Doppler Radar before and after the Project

Lahore S-Band Meteorological Radar (completed by financial support of the Asia Development Bank in 1997) currently cannot conduct Doppler Observation due to the functional deterioration of its transmission function. In addition, since there is no spare transmission tube (Magnetron), it is a concern that the operation will stop in the near future.

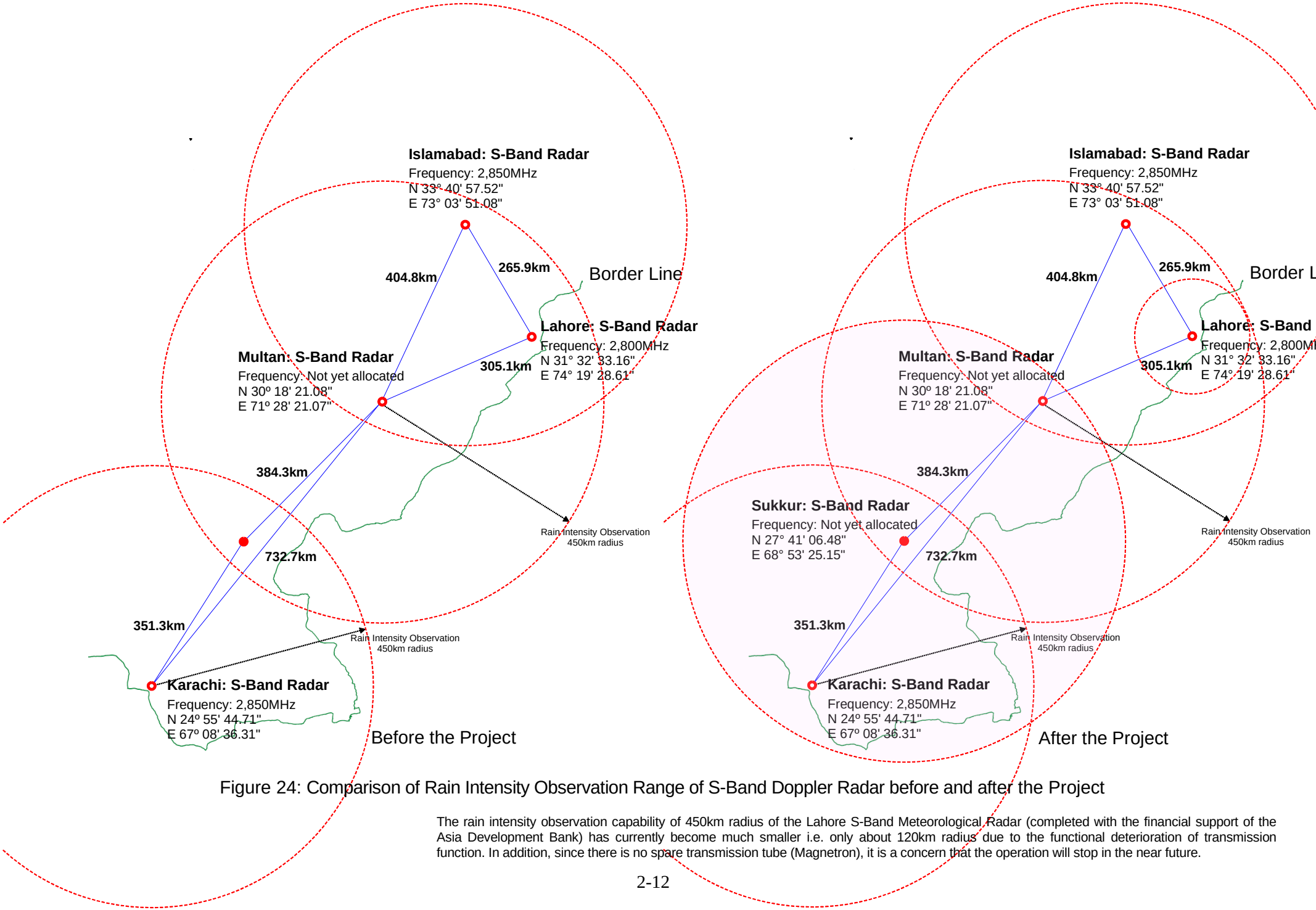


Figure 24: Comparison of Rain Intensity Observation Range of S-Band Doppler Radar before and after the Project

The rain intensity observation capability of 450km radius of the Lahore S-Band Meteorological Radar (completed with the financial support of the Asia Development Bank) has currently become much smaller i.e. only about 120km radius due to the functional deterioration of transmission function. In addition, since there is no spare transmission tube (Magnetron), it is a concern that the operation will stop in the near future.

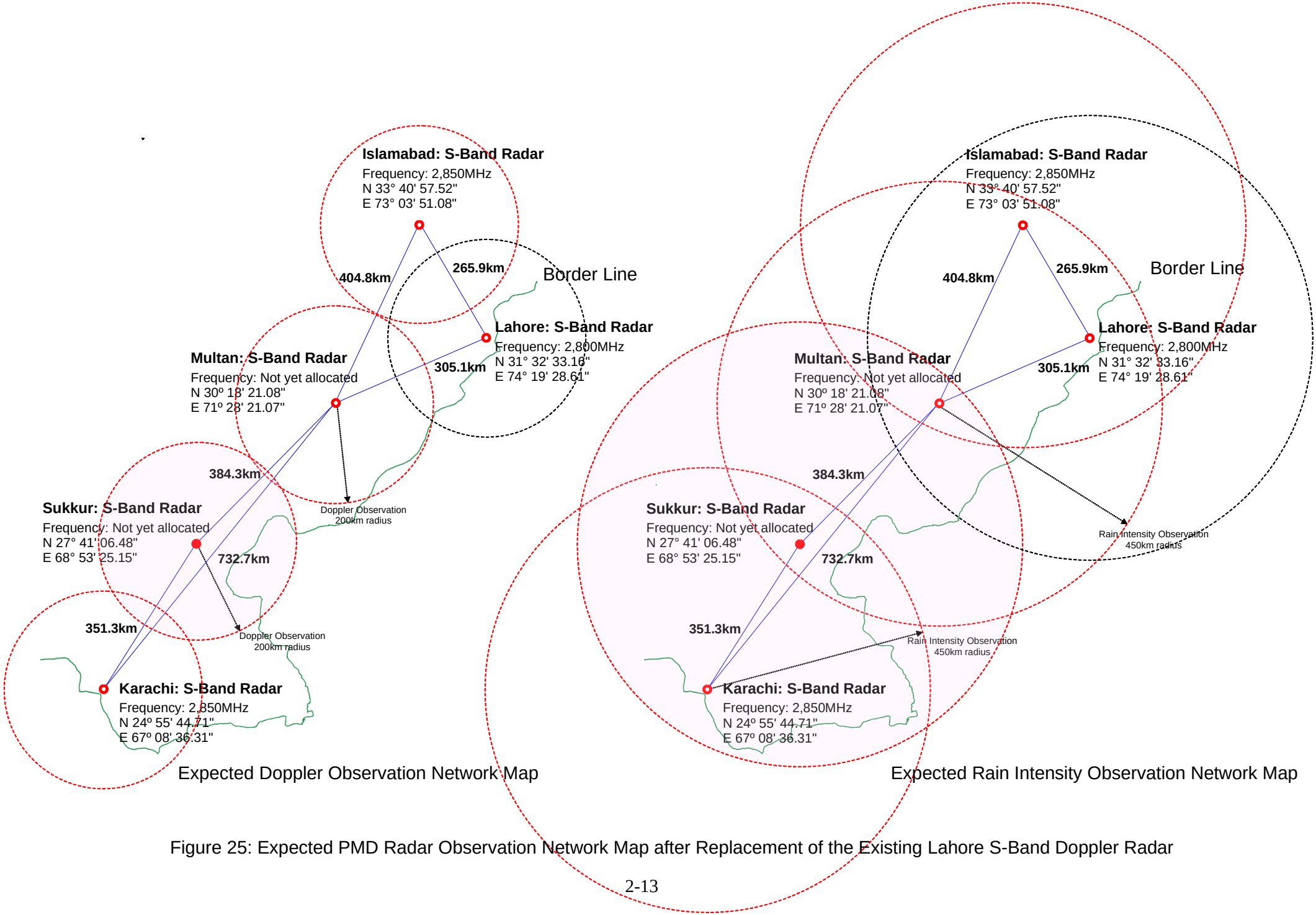


Figure 25: Expected PMD Radar Observation Network Map after Replacement of the Existing Lahore S-Band Doppler Radar

2) Meteorological Radar Central Processing System

In order to remotely operate, control and maintain the Sukkur Radar Observation Station at the National Weather Forecasting Center, PMD Islamabad Head Office, a system with the following functions is indispensable.

1. Remote control of the radar system
2. Operation monitoring of the radar system
3. Monitoring of the radar observation data for quality control
4. Alteration of the radar system configurations
5. Collection and archive of all the radar observation raw data
6. Adjustment of the signal processing
7. Radar picture composition processing
8. Remote control of air conditioning systems in the radar equipment room
9. Remote control of engine generators
10. Monitoring of the operation environment (equipment and room temperature) in the radar equipment room
11. Security monitoring in the radome room and the radar equipment room
12. Provision of the radar products for posting on the PMD Web site

3) Meteorological Radar Data Display System

As a result of the study based on the request of the PMD, the installation location and quantity of Meteorological Radar Data Display System are shown in the table below.

Table 15: Installation Location and Quantity of Meteorological Radar Data Display System

Installation Location	Meteorological Radar Data Display System
Sukkur Meteorological Radar Observation Station (Radar Tower Building)	1
National Weather Forecasting Center, PMD Islamabad Head Office	1
PMD Tropical Cyclone Warning Center, Karachi	1
PMD Flood Forecasting Division, Lahore	1
PMD Meteorological Office in the Islamabad International Airport	1
PMD Meteorological Office in the Karachi International Airport	1
PMD Meteorological Office in the Lahore International Airport	1

Displays of the system must have minimized heat production for effective room cooling, must be of the power-saving type and must have less screen reflections for a smooth and longtime operation. The meteorological radar data display system will be designed to store data files of the radar pictures as binary data of hourly accumulated precipitation data of not more than 1.0km mesh.

The required data communication speed, data volume of Long & Short Range Observation and duration of the radar data transmission (selectable radar observation schedule for the radar data transmission within 10 minutes) by the VPN connections to be arranged by the PMD are indicated in the following tables.

Table 16: Data Volume of Long Range Observation (S-Band: 450km)

Item	Unit	Azimuth Resolution Angle (Number of Azimuth Sectors)									
		0.7° (360°/0.7° = 512)					1.0° (360°/1.0° = 360)				
		Range Resolution Length (Number of Range Sectors)									
		150 (3000)	300 (1500)	450 (1000)	600 (750)	750 (600)	150 (3000)	300 (1500)	450 (1000)	600 (750)	750 (600)
Header Data Volume	byte	512									
Observation Data Volume (Azimuth Sectors × Range Sectors×2 byte)	byte	3,072,000	1,536,000	1,024,000	768,000	614,400	2,160,000	1,080,000	720,000	540,000	432,000
Total Angle Data Volume (Azimuth Sectors × 32 byte)	byte	16,384					11,520				
Single Scan Data Volume of Long Range Observation (A)*1	byte	3,088,896	1,552,896	1,040,896	784,896	631,296	2,172,032	1,092,032	732,032	552,032	444,032

*1 Single Scan Data Volume of Long Range Observation (A): Data type: Radar Reflectivity (Z)

Table 17: Data Volume of Short Range Observation (S-Band: 200km)

Item	Unit	Azimuth Resolution Angle (Number of Azimuth Sectors)									
		0.7° (360°/0.7° = 512)					1.0° (360°/1.0° = 360)				
		Range Resolution Length (Number of Range Sectors)									
		150 (1333)	300 (667)	450 (444)	600 (333)	750 (266)	150 (1333)	300 (667)	450 (444)	600 (333)	750 (266)
Header Data Volume	byte	512									
Observation Data Volume (Azimuth Sectors × Range Sectors×2 byte)	byte	1,364,992	683,008	454,656	340,992	272,384	959,760	480,240	319,680	239,760	191,520
Total Angle Data Volume (Azimuth Sectors × 32 byte)	byte	16,384					11,520				
Single Scan Data Volume of Short Range Observation (B)*2	byte	8,291,328	4,199,424	2,829,312	2,147,328	1,735,680	5,830,752	2,953,632	1,990,272	1,510,752	1,221,312
Compressed (C)*3	byte	6,218,496	3,149,568	2,121,984	1,610,496	1,301,760	4,373,064	2,215,224	1,492,704	1,133,064	915,984

*2 Single Scan Data Volume of Short Range Observation (B): Radar Reflectivity (Z), Doppler Velocity (V), Spectrum Width (W), Differential Reflectivity (ZDR), Differential Phase Shift (φDP), Polarimetric Correlation Coefficient (ρHV)

*3 Compressed Single Scan Data Volume of Short Range Observation: (B) × 0.75 (at least 25% decrease)

Table 18: Effective Speed of Communication Line Required to Transmit Radar Data in 10 Minutes (S-Band Dual Polarization Radar)

Antenna Rotation (rpm)	Number of observations for 10 minutes (Nos.)	Radar Observation Schedule (Nos/10 min)		Effective speed of communication line necessary to transmit radar data in 10 minutes (kbps)									
				Azimuth Resolution Angle (Number of Azimuth Sectors)									
				0.7° (360°/0.7° = 512)					1.0° (360°/1.0° = 360)				
		Long Range Observation	Short Range Observation	Range Resolution Length									
				150m	300m	450m	600m	750m	150m	300m	450m	600m	750m
1.5	11	2	6	1,133	573	386	293	236	796	403	271	206	166
		2	7	1,294	655	441	334	270	910	461	310	235	190
		2	8	1,456	737	496	376	304	1,024	518	349	265	214
		2	9	1,618	819	552	418	338	1,138	576	388	294	238
		3	5	1,051	531	358	271	219	739	374	252	191	154
		3	6	1,213	613	413	313	253	853	431	290	220	178
		3	7	1,375	695	468	355	287	967	489	329	250	202
		3	8	1,537	777	523	397	321	1,081	547	368	279	226
		4	4	970	490	329	250	201	682	345	232	176	142
		4	5	1,131	572	385	291	235	796	402	271	205	166
2	15	2	10	1,780	901	607	460	372	1,252	634	427	324	262
		2	11	1,942	983	662	502	406	1,366	691	466	353	286
		2	12	2,104	1,065	717	544	440	1,480	749	505	383	309
		2	13	2,266	1,147	773	586	474	1,594	807	543	412	333
		3	9	1,699	860	579	439	354	1,195	605	407	309	249
		3	10	1,861	942	634	481	388	1,309	662	446	338	273
		3	11	2,023	1,024	689	523	422	1,422	720	485	368	297
		3	12	2,185	1,106	744	565	456	1,536	778	524	397	321
		4	8	1,617	818	551	417	337	1,137	575	387	294	237
		4	9	1,779	900	606	459	371	1,251	633	426	323	261
		4	10	1,941	982	661	501	405	1,365	691	465	353	285
		4	11	2,103	1,064	716	543	439	1,479	748	504	382	309

: Radar observation schedule that cannot transmit radar data within 10 minutes at the effective speed of 2048 kbps

The “Schematic Diagram of PMD Meteorological Observation & Data Communication Network System” is attached hereunder.

Schematic Diagram of PMD Meteorological Observation & Data Communication Network System

Equipment: supplied under "the Project for Establishment of Specialized Medium Range Weather Forecasting Center and Strengthening of Weather Forecasting System", "the Project for Installation of Weather Surveillance Radar at Karachi" and "the Project for Installation of Weather Surveillance Radar at Multan"

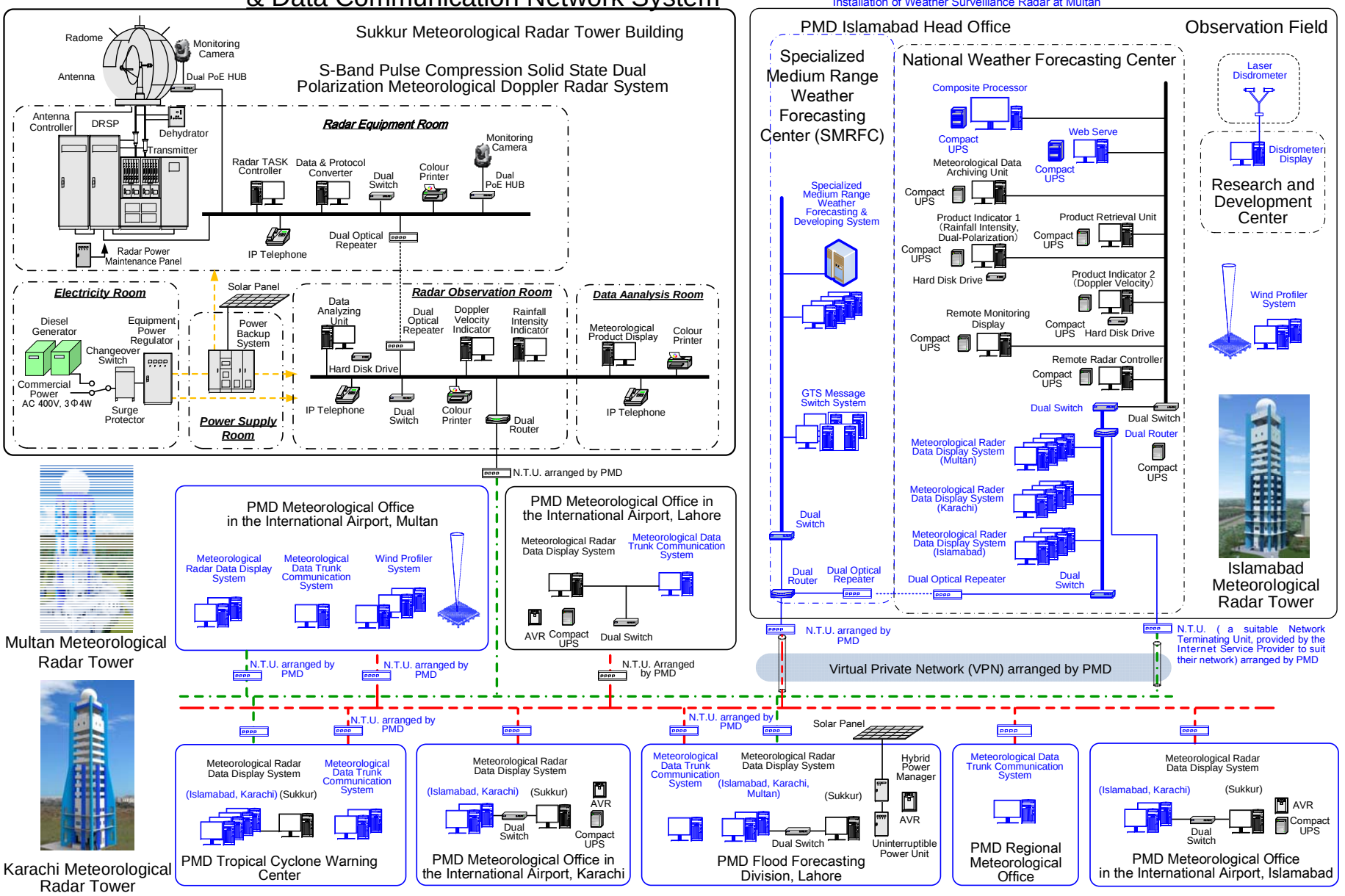


Figure 26: Schematic Diagram of PMD Meteorological Observation & Data Communication Network System

(3) Major Equipment List

As a consequence of the study, the major components of the Project are described below.

Table 19: Main Equipment Components

Component	Proposed Sukkur Meteorological Radar Observation Station	PMD Islamabad Head Office National Weather Forecasting Center	PMD Tropical Cyclone Warning Center	PMD Flood Forecasting Division, Lahore	PMD Meteorological Office in the International Airports, Karachi, Islamabad and Lahore
Procurement and Installation of Equipment					
S-Band Pulse Compression Solid State Dual Polarization (Polarimetric) Meteorological Doppler Radar System including Surge Protector, Power Back-up System, Lightning System Measuring Equipment and Spare Parts	1	-	-	-	-
Meteorological Radar Central Processing System	-	1	-	-	-
Meteorological Radar Data Display System	1	1	1	1	1 at each office

Major Equipment List

S-Band Pulse Compression Solid State Dual Polarization (Polarimetric) Meteorological Doppler Radar System

Name of Site: Sukkur Meteorological Radar Observation Station		
Equipment	Quantity	Purpose
Radome	1 set	For protecting the radar antenna assembly (a parabolic dish reflector) and the maintenance personnel from severe weather conditions and lightning attacks
Antenna	1 set	For radiating radar beam into the atmosphere and receiving scatter waves while rotating the parabola antenna in azimuth and elevation direction
Antenna Controller	1 set	For rotating the parabolic dish reflector and for controlling the antenna in azimuth and elevation by both horizontal and vertical drive motor units
Transmitter	1 set	For amplifying pulse-modulated power with stable frequency and transmitting the power to the antenna
Digital Receiver and Signal Processor (DRSP)	1 set	For receiving, pulse compression and processing echo signal from the Antenna For suppressing unnecessary echo such as clutter signals reflected from the ground. For sending ingest data to the radar TASK controller
Dehydrator	1 set	For supplying dried and pressurized air into the wave-guide to reduce wave propagation loss
Wave-guide Configuration	1 set	For feeder line propagation of the wave traveling between the antenna and transceiver & receiver
Radar Task Controller	1 set	For operating the radar system, monitoring the condition of the radar system and generating raw product data. Control and monitoring items: Radiate control & status, Azimuth & elevation position control & status, TX standby status, Pulse width control & status and Antenna local or maintenance mode status
Data & Protocol Converter	1 set	For sending raw data to the central system according to specified intervals
Radar Power Maintenance Panel	1 set	For distributing and supplying AC power to the radar system
Dual Switch-1	1 set	For connecting all the computer equipment with LAN
Colour Printer	1 set	For printing radar image
Dual Optical Repeater	1 set	For converting electrical signal and optical signal on LAN for protection against surges
Surge Protector	1 set	For protecting each equipment from surges in voltage in the main power

Equipment Power Regulator		1 set	For supplying constant or regulated voltage to the radar system
Power Backup System		1 set	For supplying uninterrupted power to the radar system when power failure occurs
Solar Panel		1 set	For supplying generated power to the Power Backup System
Optical Fiber Cable		2 sets	For transmitting optical signal on LAN
LAN Cable		10 sets	For transmitting electrical signal on LAN
Polarimetric Test Horn Device		1 set	For maintenance of the system
Spectrum Analyzer		1 set	
Test signal Generator		1 set	
Power Meter		1 set	
Power Sensor		1 set	
Frequency Counter		1 set	
Detector		1 set	
Attenuator Set		1 set	
Terminator for Detector		1 set	
Oscilloscope		1 set	
Digital Multimeter		1 set	
CW Converter		1 set	
Portable Power Supply Unit		1 set	
Monitoring Camera		2 sets	
Dual PoE HUB		2 sets	
Tool Kit		1 set	
Extension Cable		1 set	
Leveler		1 set	
Step Ladder		1 set	
Clump Current Meter		1 set	
Vacuum Cleaner		1 set	
Radar Antenna Maintenance Deck		1 set	
Spare Parts	Timing belt for antenna (for azimuth drive)	1 set	For maintenance of the system
	Timing belt for antenna (for elevation drive)	1 set	
	Encoder for antenna (for azimuth angle signal)	1 set	
	Encoder for antenna (for elevation angle signal)	1 set	
	Motor for antenna (for azimuth drive)	1 set	
	Motor for antenna (for elevation drive)	1 set	
	Servo unit for antenna controller (for azimuth drive)	1 set	
	Servo unit for antenna controller (for elevation drive)	1 set	
	Power supply unit for antenna controller	1 set	
	Power supply unit for transmitter	1 set	
	Power supply unit for digital receiver and signal processor	1 set	
	Solid-state power amplifier	2 sets	
	Fan unit for radar equipment	2 sets	
	LAN Arrester	2 sets	
	Obstruction light	2 sets	
	Stabilized local oscillator (STALO)	2 sets	
	Antenna carbon brush for power	1 set	
	Antenna carbon brush for signal	1 set	
Consumables	Grease with pump and oil with jug for antenna	1 set	For maintenance of the system
Service Manuals		2 sets	For maintenance of the system

Meteorological Radar Central Processing System

Name of Site: PMD Islamabad Head Office National Weather Forecasting Center		
Equipment	Quantity	Purpose
Remote Radar Controller	1 set	To control radar observation
Remote Monitoring Display	1 set	To monitor the radar tower building and radar system
Compact UPS	2 sets	For supplying back-up AC power to the computer equipment to enable the proper shutdown of the system in case of power failure
LAN Cable	2 sets	For transmitting electrical signal on LAN
Spare Parts LAN Arrester	2 sets	For maintenance of the system
Service Manuals	2 sets	For maintenance of the system

Meteorological Radar Data Display System

Name of Site: Sukkur Meteorological Radar Observation Station		
Equipment	Quantity	Purpose
Rainfall Intensity Indicator	1 set	For generating radar products (Rainfall Intensity, Dual-Polarization) from observed radar data and displaying
Doppler Velocity Indicator	1 set	For generating radar products (Doppler Velocity) from observed radar data and displaying
Data Analyzing Unit	1 set	For analyzing weather phenomena by observed radar data
Meteorological Product Display	1 set	For generating meteorological radar product from observed radar data and displaying
Colour Printer	2 sets	For printing radar image
Dual Switch-2	1 set	For connecting all the computer equipment with LAN
Dual Optical Repeater	1 set	For converting electrical signal and optical signal on LAN for surge protection
Dual Router	1 set	For forwarding data packets between computer networks
IP Telephone	3 sets	For voice communication through IP network
LAN Cable	10 sets	For transmitting electrical signal on LAN
Spare Parts LAN Arrester	4 sets	For maintenance of the system
Service Manuals	2 sets	For maintenance of the system

Meteorological Radar Data Display System

Name of Site: PMD Islamabad Head Office National Weather Forecasting Center		
Equipment	Quantity	Purpose
Composite Processor (Software)	1 set	For generating composite pictures from incoming data of all the radar stations
Meteorological Data Archiving Unit	1 set	For storing of radar and weather information to a selected media
Product Retrieval Unit	1 set	For retrieving and displaying radar data
Product Indicator 1 (Rainfall Intensity, Dual-Polarization)	1 set	For generating radar products (Rainfall Intensity, Dual-Polarization) from observed radar data and displaying
Product Indicator 2 (Doppler Velocity)	1 set	For generating radar products (Doppler Velocity) from observed radar data and displaying
Dual Switch-3	1 set	For connecting all the computer equipment with LAN
Compact UPS	5 sets	For supplying back-up AC power to the computer equipment in order to enable the proper shutdown of the system in case of power failure
LAN Cable	5 sets	For transmitting electrical signal on LAN
Spare Parts LAN Arrester	4 sets	For maintenance of the system
Service Manuals	2 sets	For maintenance of the system

Meteorological Radar Data Display System

Name of Site: PMD Tropical Cyclone Warning Center		
Equipment	Quantity	Purpose
Meteorological Product Display	1 set	For generating radar products from observed radar data and displaying
LAN Cable	1 set	For transmitting electrical signal on LAN
Laser Disdorometer	1 set	For maintenance of the system
Spare Parts LAN Arrester	1 set	For maintenance of the system
Service Manuals	2 sets	For maintenance of the system

Meteorological Radar Data Display System

Name of Site: PMD Flood Forecasting Division, Lahore		
Equipment	Quantity	Purpose
Meteorological Product Display	1 set	For generating radar products from observed radar data and displaying
Dual Switch-4	1 set	For connecting all the computer equipment with LAN
Automatic Voltage Regulator (AVR)	1 set	For supplying constant or regulated voltage to the system
Hybrid Power Manager	1 set	For converting solar generated DC power to AC power that can be utilized for the system and managing solar generated power to support commercial power
Uninterruptible Power Unit	1 set	For supplying back-up AC power to the system in case of power failure
Solar Panel	1 set	For generating electric power and supplying it to the system
LAN Cable	2 sets	For transmitting electrical signal on LAN
Spare Parts LAN Arrester	1 set	For maintenance of the system
Service Manuals	2 sets	For maintenance of the system

Meteorological Radar Data Display System

Name of Site: PMD Meteorological Office in the International Airports, Islamabad and Lahore		
Equipment	Quantity	Purpose
Aviation Weather Indicator	1 set	For monitoring aviation weather by using various Doppler radar products
Dual Switch-4	1 set	For connecting all the computer equipment to LAN
Compact UPS	1 set	For supplying back-up AC power to the computer equipment in order to enable the proper shutdown of the system in case of power failure
Automatic Voltage Regulator (AVR)	1 set	For supplying constant or regulated voltage to the system
LAN Cable	2 sets	For transmitting electrical signal on LAN
Spare Parts LAN Arrester	1 set	For maintenance of the system
Service Manuals	2 sets	For maintenance of the system

Meteorological Radar Data Display System

Name of Site: PMD Meteorological Office in the International Airport, Karachi		
Equipment	Quantity	Purpose
Weather Bulletin Receiving Terminal	1 set	For receiving meteorological bulletins from the Islamabad Head Office
Dual Switch-4	1 set	For connecting all the computer equipment to LAN
Compact UPS	1 set	For supplying back-up AC power to the computer equipment in order to enable the proper shutdown of the system in case of power failure
Automatic Voltage Regulator (AVR)	1 set	For supplying constant or regulated voltage to the system
LAN Cable	2 sets	For transmitting electrical signal on LAN
Spare Parts LAN Arrester	1 set	For maintenance of the system
Service Manuals	2 sets	For maintenance of the system

(4) Basic Plan of the Facility

1) Proposed Construction Site

The figure attached on the right side is the Proposed Site for Sukkur Meteorological Radar Observation Station (PMD Meteorological Observatory, Rohri-Sukkur).

Figure 27: Proposed Site for Sukkur Meteorological Radar Observation Station (PMD Meteorological Observatory, Rohri-Sukkur)

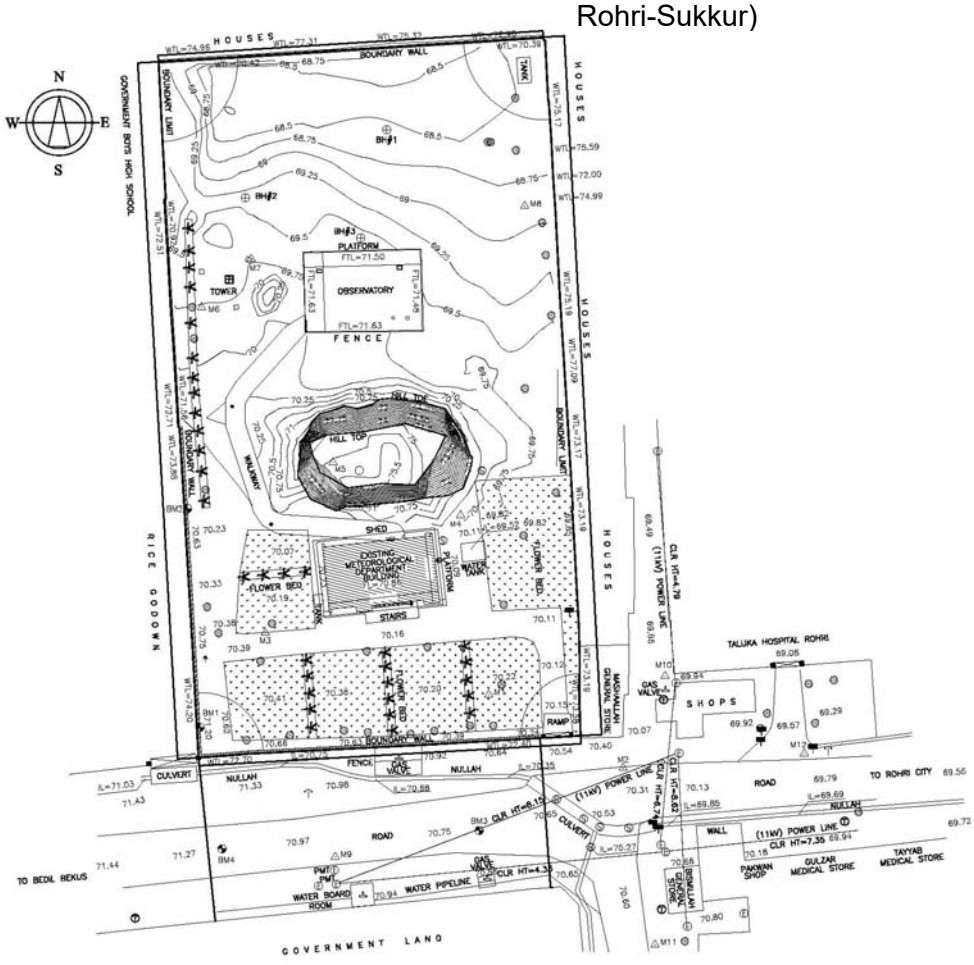


Figure 28: Proposed Construction Site Plan for Sukkur Meteorological Radar Observation Station

2) Architectural Design

[1] Floor Plan

The floor plan is virtually symmetrical, making possible a structural design that is safe and void of any kind of eccentricity. The floor plan for the central portion of the radar tower building allows the various rooms to be arranged with greater flexibility since there are no obstructing structures such as columns and beams protruding into the internal staircase (which will also serve as an evacuation route). Construction methods and materials follow local practice and the building is of standard grade in Pakistan.

The floor area of each room, the number of working staff, the room's function and the method of calculation of the size of each room are presented in the following table.

Table 20: Calculation Base of Each Room in the Proposed Meteorological Radar Tower Building

Name of the Room	Sukkur Meteorological Radar Tower Building Floor Area (m^2)	Room Function	Calculation Base
9 FL			
Radome Room	35.78	Installation space for radar antenna apparatus.	Maintenance space for radar antenna apparatus. Room area depends upon radome base of 7.0m in diameter.
4 FL			
Radar Equipment Room including Spare Parts Storage	84.26	Installation space for antenna controller, transmitter, solid state power amplifier, digital receiver, signal processor, dehydrator, wave-guide configuration, radar task controller, power distribution box, optical repeater, maintenance box, maintenance cabinet, measuring instrument cabinet, air-conditioning units, etc.	Operation and maintenance space for all the apparatuses described in the left column. For installation of all the required equipment, at least 80 m^2 is required.
Storage 7	5.44	Storage space for spare materials and miscellaneous goods.	Storage space for spare materials and miscellaneous goods.
3 FL			
Radar Observation Room	159.61	For the following equipment and furniture. • weather observation terminals • data analysis terminal • VoIP exchange • optical repeater • dual switch • printer • IP telephone • UPS for PCs • desk for the terminal • filing cabinets • white board	• Radar observation space • Installation space for all the equipment described in the left column • Space for data analysis terminal, desk and data storage cabinets • Working space • Space for keeping all data secured • Space for maintenance instruments, measuring equipment • Space for spare parts and consumables of the equipment

		➢ data storage cabinets for keeping observation records and observed data of the radar system for analysis ➢ cabinets for maintenance instruments and operation & maintenance manuals	
Storage 6	5.05	Storage space for spare materials and miscellaneous goods.	Storage space for spare materials and miscellaneous goods.
2 FL			
Electricity & Power Supply Room	41.93	For isolation transformer, power receiving panel, power distribution boards, commercial power voltage controller, cable rack, ground test terminals, cabling space, etc. For surge protector, equipment power regulator, cabling, etc. For radar power back-up system and control rack.	Installation and maintenance space and cabling space for all the apparatuses described in the left column. Installation and maintenance space for radar power back-up system and control rack
Toilet (F) 2 Toilet (M) 2	7.90 7.90	(F) European Style Commode: 1+Wash Basin: 1 (M) European Style Commode: 1+ Urinal:1+ Wash Basin: 1 Slop Sink: 1	—
Tea Kitchen 2	6.92	Kitchen: 1	—
Changing Room	2.55	Changing space after taking a shower.	—
Shower Room	3.69	Space for taking a shower.	—
Storage 4	4.04	Storage space for spare materials and miscellaneous goods.	Storage space for spare materials and miscellaneous goods.
Storage 5	3.39	Storage space for spare materials and miscellaneous goods.	Storage space for spare materials and miscellaneous goods.
1 FL			
Surface Observation Room	15.84	Working space for surface observation.	Necessary space for the routine work of 1 personnel of the PMD estimated according to the existing facility as reference.
Data Analysis Room	16.33	Working space for observation data analysis.	Necessary space for the routine work of 1 personnel of the PMD estimated according to the existing facility as reference.
Plotting Room	15.96	Working space for data plotting.	Necessary space for the routine work of 1 personnel of the PMD estimated according to the existing facility as reference.
Rest Room	3.84	European Style Commode: 1+Wash Basin: 1	—
Operation & Administration Room	18.51	Working space for operation and administration at the PMD Meteorological Observatory, Rohri-Sukkur.	Necessary space for the routine work of 2 personnel of the PMD estimated according to the existing facility as reference.
Toilet (F) 1 Toilet (M) 1	6.47 6.87	(F) European Style Commode: 1+Wash Basin: 1 (M) European Style Commode: 1+ Urinal:1+ Wash Basin: 1 Slop Sink: 1	—
Tea Kitchen 1	7.11	Kitchen: 1	—
Engine Generator Room	67.51	For 125kVA engine generators: 2, oil tank & oil pump: 1, automatic change-over switch, etc.	Installation, operation and maintenance space and cabling space for all the apparatuses described in the left column.

Pump Room	7.68	Water reservoir tank: 1 Pump for water reservoir tank: 2	For maintenance space and installation space for Water reservoir tank: approx. 8m^2 required.
Storage 1	2.39	Storage space for spare materials and miscellaneous goods.	Storage space for spare materials and miscellaneous goods.
Storage 2	2.47	Storage space for spare materials and miscellaneous goods.	Storage space for spare materials and miscellaneous goods.
Storage 3	3.84	Storage space for spare materials and miscellaneous goods.	Storage space for spare materials and miscellaneous goods.

[2] Sectional Plan

I. Height of the Radar Tower Building

<Restrictions on the construction of high-rise buildings in the surrounding area of the Sukkur Meteorological Radar Observation Station>

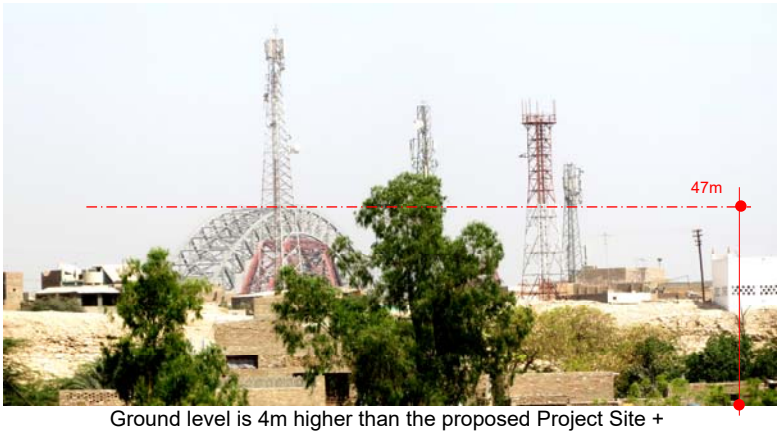
Regarding the development plan for Sukkur sub-division and Rohri sub-division that constitute Sukkur city (district), it has been confirmed by the Sindh Building Control Authority, Regional Office at Sukkur that there is no plan to construct a building with a height of 22.86m (75 feet) or more, except for the buildings that have already been constructed. The height, which came into effect in 2016, applies for Sukkur sub-division; however, has an upper limit of 22.86m (75 feet), but Rohri sub-division, in which the proposed Sukkur Meteorological Radar Observation Station Site (PMD Meteorological Observatory, Rohri-Sukkur) will be located, is excluded. Therefore, the buildings which were already constructed are unavoidable; however, it is necessary to take appropriate measures in Rohri in order to restrict the height of any buildings that could hamper radar observation.

Since the Project is planned to be implemented under Japan's Grant Aid and as one of the National Projects of Pakistan, the Preparatory Survey Team recommended that it is necessary to strictly control construction restrictions on high-rise buildings in the surrounding area of the proposed Sukkur Meteorological Radar Observation Station (at least within a 10km radius from the Station) in order to prevent serious obstacles to future radar observation and the Pakistan side understood the necessity.

<Investigation from meteorological radar observation>

The nearest identified obstructive facility for radar observation is the Lansdowne Bridge located about 1km south from the PMD Meteorological Observatory, Rohri-Sukkur (proposed Sukkur Meteorological Radar Observation Station). This Bridge consists of two bridges (a railway bridge: silver color and a road bridge: red color) which are parallelly arranged and constructed over the Indus River. In addition, several telecommunication steel towers which are unsurpassable and unavoidable obstructions for radar observation, can be found around the Bridge. Since these telecommunication steel towers are not

completely solid structures, they are not considered major obstructions for radar observation. However, as can be seen from the photos, since the Lansdowne Bridge has two bridges in parallel and forms a flat shielding surface like a solid structure, which will surely hamper radar observation, it is required to design the radar antenna center height of Sukkur Meteorological Radar System such that the radar beam can pass over this bridge. Since it is necessary to inevitably start the antenna elevation angle from about +0.5 degrees to avoid the radar beam hitting the ground due to the Sukkur Meteorological Radar Tower Building being planned to be built on the flatland, it is reasonable to set the radar antenna center height of the Sukkur Meteorological Radar System to be 48m.



Ground level is 4m higher than the proposed Project Site +
Height of Lansdowne Bridge 43m = 47m + 1m Clearance = 48m

It is technically possible to complement the shadow areas created by the identified obstructive facilities (including telecommunication steel towers) in the radar detection range with the CAPPI (Constant Altitude PPI (Plan Position Indicator)) data. It is, unfortunately, an inescapable fact that the radar observation range will become shorter due to the higher elevation angle of the radar antenna to eliminate the shadow areas caused by the above identified obstructive facilities.

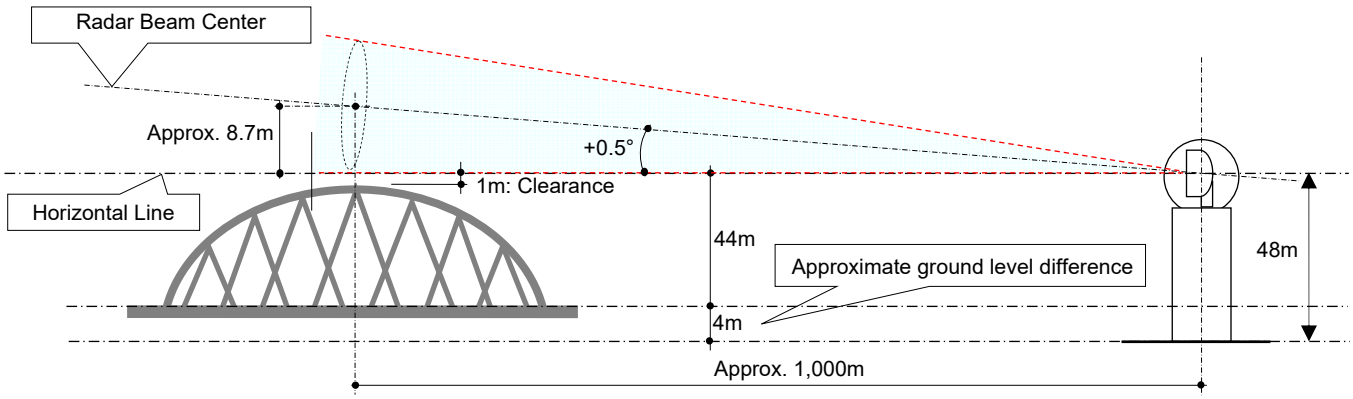


Figure 29: Sukkur Meteorological Radar Antenna Center Height
(Antenna Elevation Angle: +0.5º) Considering the Height of Lansdowne Bridge

The existing obstructive facilities around the proposed Project Site for the Sukkur Metrological Radar Observation Station in Sukkur are indicated in the following table.

Table 21: Existing Obstructive Facility to Radar Observations in Sukkur (as of June 2019)

Location Map No.	**1**	**2**
Name of the Existing Obstructive Facility	Rohri Cement (PVT) Ltd. (under construction)	Lansdowne Bridge
Picture		
Height	108m	43m
Latitude(N) Longitude(E)	N 27º 40’ 10.76” E 68º 53’ 29.18”	N 27º 41’ 37.79” E 68º 53’ 17.81”
Altitude	70m	71m
Distance from the proposed Project Site in Sukkur	Approx. 1.72km	Approx. 1.00km
Direction from the proposed Project Site in Sukkur	176.3º	348.5º
Approximate ground level difference	Approx. 70m-67m=3m Ground level is 3m higher than the proposed Project Site	Approx. 71m-67m=4m Ground level is 4m higher than the proposed Project Site
Required radar antenna angle to eliminate the shadow area caused by the identified facility	Approx. +2.6º	Approx. +0.5º
Location Map No.	**3**	**4**
Name of the Existing Obstructive Facility	Monument Tower, Aror University of Art, Architecture, Design & Heritages, Sukkur	Engro Foods Limited, Sukkur Plant
Picture		
Height	43m	30m
Latitude(N) Longitude(E)	N 27º 39’ 27.30” E 68º 53’ 57.27”	N 27º 40’ 37.74” E 68º 51’ 43.10”
Altitude	77m	63m
Distance from the proposed Project Site in Sukkur	Approx. 3.17km	Approx. 2.93km
Direction from the proposed Project Site in Sukkur	163.94º	252.42º
Approximate ground level difference	Approx. 77m-67m=10m Ground level is 10m higher than the proposed Project Site	Approx. 63m-67m=-4m Ground level is 4m lower than the proposed Project Site

Required radar antenna angle to eliminate the shadow area caused by the identified facility	Approx. +0.6º	Approx. +0.1º
Location Map No.	**5**	**6**
Name of the Existing Obstructive Facility	Chamber Avenue Bldg.	Hussain Heights
Picture		
Height	40m (12 Stories)	47m (14 Stories)
Latitude(N) Longitude(E)	N 27º 41' 29.75" E 68º 52' 21.81"	N 27º 41' 35.79" E 68º 52' 20.00"
Altitude	68m	74m
Distance from the proposed Project Site in Sukkur	Approx. 1.88km	Approx. 2.00km
Direction from the proposed Project Site in Sukkur	292.70º	297.11º
Approximate ground level difference	Approx. 68m-67m=1m Ground level is 1m higher than the proposed Project Site	Approx. 74m-67m=7m Ground level is 7m higher than the proposed Project Site
Required radar antenna angle to eliminate the shadow area caused by the identified facility	Approx. +0.4º	Approx. +0.7
Location Map No.	**7**	**8**
Name of the Existing Obstructive Facility	Dolphin Tower	Queens Tower
Picture		
Height	52m (16 Stories)	40m (12 Stories)
Latitude(N) Longitude(E)	N 27º 41' 49.83" E 68º 52' 29.15"	N 27º 42' 03.41" E 68º 52' 46.35"
Altitude	72m	69m
Distance from the proposed Project Site in Sukkur	Approx. 2.04km	Approx. 2.05km
Direction from the proposed Project Site in Sukkur	311.30º	328.99º
Approximate ground level difference	Approx. 72m-67m=5m Ground level is 5m higher than the proposed Project Site	Approx. 69m-67m=2m Ground level is 2m higher than the proposed Project Site
Required radar antenna angle to eliminate the shadow area caused by the identified facility	Approx. +0.7º	Approx. +0.4º

Location Map No.	**9**	**10**
Name of the Existing Obstructive Facility	Madina Mall	National Institute of Cardiovascular Diseases, Sukkur
Picture		
Height	41m (11 Stories)	50m (9 Stories)
Latitude(N) Longitude(E)	N 27º 41' 27.29" E 68º 51' 22.56"	N 27º 42' 10.16" E 68º 50' 02.10"
Altitude	65m	59m
Distance from the proposed Project Site in Sukkur	Approx. 3.42km	Approx. 5.90km
Direction from the proposed Project Site in Sukkur	280.93º	289.56º
Approximate ground level difference	Approx. 65m-67m=-2m Ground level is 2m lower than the proposed Project Site	Approx. 59m-67m=-8m Ground level is 8 m lower than the proposed Project Site
Required radar antenna angle to eliminate the shadow area caused by the identified facility	Approx. +0.4º	Approx. +0.5º

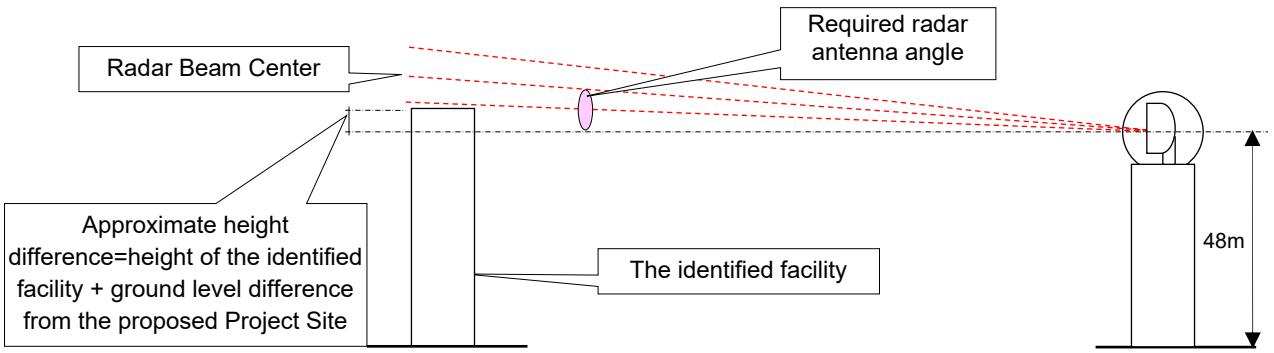


Figure 30: Relationship of Radar Antenna Center Height & Antenna Angle and Identified Obstructive Facility

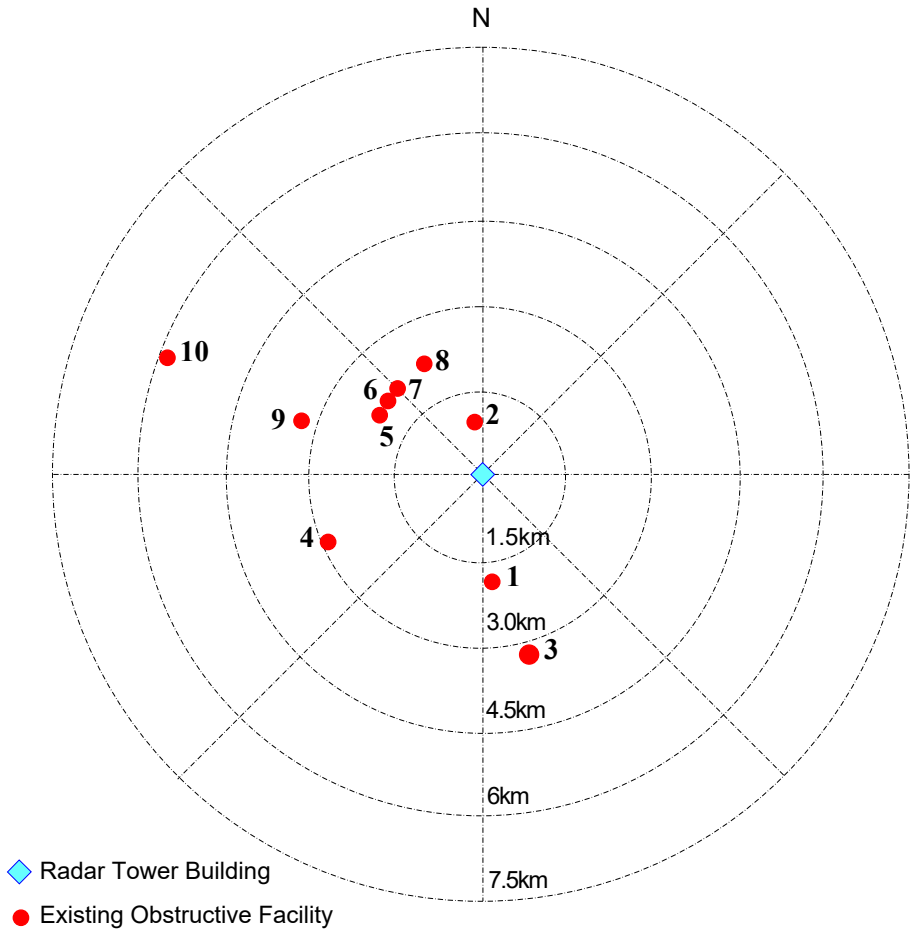
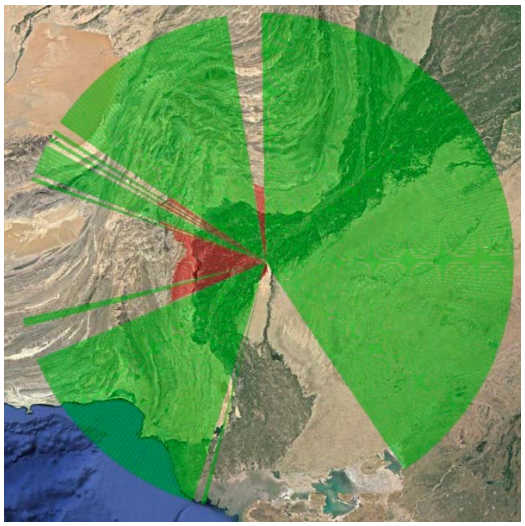


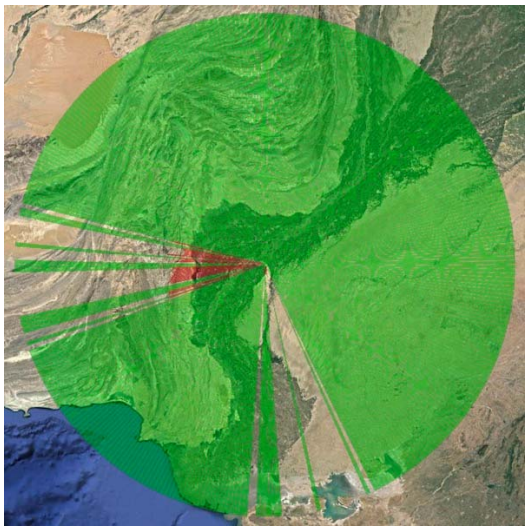
Figure 31: Location Map of the Existing Obstructions around the Proposed Project Site for Sukkur Meteorological Observation Station

<Radar Shadow Area>

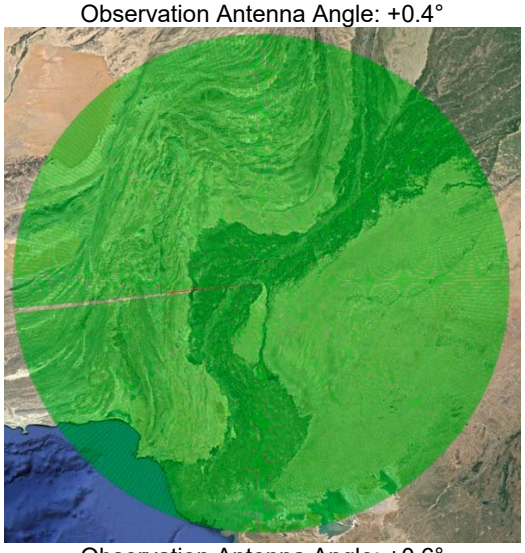
By using the Radar Shadow Area Analysis Software developed by the consultant, the required height of the antenna center was analyzed and determined for the Sukkur Meteorological Radar to avoid obstructions within its 450km observation radius. The digital elevation model used for the estimation of obstructions is NASA's SRTM-3 (Shuttle Radar Topography Mission) data with 3-second (approximately 90 m) resolution meshes. The software extracts the altitude data from the digital elevation model, maps them from the WGS84 coordinates system, where a location is identified through latitude and longitude, into the polar coordinates system where the location of the Meteorological Radar is set at the origin of the coordinates, and computes the distance to ground obstructions (except for buildings) for every 1.0 degree azimuth angle. The difference between the height of the meteorological radar beam and the ground altitude is computed by using the effective earth radius to take into account the earth's curvature and the refractive index of radio waves. If at least a part of the radar beam is blocked at a certain location, then the location is considered to occlude the space beyond. The computation result is then saved into KML files to render sectors of 1.0-degree angle for every azimuth to indicate the observable areas by the radar. The expected observation range of Sukkur Meteorological Radar System is shown below.



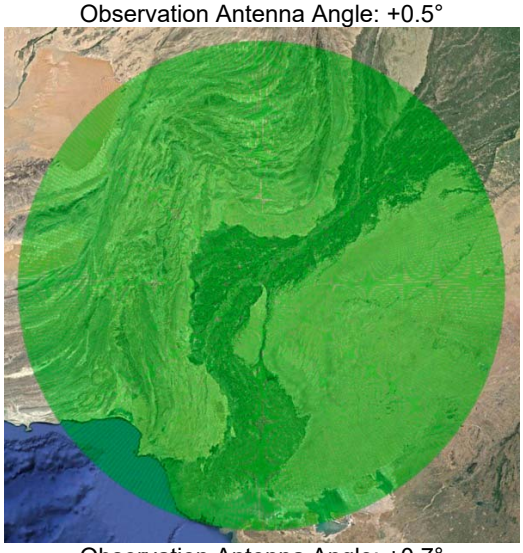
Observation Antenna Angle: +0.4°



Observation Antenna Angle: +0.5°



Observation Antenna Angle: +0.6°



Observation Antenna Angle: +0.7°

Figure 32: Expected Observation Range of Sukkur Meteorological Radar
(Height of Radar Antenna Center from Ground Level: 48m)
(No consideration of the existing obstructive facilities around the proposed Project Site in Sukkur)

It is projected that approximately two-thirds of the observation area can be detected with the antenna elevation at +0.4°, and that there will be no shadow area/s left with the antenna elevation set at +0.7°. Such projections are therefore intended to be used as the base in deciding the observation schedule, wherein the antenna elevation set at +0.4° can detect the echoes near the ground while the antenna elevation fixed at +0.7° can observe the entire observation area without shadow areas, and other antenna elevations will be suited into the observation schedule.

II. Ground Level

At the proposed site, there is a benchmark which is the reference ground level made or determined in the course of the topographic survey work. Such reference will be used for the construction of the radar

tower building.

III. Equipment Installation

In order to install all the equipment inside the radar equipment room, a large opening would be needed to allow equipment ingress. However, a large opening would be undesirable from the standpoint of air-tightness and dust proofing. The equipment will, therefore, be brought in via a loading balcony through the adjacent staircase room. For lifting the equipment, a lifting hook with a capacity of 2-tons will be installed on the upper part of this balcony.

[3] Elevation Plan

The structural columns and beams will extend outside the building, thereby, enhancing the building design. Given that the columns and beams will not intrude into the staircase, the staircase will be able to comfortably handle traffic in both directions.

[4] Internal and External Finishing Plan

I. Finishing of Major Rooms (Radar Equipment Room and Radar Observation Room)

a) Floor

The radar equipment room and the radar observation room will have an access floor with a clearance of 15 cm for easy wiring of power and signal cables, trouble-free maintenance and simple future expansion. An anti-static, heavy-duty access floor has been selected for the radar equipment room in which a high-power radar transmitter weighing about 1 ton is to be installed.

b) External Walls

To reduce the effects of local temperature and humidity, the external walls of the electricity room, the radar observation room and the radar equipment room, which are to be air-conditioned, are designed as cavity walls in which glass wool is sandwiched in between for heat insulation. Because of the thermal insulation provided by the building design, the recurrent electric power cost to the PMD for air-conditioning systems will be minimized.

c) Ceiling

The radar equipment cable rack, which is located in the radar equipment room and the radar observation room (the major rooms of the proposed radar tower building), must be protected against dust. In addition, so as to improve the air tightness of these rooms and to reduce equipment noise, the ceilings will be finished with acoustic boards. Since both of these rooms are to be air-conditioned, the use of ceiling boards will also improve the efficiency of air-conditioning.

d) Window

Since the sustained wind pressure to be used for the windows of the radar equipment room located at a height of 22m is expected to reach approximately 2,100 N/m^2 a laminated glass with reinforced film will be used. In order to ensure double protection for preventing wind and rain water from entering into the room, two aluminum windows will be individually installed inside and outside.

II. Material Plan

Materials specified for both the exterior and interior finishing, which are all available locally, have been selected with a view to ease maintenance for the PMD and are stated as follows.

Table 22: Finishing Materials of the Proposed Meteorological Radar Tower Building

		Finishing Materials
Exterior Finishing	Observation Deck	Cement sand mortar base, Asphalt waterproofing, Insulation, Protection concrete, Base mortar, Cement tiles
	Roof Floor	Cement sand mortar base, Asphalt waterproofing, Insulation, Protection concrete, Base mortar, Cement tiles
	Walls	Concrete blocks Cement sand mortar base, Spray tile finish
Interior Finishing	Floors	Carpet tiles Vinyl tiles Porcelain tiles Cement sand mortar base, Epoxy resin paint finish
	Skirtings	Wooden skirting, Synthetic resin oil paint finish Cement sand mortar, Vinyl paint finish Cement sand mortar, Epoxy resin paint finish Porcelain tiles
	Walls	Cement Sand mortar base, Vinyl paint finish Glazed ceramic tiles Glass wool with glass cloth
	Ceilings	Acoustic panels (Grid ceiling system) Cement board (Grid ceiling system) Cement sand mortar base Emulsion paint finish Glass wool with glass cloth
Window and Door	Exterior	Aluminum windows Aluminum grilles Aluminum doors, Steel doors
	Interior	Aluminum doors, Steel doors, Wooden doors

Table 23: Basis for Adoption of Materials of the Proposed Meteorological Radar Tower Building

		Bases for adoption of materials	Procurement
Exterior Finishing	Roof Floor	Since external temperatures are high (reaching over 45 degrees), an insulation board t=30mm will be required. Asphalt waterproofing is the most reliable waterproofing material to be protected by protection concrete, cement sand mortar and cement tiles.	
	Walls	Reinforced concrete blocks will be applied. Concrete blocks are generally used locally and are considered highly reliable in terms of both ease and accuracy of construction.	
Interior Finishing	Floors	Materials will be selected on the basis of superior durability and ease of maintenance. Vinyl tiles around offices, corridors and staircases will be applied. In rooms where dust must be avoided, a dust-proof paint finish will be specified.	

		In the offices where computer systems will be installed, access floors shall be applied for cabling under the floor.	To be procured locally
	Walls	Cement sand mortar (trowel-coated) will be applied primarily for its durability, and vinyl paint will be applied to avoid dirt. Glazed ceramic tiles will be laid in the toilets, the slop sink booth and shower room.	
	Ceilings	In order to enhance the environment and efficiency of air-conditioning, non-asbestos acoustic mineral boards will be used. Other rooms which will not require any ceiling board will be directly applied with emulsion paint finish on the cement and sand mortar.	
Windows and Door	Exterior	Aluminum and steel will be chosen all throughout for reasons of durability, ease of handling and accuracy.	
	Interior	Wooden and steel with synthetic oil resin paint will be employed all throughout for its handling ease during construction and from a maintenance standpoint.	

[5] Structural Plan

I. Structural Design Standard

In order to formulate and develop the structural design of the proposed radar tower building, the Building Code of Pakistan is mainly applied along with the Building Standard Law of Japan, the Standard of Architectural Institute of Japan (AIJ) and the Uniform Building Code (UBC) of the USA are used as a reference, if so required.

II. Soil Condition and Foundation Plan

To ensure radar observation accuracy, building robustness is important and the permissible horizontal deflection of the building by the design wind pressure must not be more than 1/1000 of the height of radar tower building. Due to this, the foundation structures must prevent the building differential settlement. The bearing layer and foundation of the Proposed Meteorological Radar Tower Building are indicated in the following table.

Table 24: Bearing Layer, Pile and Foundation of the Proposed Sukkur Meteorological Radar Tower Building

	Sukkur Meteorological Radar Tower Building
Depth of Bearing Layer	Design GL-4.5m
N value of Bearing Layer	Over 50
Piling	Not Required
Foundation type	Spread foundation

III. Structure Type

Reinforced concrete has been selected as the construction material for the proposed radar tower building. Floor slabs are to be constructed using reinforced concrete while exterior walls and partition walls are to be locally made out of concrete blocks.

IV. Design Load

a) Dead load

The weight of all the structural and finishing materials has been included in the calculation of the dead weight of the radar tower building. The following combined weight as a special dead load will be considered.

Table 25: Weight of Meteorological Radar System Unit

Installation Place (Room Name)	Name of Meteorological Radar System Unit	Weight
Roof Top	Radome, Antenna, Pedestal and Base Ring	14.0 tons
Radar Equipment Room	Transmitter/Receiver, Signal Amplifier, Signal Processor, Antenna Controller, etc.	3.0 tons
Electricity & Power Supply Room	Isolation Transformer, Surge Protector, Commercial Power Voltage Controller, Equipment Power Regulator and Power Backup System	7.5 tons

b) Live load

Since virtually most of all the major rooms in the proposed radar tower building are equipment installation spaces, the live load of the proposed radar tower building is deemed to be identical to that of telecommunication equipment rooms in Japan.

c) Wind load

To calculate the wind load of the proposed Radar Tower Building, the following calculation formula for the design wind pressure as shown in BCP-SP-2007 (Building Code of Pakistan-Seismic Provisions-2007) is utilized.

Design wind pressure: $P=Ce\times Cq\times Iw\times Qs$ (kN/m^2)

Ce: Combined height, exposure and gust factor coefficient

Cq: Pressure coefficient for the structure

Iw: Importance Factor

Qs: Wind stagnation pressure (kN/m^2)

- $P=1.87\times3.6\times1.15\times0.78=6.04kN/m^2 \approx 6kN/m^2$

  Ce=1.87 Cq=3.60 Iw=1.15 Qs=0.78

d) Seismic load

For the calculation of the seismic load, the seismic zone factor in Sukkur (Zone 2A, Z = 0.15) as indicated in the BCP-SP-2007 (Building Code of Pakistan-Seismic Provisions-2007) is applied. The importance factor: I = 1.25 is used, since the importance of the building is considered.

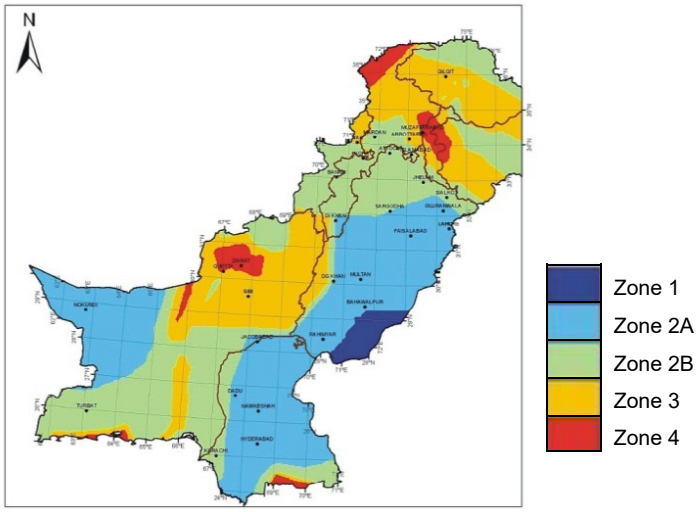


Figure 33: Seismic Zoning Map of Pakistan

V. Structural Building Material

All the materials for the building structure will be procured in Pakistan.

- Concrete (conventional concrete)
  Design standard concrete strength: Fc= 21N/mm^2
- Cement: American Society for Testing and Materials (ASTM) or equivalent
- Deformed reinforcing bars : ASTM A615 Grade 60 or equivalent

[6] Electrical Facility Design

I. Power intake facility

Table 26: Power Intake Facility

	Sukkur Meteorological Radar Tower Building
Intake Power (Nominal Voltage)	400V, 3-phase 4-wire, 50Hz

II. Power generating facility

Table 27: Power Generating Facility

	Sukkur Meteorological Radar Tower Building
Number of Engine Generator	2
Capacity	125kVA
Output	400V, 3-phase 4-wire, 50Hz
Fuel Tank Capacity	1,500 liters

III. Trunk line and power facility

Power will be distributed to the switchboard for lighting and to the electricity control panel from the distribution panel in the electrical room. The trunk line for distribution and the power line will use

suitable cabling through conduits. An alarm for the power equipment will be shown on an alarm panel in the radar observation room. The electrical systems for the trunk line and branch circuits are as follows.

Table 28: Trunk Line and Power Facility

	Sukkur Meteorological Radar Tower Building
Trunk line for lighting and power	230V/400V, 3-phase 4-wire
Branch power circuits	400V, 3-phase 4-wire
Branch lighting circuits	230V, single-phase 2-wire
Branch equipment circuits	400V, 3-phase 4-wire

IV. Lighting and power outlet

The voltage required for lighting and power sockets is a single-phase 230V and all the fixtures must be grounded. Steel pipes will be used for wiring conduits. Lighting fixtures will be LED due to low power consumption. The lighting levels in the various rooms will be approximately as shown below.

Table 29: Approximate Lighting Levels in the Various Rooms

	Sukkur Meteorological Radar Tower Building
Radome Room	200 Lx
Radar Equipment Room	300 Lx
Radar Observation Room	300 Lx
Engine Generator Room	200 Lx
Electricity & Power Supply Room	200 Lx
Pump Room	200 Lx
Entrance Hall	200 Lx
Surface Observation Room	200 Lx
Data Analysis Room	200 Lx
Plotting Room	200 Lx
Operation & Administration Room	200 Lx
Other Rooms	200 Lx

Dedicated power outlets are required in the radar equipment room and the radar observation room for the Project computing equipment.

V. Telephone system

A service terminal box, a relay terminal box and telephone sets will be installed inside the radar tower building and telephone lines will be installed in outlets in those rooms requiring a telephone.

VI. Intercom system

In order to control night shift personnel and visitors and as a security measure, intercom systems will be installed in various operating rooms (radar equipment room and radar observation room) and outside of the building entrance.

VII. Alarm system

An alarm panel will be installed in the radar observation room. The following building equipment

warnings will also be provided.

- System failure of air-conditioning units in the radar equipment room
- System failure of radar power backup unit
- System failure and overheating of the engine generators
- Breaker tripping of the distribution boards

VIII. Grounding system

Grounding cables for the equipment installed on the 3rd floor will be connected to the terminal box for earthing. All the equipment to be installed in the electricity room will be grounded via the terminal box while the telephone equipment will be grounded by erecting a grounding electrode and running a wire from there to the terminal box.

IX. Lightning protection system

A lightning rod will be installed on top of the radome (included in the equipment portion of the Project), with roof conductors on the concrete handrails of parapets, the roof top, and the observation deck, to protect all the equipment and the radar tower building. A connection box will be placed at the radome room for the lightning rod. Inside the building structure, copper tapes will be laid on a vinyl pipe and grounded via the test terminal boxes.

X. Aviation obstruction light

A connection box for LED obstruction lights on the top of the radome (which is part of the equipment portion of the Project) will be placed in the radome room. Obstruction lights (LED), to be installed at the radome roof, will be included in the building portion of the Project. For all of the obstruction lights, power distribution boards will be installed in the radar equipment room and an automatic blinking switch will be installed on the first floor. All the aviation obstruction lights will be furnished with surge arresters. Connecting work between the obstruction lights on top of the radome and a connection box placed in the radome will be included in the equipment portion of the Project.

XI. Fire detection and alarm system

Fire detectors will be installed in the radar equipment room, the electricity & power supply room and the engine generator room. An alarm system will be installed in the radar observation room.

[7] Water Supply, Drainage and Sanitary Fixture Design

I. Water supply system

Public water supply is unavailable. As such, the construction of a well is required for the construction work of the radar tower building at the proposed site. After the construction phase, this well would be used as the water supply facility for the radar tower building. For the well water intake for the radar

tower building, a water supply gate valve will be installed.

II. Drainage system

Drainage will be divided into 2 systems - sewage and miscellaneous drainage. Sewage will primarily be treated in a septic tank and then be permeated through a seepage pit into the ground. Miscellaneous drainage will be fed directly into a seepage pit. A septic tank and a seepage pit must be constructed. The capacity of the septic tank and seepage pit for the radar tower building has been designed for 25 PMD personnel in the operations area and for some visitors.

III. Sanitary fixtures

- Closet bowl: tank type western-style
- Urinal: stall type
- Washbasin: wall-mounted type
- Slop sink: wall-mounted type

IV. Fire extinguisher

Fire extinguishers will be supplied in the following rooms.

Table 30: Fire Extinguisher

	Sukkur Meteorological Radar Tower Building
Radome Room	CO_2 type
Radar Equipment Room	CO_2 type
Radar Observation Room	CO_2 type
Engine Generator Room	ABC type
Electricity & Power Supply Room	CO_2 type
Pump Room	CO_2 type
Tea Kitchen	ABC type

[8] Air-conditioning and Ventilation System Design

Air-conditioning systems will be installed in the rooms listed below. It is essential to have a good operating environment especially for the equipment in the radar equipment room, the radar observation room and the electricity & power supply room. Therefore, a substantial number of air-conditioning systems is indispensable. Package type air-conditioning systems have been selected to minimize any impact to the operation of the radar system if an air-conditioning system fails.

Table 31: Air-conditioning and Ventilation System

	Sukkur Meteorological Radar Tower Building
Radome Room	Fan forced ventilation
Radar Equipment Room	Air-conditioning system Heat exchange system
Radar Observation Room	Air-conditioning system Fan forced ventilation
Electricity & Power Supply Room	Air-conditioning system Fan forced ventilation

Surface Observation Room	Air-conditioning system Fan forced ventilation
Data Analysis Room	Air-conditioning system Fan forced ventilation
Plotting Room	Air-conditioning system Fan forced ventilation
Operation & Administration Room	Air-conditioning system Fan forced ventilation
Engine Generator Room	Fan forced ventilation
Pump Room	Fan forced ventilation
Shower Room	Fan forced ventilation
Toilet (M & F)	Fan forced ventilation
Tea Kitchen 1 and 2	Air-conditioning system Fan forced ventilation

Ceiling fan forced ventilation will be installed in the tea kitchen and the toilets. Due to the heat generated by the equipment in the radar equipment room, the engine generator room, the electricity & power supply room, pump room, etc., forced ventilation systems will also be adopted. Furthermore, appropriate ventilation systems will be installed in the other rooms to meet the following conditions.

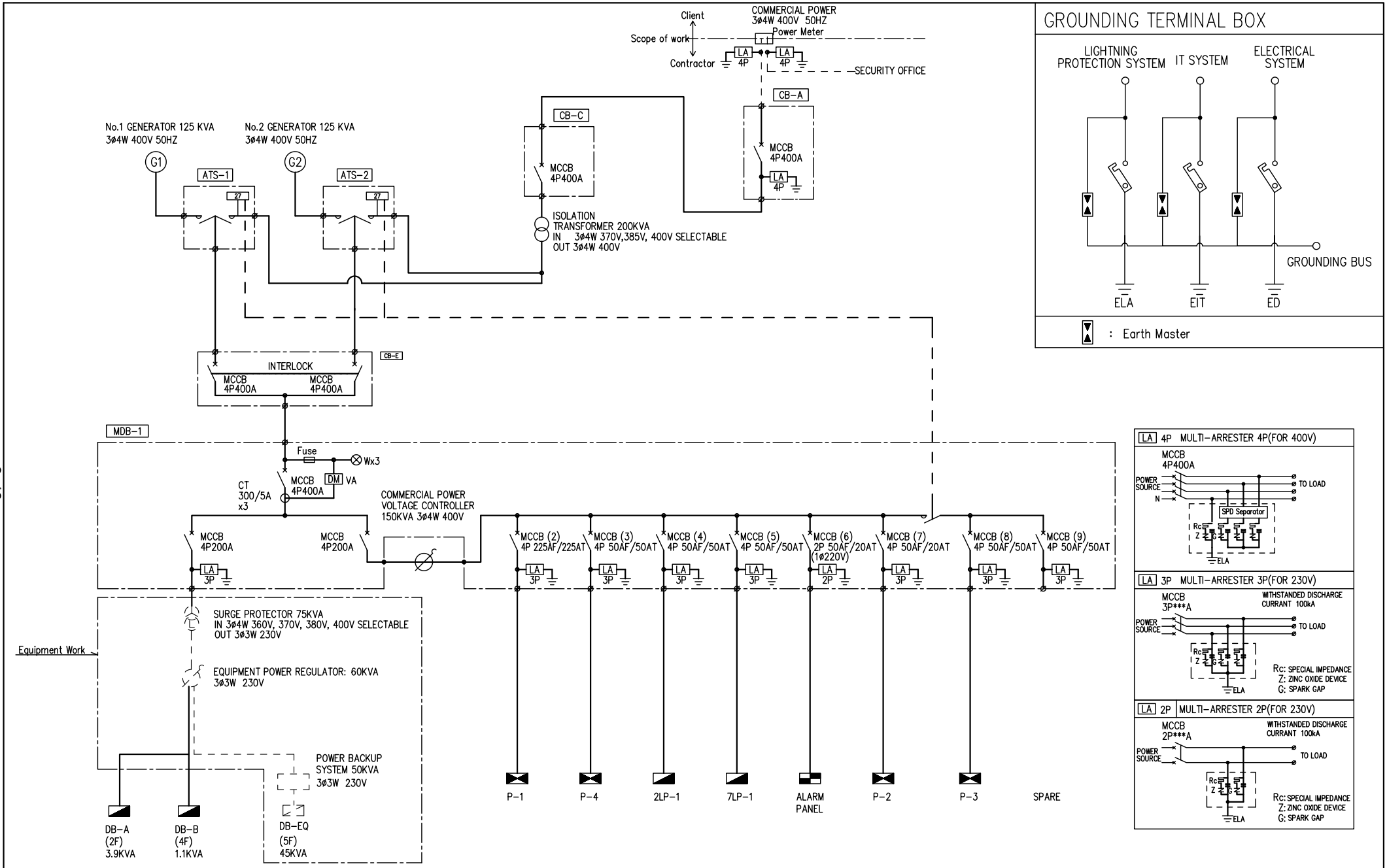
<Environmental conditions>

- Outside condition: temperature 45°C (maximum temperature: 51.0°C on June 01, 1996)
- Indoor condition: temperature 26°C humidity 40-60%
  In the radar equipment room and the electricity & power supply room: temperature 25°C humidity 40-60%

The following diagrams of the building equipment plan for the meteorological radar tower building can be found in the subsequent pages immediately hereafter.

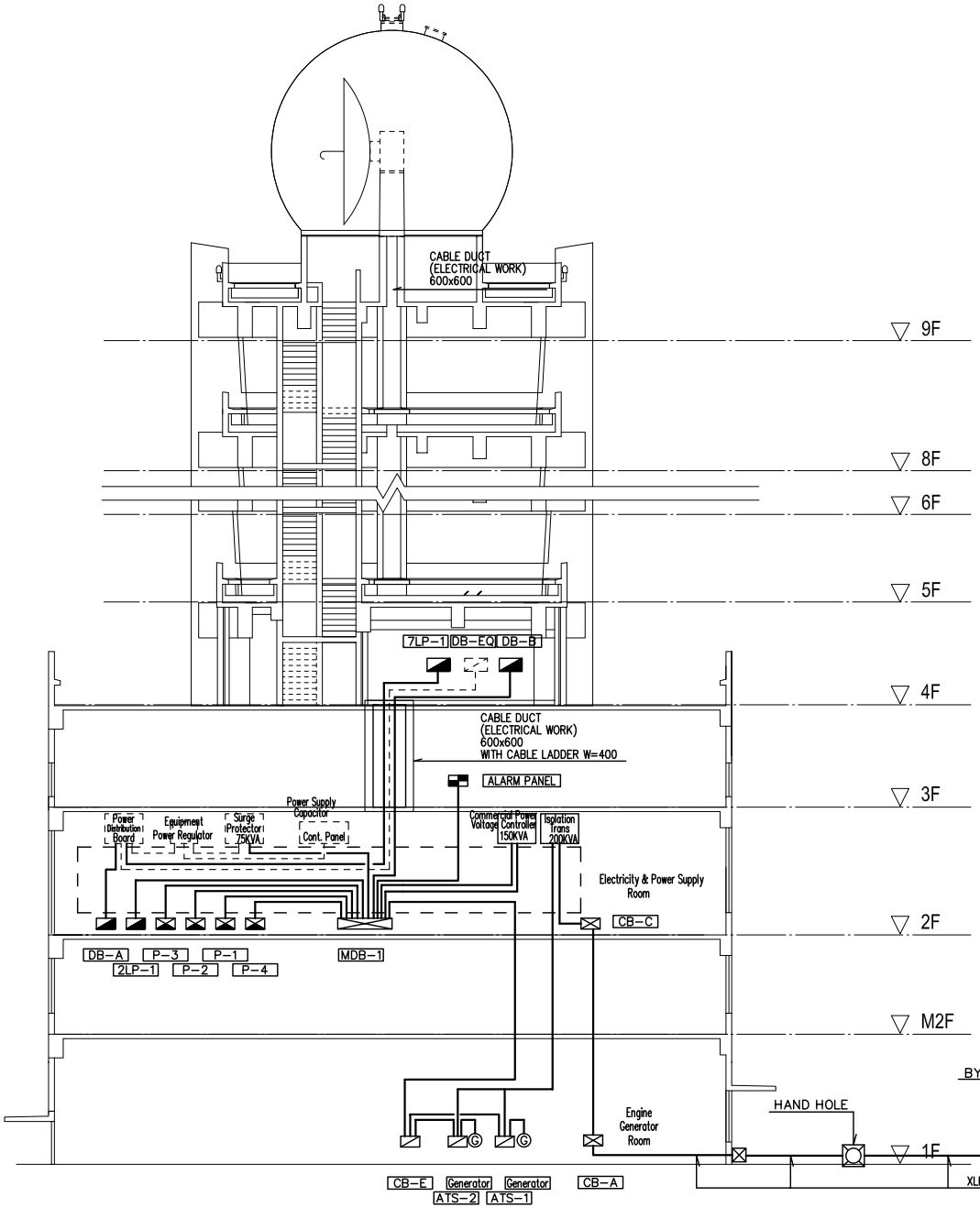
<Sukkur Meteorological Radar Tower Building>

- Power Feeder System : SD-01
- Power Riser System : SD-02
- Interphone & Tel System : SD-03
- Fire Alarm System : SD-04
- Alarm System : SD-05
- Lightning Protection & Grounding System : SD-06
- Obstruction Lighting System : SD-07
- Water Supply & Drainage System : SD-08
- Air-Conditioning & Ventilation System : SD-09



GROUNDING TERMINAL BOX

International Meteorological Consultant Inc. Ando Building 2F, 1-11-6 Nishi-Gotanda, Shinagawa-ku, Tokyo 141-0031, Japan Tel. +81-3-6431-9559 Fax. +81-3-6431-9759	THE PROJECT FOR THE INSTALLATION OF WEATHERE SURVEILLAMCE RADAR AT SUKKUR IN THE ISLAMIC REPUBLIC OF PAKISTAN	DRAWING TITLE SUKKUR METEOROLOGICAL RADAR TOWER BUILDING POWER FEEDER SYSTEM	SCALE NONE	DRAWING No. SD - 01



POWER CABLE LIST

FROM	TO	CABLE SIZE	CONDUIT
CB-A	CB-C	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDER
CB-C	ISOLATION TRANS 150KVA	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDER
ISOLATION TRANS	ATS-1	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDER
ISOLATION TRANS	ATS-2	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDER
GENERATOR	ATS-1	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDER
GENERATOR	ATS-2	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDER
ATS-1	CB-E	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDER
ATS-2	CB-E	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDER
CB-E	MDB-1	XLPE/PVC 1C-4x120sq +E70sq	(G80) / CABLE LADDER
MDB-1	ISOLATION TRANS 75KVA(EQUIP WORK)	XLPE/PVC 4C-30sq +E22sq	(G50) / CABLE LADDER
MDB-1	P-1	XLPE/PVC 1C-4x70sq +E50sq	(G70) / CABLE LADDER
MDB-1	P-2	XLPE/PVC 4C-16sq +E16sq	(G40) / CABLE LADDER
MDB-1	P-3	XLPE/PVC 4C-16sq +E16sq	(G40) / CABLE LADDER
MDB-1	P-4	XLPE/PVC 4C-16sq +E16sq	(G40) / CABLE LADDER
MDB-1	2LP-1	XLPE/PVC 4C-16sq +E16sq	(G40) / CABLE LADDER
MDB-1	7LP-1	XLPE/PVC 4C-16sq +E16sq	(G40) / CABLE LADDER
MDB-1	ALARM PANEL	XLPE/PVC 2C- 6sq +E 6sq	(G32) / CABLE LADDER
PowerDistributionBoard	DB-A	XLPE/PVC 2C-10sq +E10sq	(G40) / CABLE LADDER
PowerDistributionBoard	DB-B	XLPE/PVC 2C-10sq +E10sq	(G40) / CABLE LADDER
MDB-1	Commercial Power Voltage Controller 150kVA	XLPE/PVC 1C-4x95sq +E50sq	(G70) / CABLE LADDER
AVR 100kVA	MDB-1	XLPE/PVC 1C-4x95sq +E50sq	(G70) / CABLE LADDER

SPARE PARTS LIST FOR LIGHTNING PROTECTION SYSTEM

FROM	DESCRIPTION	UNIT
CB-A	MCCB 4P300A	1
ARRESTER	MULTI-ARRESTER 4P	2
CB-C	MCCB 4P300A	1
ATS-1	UNDER VOLTAGE RELAY	1
	CHANGE OVER SWITCH	1
	RELAY	4
MDB-1	MCCB 3P300A	1
	FUSE	6
	INDICATING LAMP	3
	VOLTAGE AMPERE INDICATOR	1
	ARRESTER 2P	2
	ARRESTER 3P	7
CB-E	MCCB 3P300A	1
	RELAY	4
	FUSE	4
GENERATOR	CONTROL CIRCUIT BOARD	1
	RELAY	4
	FUSE	4
	VOLT METER	1

- - - EQUIPMENT WORK

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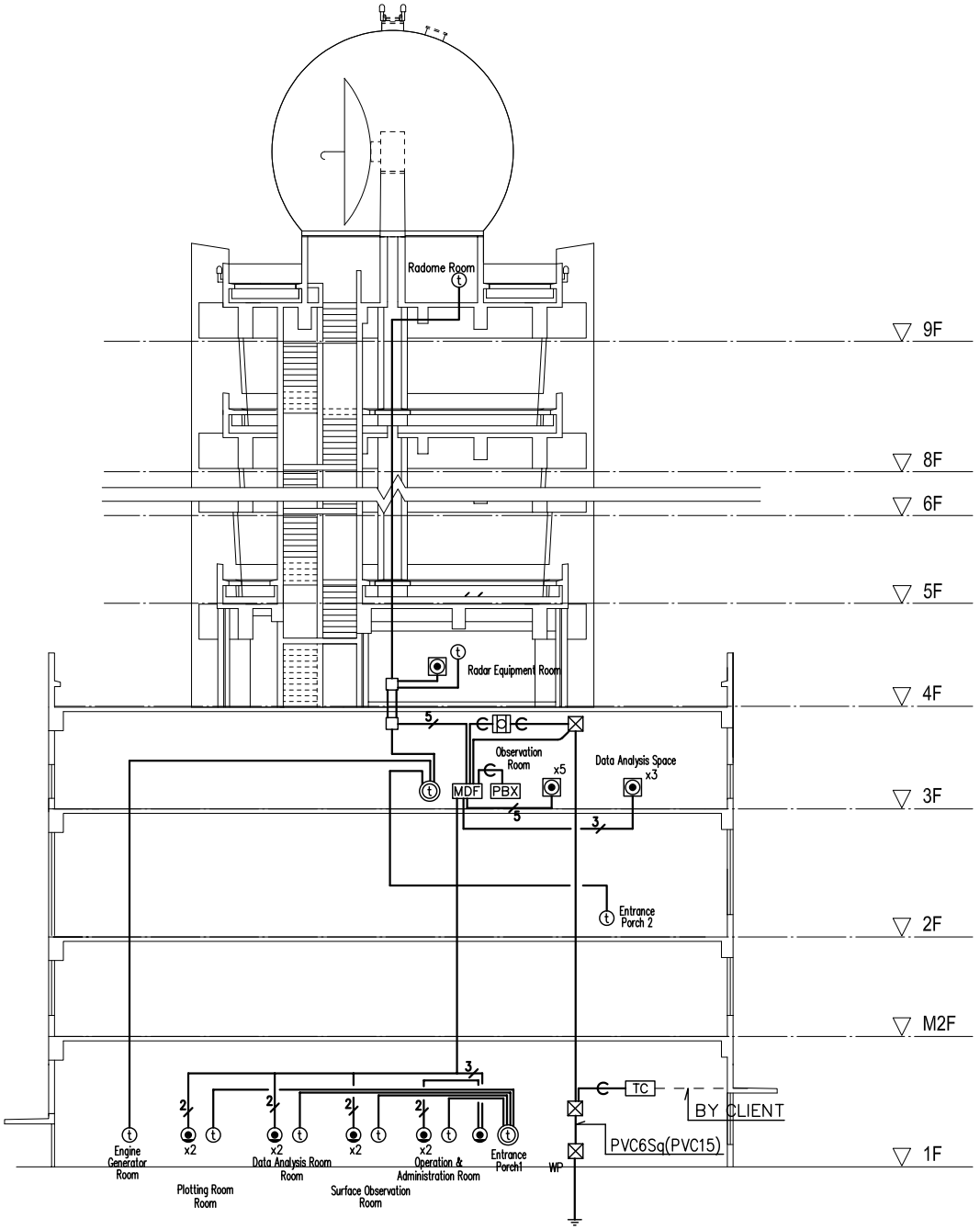
THE PROJECT FOR THE INSTALLATION OF
WEATHERE SURVEILLAMCE RADAR AT SUKKUR
IN THE ISLAMIC REPUBLIC OF PAKISTAN

DRAWING TITLE
SUKKUR METEOROLOGICAL RADAR TOWER BUILDING
POWER RISER SYSTEM

SCALE
NONE

DRAWING No.
SD - 02



REMARK

- —C— : —C— (G36)
- : TIEV 0.65−4C (G20)
- 2 : TIEV 0.65−4Cx2 (G20)
- 3 : TIEV 0.65−4Cx3 (G25)
- : TIEV 0.65−4C (UNDER THE ACCESS FLOOR)
- 2 : TIEV 0.65−4Cx2 (UNDER THE ACCESS FLOOR)
- 3 : TIEV 0.65−4Cx3 (UNDER THE ACCESS FLOOR)
- : AE 0.9−2C (G20)
- : AE 0.9−2C (UNDER THE ACCESS FLOOR)
- PBX : PBX COT. 5L , EXT. 15L
- MDF : MAIN DISTRIBUTION FRAME 30P TELEPHONE 7UNIT
- : TELEPHONE OUTLET (MODULAR JACK)
- : TELEPHONE OUTLET SLAB MOUNT
- : ARRESTER
- : INTERCOM (POWER SUPPLY FOR INTERCOM)
- : INTERCOM
- : PULL BOX 200x200x200 (WATER PROOF TYPE)
- TC : INCOMING TERMINAL FRAME

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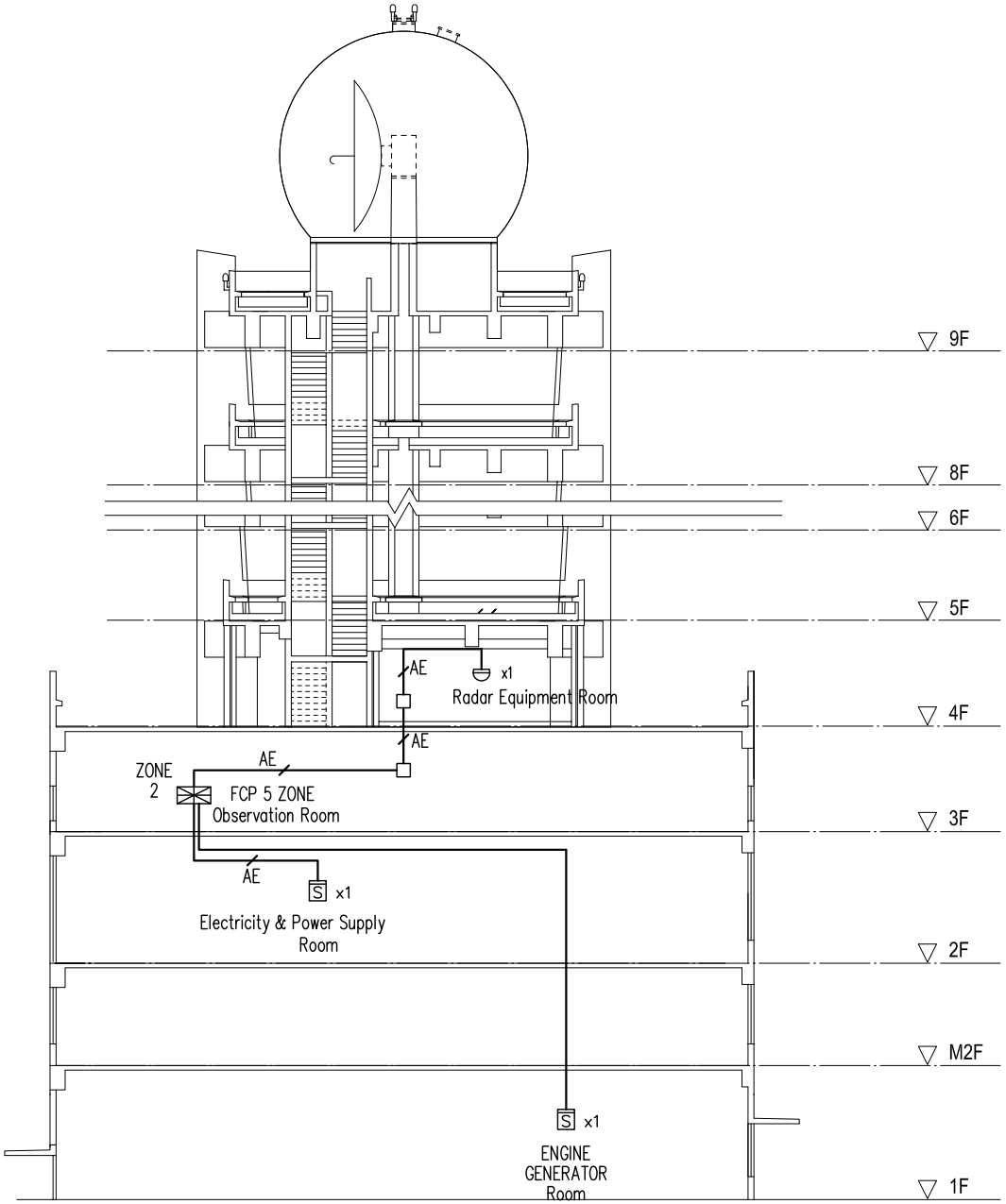
DRAWING TITLE
SUKKUR METEOROLOGICAL RADAR TOWER BUILDING
INTERPHONE & TEL SYSTEM

SCALE
NONE

DRAWING No.
SD - 03



FIRE ALARM CONTROL PANEL 5 ZONE

SMOKE DETECTOR (PHOTO TYPE)

RATE OF RISE HEAT DETECTOR

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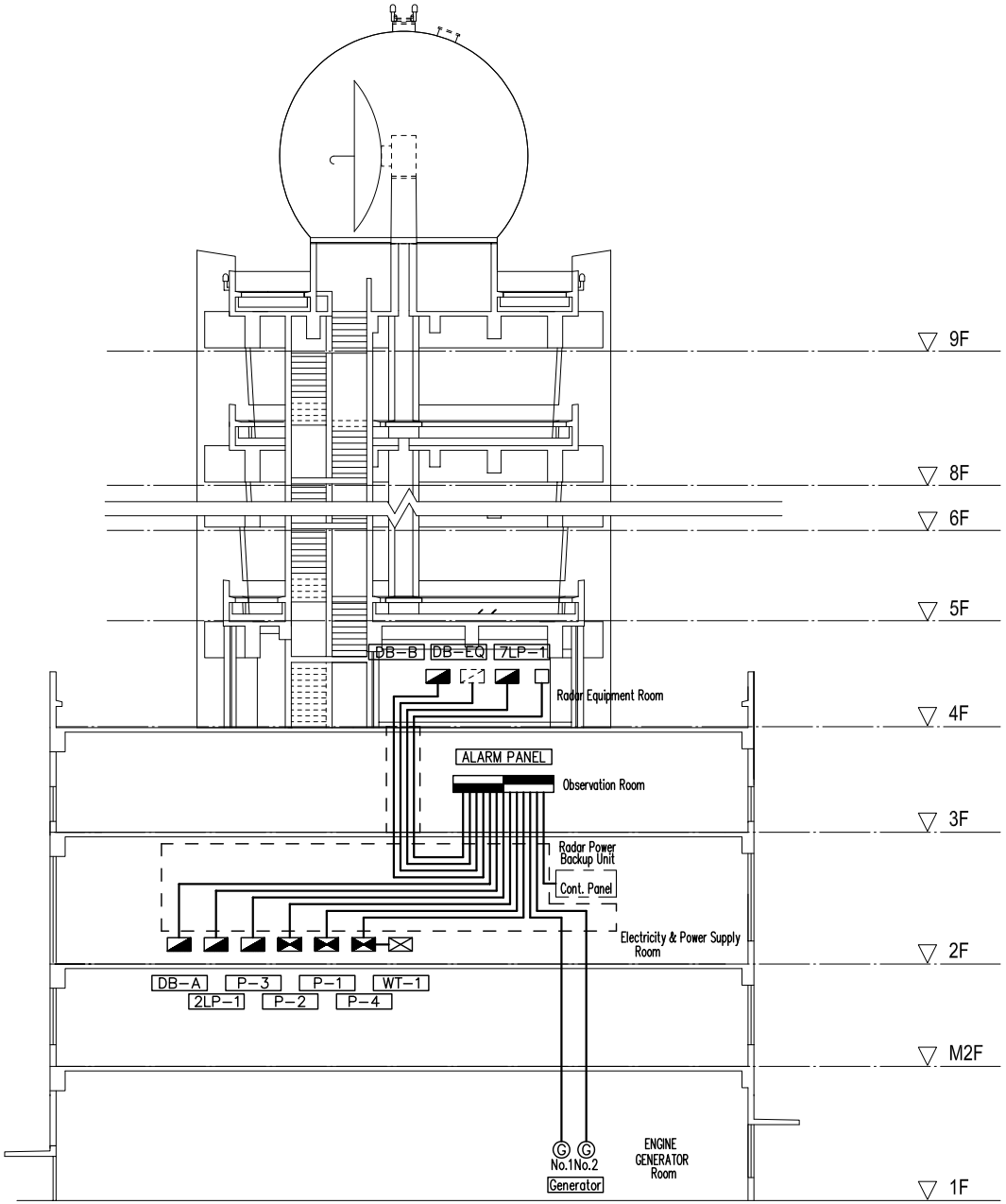

☐ TEMPERATURE SWITCH FOR ROOM TEMPERATURE ALARM

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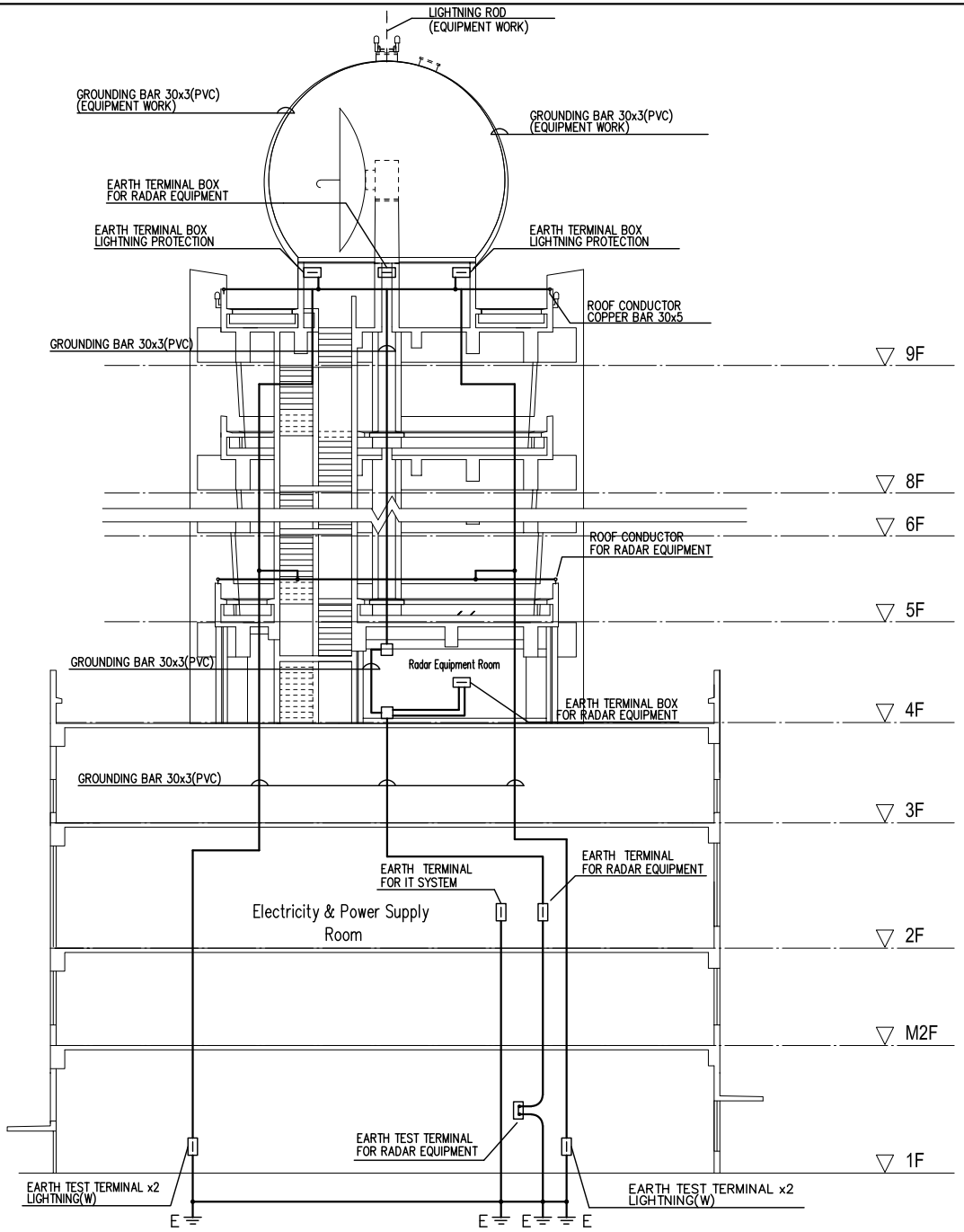

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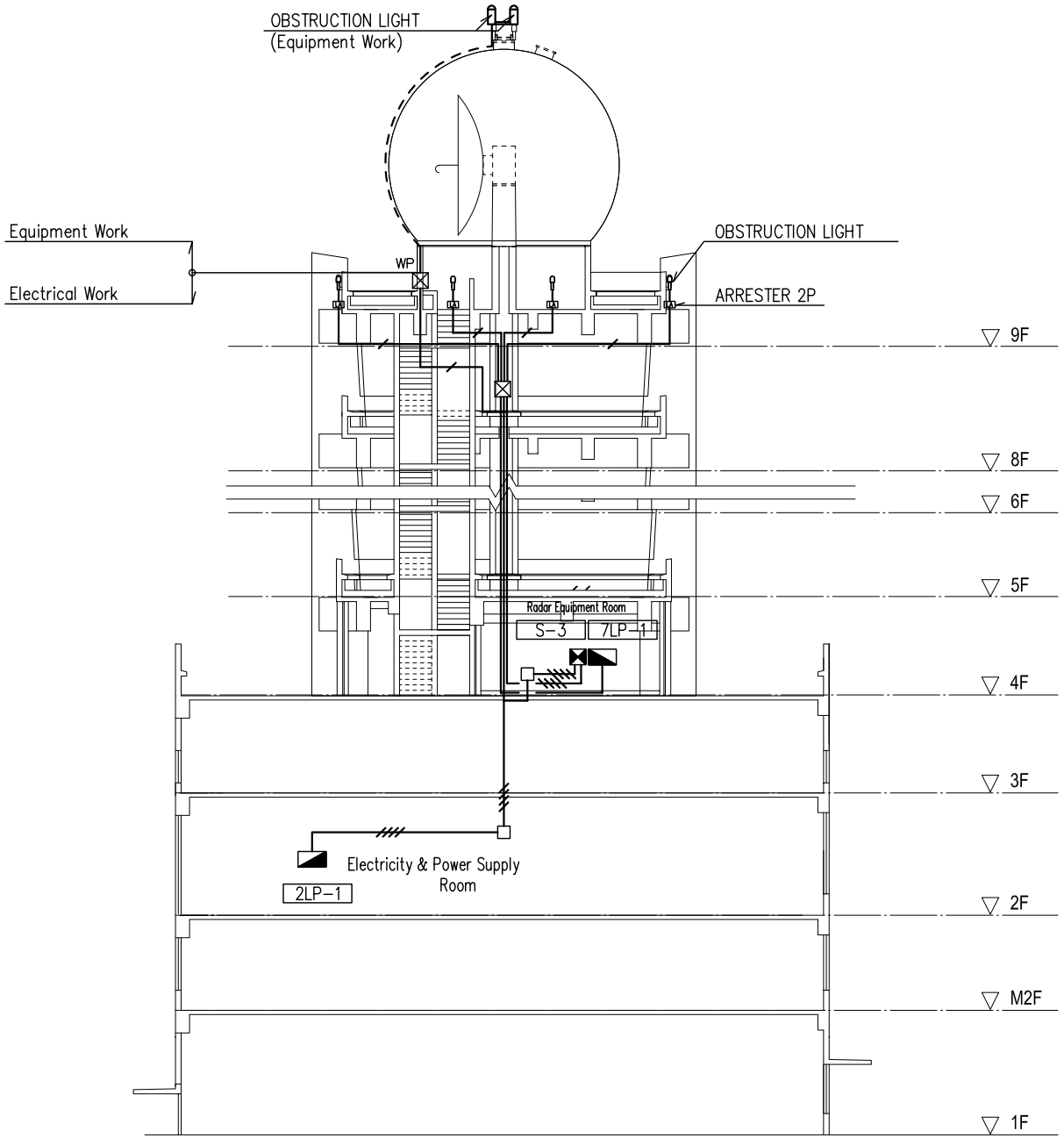
DRAWING TITLE
SUKKUR METEOROLOGICAL RADAR TOWER BUILDING
LIGHTNING PROTECTION &
GROUNDING SYSTEM

SCALE
NONE

DRAWING No.
SD - 06



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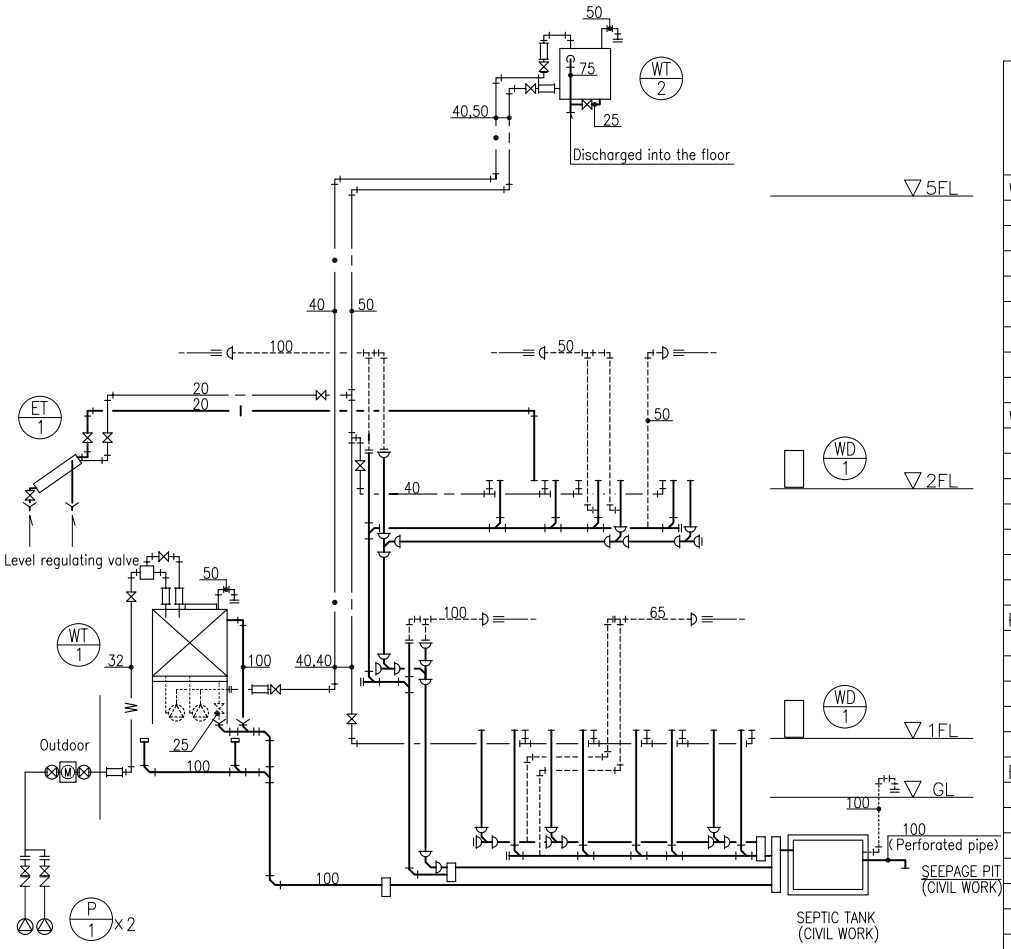

ITEM	1F Pump Room	1F Toilet (M) 1	1F Toilet (F) 2	1F Rest Room	1F Tea Kitchen 1	1F SK 1	2F Toilet (M) 2	2F Toilet (F) 2	2F ShowerRoom 1	2F SK 2	2F ROOF	5F ROOF	TOTAL	REMARK
WATER CLOSET		1	1	1			1	1					5	
LAVATORY		1	1	1			1	1					5	
PAPER HOLDER		1	1	1			1	1					5	
FAUCET	1	1	1	1	1	1	1	1		1	1	1	11	
MIRROR		1	1	1			1	1					5	
SHOWER HEAD									1				1	
KITCHEN SINK					1								1	
URINAL		1					1						2	
SERVICE SINK						1				1			2	
HAND SHOWER		1	1	1			1	1					5	

NO.	NAME	SPECIFICATION	Q'TY	POWER SUPPLY PHASE	VOLT (V)	FREQUENCY (Hz)	MOTOR (KW)	EMERGENCY POWER SUPPLY	LOCATION	REMARKS
WT-1	POTABLE WATER	FPR Tank	1					○	1F Pump Room	RC FOUNDATION
	TANK / PUMP	Rated capacity 4.0 m^3								(CIVIL WORK)
		Dimension 2,500 x 1,500 x 1,500H								
		Accessories Manhole 600ø								
		Electrode 4P								
		Constant pressure type pump	2	3	230	50	1.1x2			
		32 ø x 40 l/min x 370 kpa x 2 pcs (1 spare)								
WT-2	POTABLE WATER	FRP tank	1						6FL Roof	RC FOUNDATION
	GRAVITY TANK	Rated capacity 2.0 m^3								(CIVIL WORK)
		Dimension 1,000 x 1,500 x 1,500H								
		Earthquake proof 2.0G(Wind –Proof type)								
		Accessories manhole 600 ø								
		Electrode 4P								
P-1	PUMP	Model : Deep Well Submerged Pump (50mDeep)	2	3	230	50	1.5	○	Out door	Automatic-
		stainless steel								alternate operation
		25ø x 30 l/min x 1350 kpa								
		Accessories : Panel,Ball valve,Check valve								
		Automatic alternate operation								
ET-1	Solar powered water	Model : Natural circulation 2 circuits type	1						3F Balcony	
	heater	Dimension: Solar heater panel 2010x1250x80								
		Heat to collect Area : 2.5m^2								
		Water storage volume : 200 LIT								
ABC	FIRE EXTINGUISHER	ABC Dry chemical, wall hang	3						Each room	
		10 Lbs Discharge time 14 sec								
CO2	FIRE EXTINGUISHER	Carbon dioxicide, wall hang	5						Each room	
		10 Lbs Discharge time 14 sec								
WD-1	Water Dispenser	Hot & Cool Water type	2	1	230	50	0.5		Tea Kitchen1,2	
	SEPTIC TANK	Septic tank & Seepage pit (RC type, Civil work)	1						Out door	
	(CIVIL WORK)									

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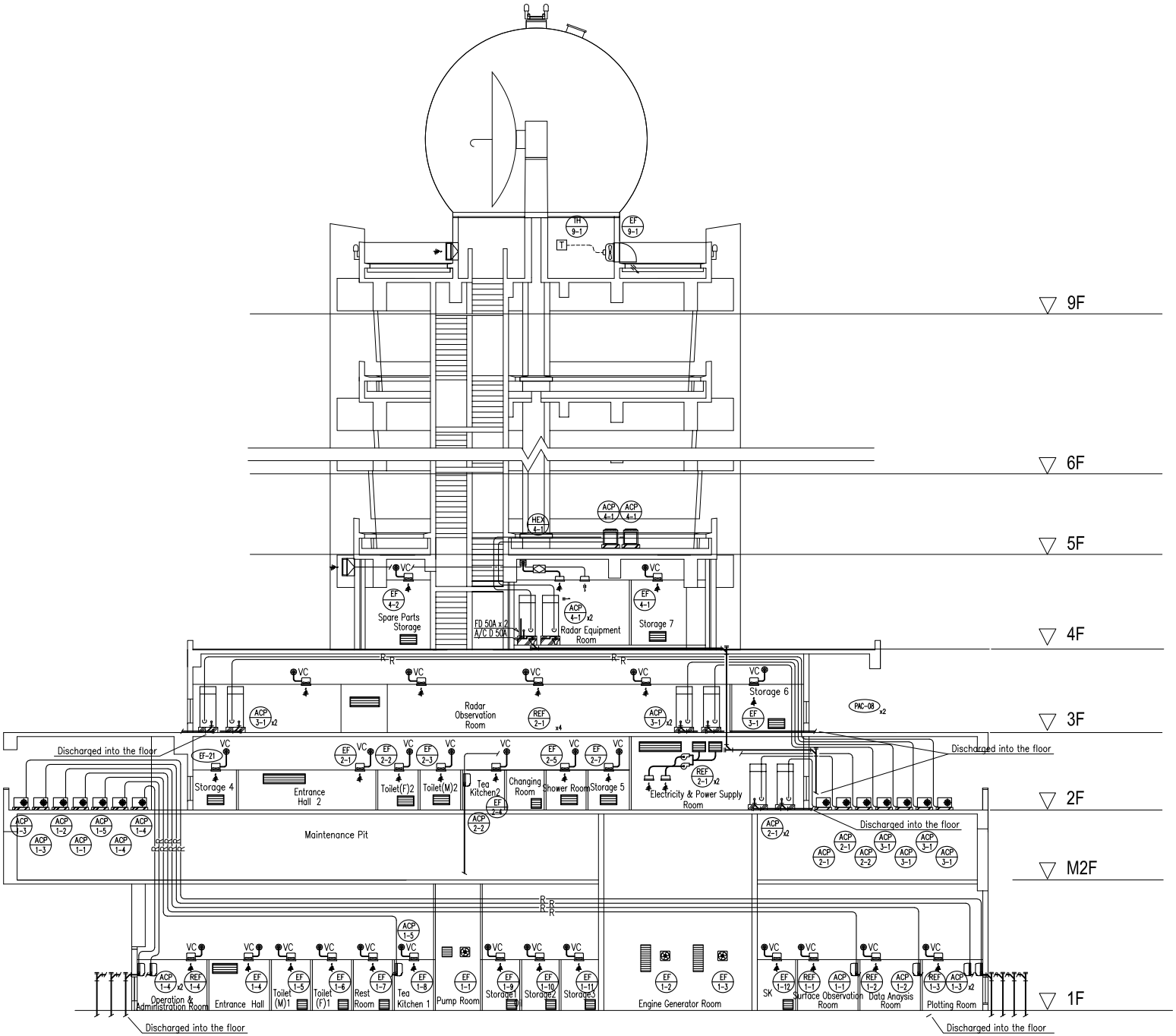
DRAWING TITLE
SUKKUR METEOROLOGICAL RADAR TOWER BUILDING
WATER SUPPLY & DRAINAGE SYSTEM

SCALE
NONE

DRAWING No.
SD - 08



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