# STRATEGIC ENVIRONMENTAL ASSESSMENT OF PUNJAB SPATIAL STRATEGY 2047

Volume
02

Punjab Spatial Strategy

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

# Annex - 4

# Punjab Spatial Strategic 2047: Strategic Environmental Assessment – Climate Change

# Contents

# 1. Introduction

In the ever-warming era, global temperature has been observed to increase up to 0.72°C over the period 1951–2012 (McCoy et al., 2014) which is predicted to increase around 1°C to 3°C by 2050s and 2°C to 5°C by 21st century under the representative emission scenario RCP4.5 and RCP8.5 (IPCC, 2013). In Pakistan, the rate of warming is considerably higher than the global average and especially in the upper latitude regions around 5.8°C e.g. north Pakistan (Ali et al. 2015). These variations in temperature can influence water resources over north regions of Pakistan which consequently raise concern in downstream irrigation demand areas. Regarding this, increased flood risk has been observed in recent decades in Pakistan, particularly consecutive flooding from 2010 to 2016 caused damage to millions of people, economy, and infrastructure. The reliability of present and future climatology, simulated by climate models, greatly depends on their validation and application for particular region. These climate models' projections assist as a major base of knowledge for policy makers. However, the efficiency of climate models simulations has been criticized due to presence of uncertainty factor in simulating future climatology. Therefore, to establish the confidence of policy makers on model projections, the goal of scientific community is to bring improvements in the model's performance and to choose better performing climate models through inter-comparison (such as coupled models inter-comparison project). Regarding this, skill assessment of Global Climate Models (GCMs) is essential step pertaining to variability in modelling processes and assumptions. Usually, global models individually do not simulate all the atmospheric phenomena effectively and display widespread variations in simulation of finer scale climate. Some models show efficiency in simulating one process for instance Madden-Julian Oscillation (MJO), El Niño/Southern Oscillation (ENSO) and Indian Ocean Dipole (IOD) whereas are passive to simulate other phenomenon like monsoon. Moreover, GCMs show passiveness to cope up with the intricate topography of mountainous pertaining to sudden changes in elevation, coarse horizontal resolutions and systematic biases, consequently yielding less accurate fine scale climatic information (Fu et al., 2008; Sillmann et al. 2013). Difference between the spatial resolution of GCMs (on global scale with low resolution) and local scale impact studies (high resolution) are present e.g hydrological

modelling. Hence, to use the model for local scale studies, downscaling techniques are applied to bridge this gap (Wilby et al., 2000; Wood et al., 2002).

Still, climate models datasets involve several uncertainties from models and data which induce systematic bias in the model output. Consequently, unrealistic climatic and hydrological modelling results are produced which need to be improved before presenting to the policy makers. To provide reliable climate data for climate assessment, extensive work over the region is required. This report aims to provide the requirements and methodology for reliable statistical and dynamical downscaled and bias correction of data of daily maximum temperature, minimum temperature and precipitation for historic and future assessment of climate in Punjab. The current study also aims to provide baseline and projection of climatic extremes of temperature (TXn, TXx, TX10p, TX90p,TNn, TNx and TN10p) and precipitation (CDD,CWD,PRCPTOT,Rx1day,Rx5day and R95pTOT) that can be utilized for adaptation purposes.

# 2. Data and Methodology

## 2.1. Baseline analysis (1971-2017)

The data for baseline study over Punjab is based on Pakistan Meteorological Department (PMD) which needs NOC from PMD prior to publication of report and consultant will not be responsible in case of conflict of interest of authorization. The dataset consists of daily observed temperature (maximum and minimum) and precipitation data from 1971-2017 over 11 meteorological stations of Punjab.

In order to analyse baseline climatic conditions in Punjab, yearly, seasonal and monthly average of maximum and minimum temperature and precipitation for the period 1971-2000 is calculated as reference value. A comparison of overall 17 years average temperature and precipitation period 2001-2017 has been made with average 1971-2000. To analyse the yearly change in temperature and precipitation, each year from 2001-2017 has been compared with the average value of 1971-2000 temperature and precipitation on annual and seasonal basis. Also, trend analysis of temperature and precipitation has also been done from 2001-2017 to analyse the changes after 2000 in Punjab. Similar procedure has been carried out for baseline analysis of climate extremes and heatwaves to investigate their trends between 1971-2000 and 2001-2017. The extreme event indices analysed in this study are based on Expert Team

on Climate Change Detection and Indices (ETCCDI) developed by World Meteorological Organization (WMO) (Table 2.1).

**Table 2.1: Extreme Events Climate Indices of Expert Team on Climate Change Detection and Indices (ETCCDI)**

| ID | Indicator name | Indices | Units |
|---|---|---|---|
| CDD | Consecutive dry days | Maximum number of consecutive days with RR<1mm | Days |
| CWD | Consecutive wet days | Maximum number of consecutive days with RR>=1mm | Days |
| DTR | Diurnal temperature range | Monthly mean difference between TX and TN | ºC |
| PRCPTOP | Annual total wet-day precipitation | Annual total PRCP in wet days (RR>=1mm) | mm |
| R10mm | Number of heavy precipitation days | Annual count of days when PRCP>=10mm | Days |
| R20mm | Number of very heavy precipitation days | Annual count of days when PRCP>=20mm | Days |
| R95p | Very wet days | Annual total PRCP when RR>95$^{th}$ percentile | mm |
| R99p | Extremely wet days | Annual total PRCP when RR>99$^{th}$ percentile | mm |
| Rx5day | Max 5-day precipitation amount | Monthly maximum consecutive 5-day precipitation | Mm |
| SU | Summer days | Annual count when TX(daily maximum)>25ºC | Days |
| TN10p | Cool nights | Percentage of days when TN<10th percentile | Days |
| TN90p | Warm nights | Percentage of days when TN>90th percentile | Days |
| TR20 | Tropical nights | Annual count when TN(daily minimum)>20ºC | Days |
| TX10 | Cool days | Percentage of days when TX<10th percentile | Days |
| TX90p | Warm days | Percentage of days when TX>90th percentile | Days |
| WSDI | Warm spell duration indicator | Annual count of days with at least 6 consecutive days when TX>90th percentile | Days |

## 2.2. Climate Modelling and Future Assessment of Climate Change

### 2.2.1. Data Collection

On the basis of literature review (Ashfaq et al., 2017; Lutz et al., 2016) along with the availability of data, 14 CMIP5 GCMs (**Table 2.2** ) were selected and data for variables PRCP, TMAX, TMIN were downloaded from http://cmip-pcmdi.llnl.gov/cmip5/data_portal.html for the period of 1976-2050 with two Representative Concentration Pathways (RCP4.5 and RCP8.5). RCPs are developed by considerations of the changes in energy generation and land use, developments in technology, population growth, global and regional economic circumstances. There are four representative pathways: RCP2.6, RCP4.5, RCP6 and RCP8.5. RCP 8.5 is the highest greenhouse gas emissions scenario over time and RCP 4.5 is a stabilization so RCP 8.5 is selected as highest emission scenario if there is no effort to combat climate change, so we select the realistic one RCP4.5. The output of climate model datasets is created on future emission scenarios of RCP4.5 (Clarke et al., 2007) with radiative forcing 4.5 W/$m^2$ and RCP8.5 (Riahi et al., 2007) having 8.5 W/m2 radiative forcing by 21st Century. These emission scenarios are selected due to highest priority by IPCC (CMIP5, Taylor et al., 2012) and data availability. Based on evaluation and validation out of 14 GCMs, 3 GCMs data (MPI-ESM-LR , NorESM1-M , CCSM4) are used for statistical downscaling and analysis of extreme events especially the changes in four Expert Team on Climate Change Detection and Indices (ETCCDI) for instance consecutive wet day (CWD), extremely wet days (R99pTOT), cold spell duration index (CSDI), warm spell duration index (WSDI), consecutive dry day (CDD) are calculated for the period of 1976-2005 and 2006-2050. These observed datasets are also used for the statistical downscaling/bias correction of GCMs' temperature and precipitation and also for accurate assessment.

### 2.2: CMIP5 global climate model (GCMs) downscaled in this study

| | | | |
|---|---|---|---|
| 1 | CanESM2 | 2.7906x 2.8125 | Canadian Centre for Climate Modelling and Analysis |
| 2 | CCSM4 | 1.250x 0.942 | National Center for Atmospheric Research |
| 3 | CESM1-CAM5 | 1.250x 0.942 | National Center for Atmospheric Research |
| 4 | CMCC-CMS | 1.875x 1.865 | Centro Euro-Mediterraneo per I Cambiamenti Climatici |
| 5 | CNRM-CM5 | 1.406x 1.401 | Centre National de Recherches Meteorologiques |
| 6 | EC-EARTH | 1.1215x 1.125 | Irish Centre for High-End Computing (ICHEC), European Consortium |
| 7 | FGOALS-s2 | 2.813x 1.659 | LASG, Institute of Atmospheric Physics, Chinese Academy of Sciences |
| 8 | GFDL-ESM2G | 2.500x 2.023 | Geophysical Fluid Dynamics Laboratory |
| 9 | GFDL-ESM2M | 2.500x 2.023 | Geophysical Fluid Dynamics Laboratory |
| 10 | INM-CM4 | 2.000x 1.500 | Institute for Numerical Mathematics |
| 11 | MIROC-ESM-CHEM | 2.7906x 2.8125 | National Institute for Environmental Studies, The University of Tokyo |
| 12 | MPI-ESM-LR | 1.875x 1.865 | Max Planck Institute for Meteorology (MPI-M) |
| 13 | MPI-ESM-MR | 1.875x 1.865 | Max Planck Institute for Meteorology (MPI-M) |
| 14 | NorESM1-M | 2.500x 1.895 | Norwegian Climate Centre |

#### 2.2.2. Methodology for Climate Change Assessment

Based on literature review (Ashfaq et al., 2017; Lutz et al., 2016) and availability of data, 14 GCMs data (**Table 2.2)** was extracted over project areas for maximum, minimum temperature and precipitation for 1976-2005 and 2006-2050. On the basis of validation and performance of GCMs, 03 out of 14 GCMs were selected for the preparation of deliverable and further analysis. The skill assessment of the models is performed with time period of 1976-2005, and skill scores for each model are calculated. The ability of each model to simulate the reference climate is evaluated by agreement between model simulation and observed data (shown in **Table 2.3**).The 03 GCMs data were first downscaled over project area shown in **Figure 2.1** and then were applied latest bias correction methods of Spatial Disaggregation Quantile Mapping (SDQM), Spatial Disaggregation Detrended Quantile Mapping (SDQM) and Spatial Disaggregation Quantile Delta Mapping (SDQDM) bias correction methods, DQM and QDM

can preserve long-term future trends of extreme events. These statistical and bias correction techniques are the latest one (Ali et al., 2016; Eum and Cannon, 2016; Cannon et al., 2015).

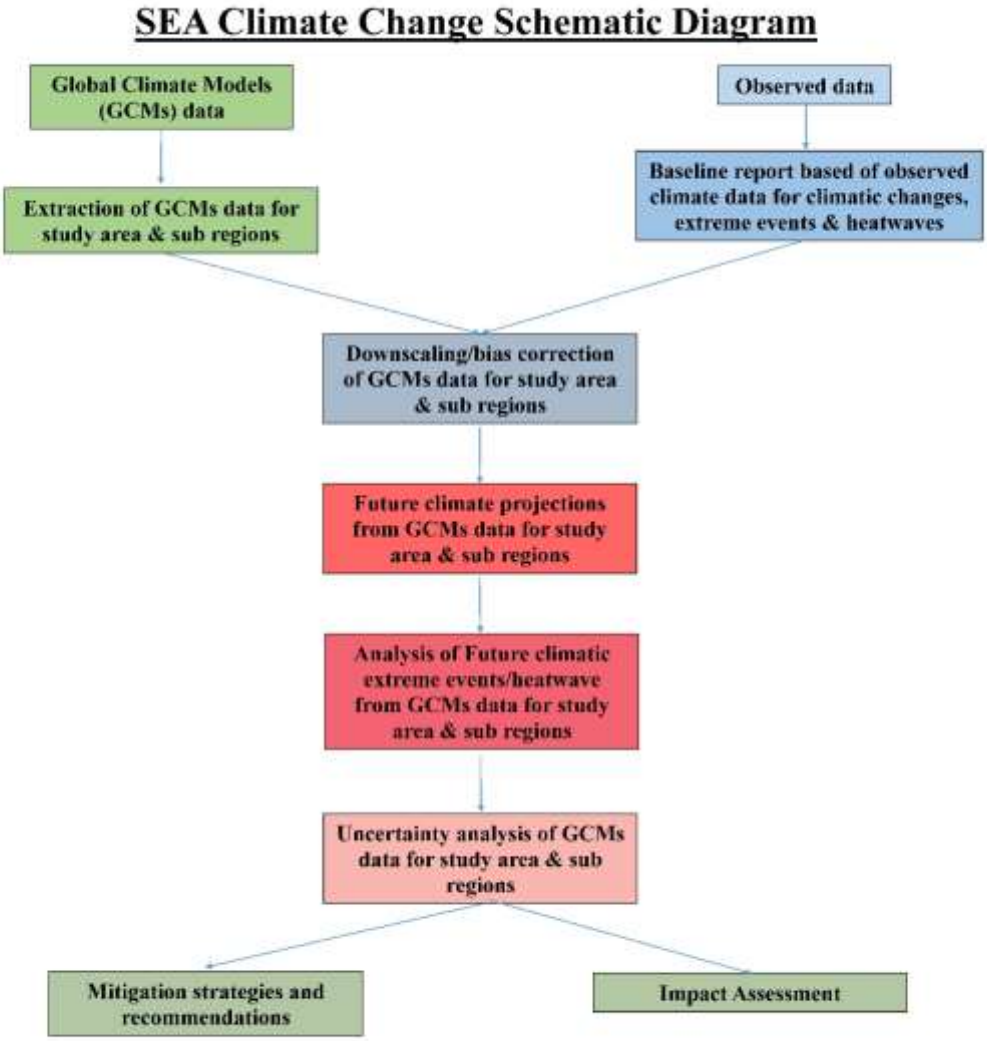



**Figure 2.1: Climate Change Impact Methodology**

**Table 2.3: Models showing highest agreement with observed data w.r.t. SD, RMSE and R value**

| Station Name | SD | RMSE | R Value |
|---|---|---|---|
| **Minimum Temperature** | | | |
| Bahawalnagar | FGOALS-s2 | MPI-ESM-LR | MPI-ESM-LR |
| Bahawalpur | FGOALS-s2 | MPI-ESM-LR | MPI-ESM-LR |
| Faisalabad | GFDL-ESM-2M | MPI-ESM-MR | MPI-ESM-LR |
| Jehlum | inmcm4 | FGOALS-s2 | FGOALS-s2 |
| Lahore | CCSM4 | FGOALS-s2 | FGOALS-s2 |

| Station Name | SD | RMSE | R Value |
|---|---|---|---|
| **Minimum Temperature** | | | |
| Mianwali | CMCC-CMS | FGOALS-s2 | MPI-ESM-LR |
| Multan | FGOALS-s2 | MPI-ESM-LR | MPI-ESM-LR |
| Murree | inmcm4 | EC-EARTH | EC-EARTH |
| Sargodha | GFDL-ESM2G | MPI-ESM-LR | MPI-ESM-LR |
| Sialkot | CCSM4 | FGOALS-s2 | FGOALS-s2 |
| **Maximum Temperature** | | | |
| Bahawalnagar | GFDL-ESM2M | NorESM1-M | NorESM1-M |
| Bahawalpur | CMCC-CMS | Nor-ESM1-M | NorESM1-M |
| Faisalabad | CanESM2 | NorESM1-M | NorESM1-M |
| Jehlum | MIROC-ESM-CHEM | NorESM1-M | CCSM4 |
| Lahore | CNRM-CM5 | NorESM1-M | NorESM1-M |
| Mianwali | CNRM-CM5 | FGOALS-s2 | MIROC-ESM-CHEM |
| Multan | CCSM4 | NorESM1-M | NorESM1-M |
| Murree | GFDL-ESM2M | NorESM1-M | NorESM1-M |
| Sargodha | MIROC-ESM-CHEM | NorESM1-M | NorESM1-M |
| Sialkot | GFDL-ESM2G | NorESM1-M | NorESM1-M |
| | **Precipitation** | | |
| Bahawalnagar | NorESM1-M | CESM1-CAM5 | CESM1-CAM5 |
| Bahawalpur | CNRM-CM5 | CCSM4 | MIROC-ESM-CHEM |
| Faisalabad | Nor-ESM1-M | MPI-ESM-LR | EC-EARTH |
| Jehlum | CNRM-CM5 | NorESM1-M | CNRM-CM5 |
| Lahore PBO | GFDL-ESM2M | inmcm4 | inmcm4 |
| Mianwali | GFDL-ESM2M | CESM1-CAM5 | CCSM4 |
| Multan | GFDL-ESM2M | inmcm4 | CCSM4 |
| Murree | CMCC-CMS | MPI-ESM-LR | NorESM1-M |
| Sargodha | NorESM1-M | inmcm4 | CESM1-CAM5 |
| Sialkot | CESM1-CAM5 | CCSM4 | CCSM4 |

Future extremes are projected by using standard indices of Expert Team on Climate Change Detection and Indices (ETCCDI) recommended by World Meteorological Organization (WMO) shown in **Table 2,1**. General methodology of the study is shown in **Figure 2.1.**

### 2.2.3. Technical Details

Bias correction of climate models data is important as without applying bias correction unrealistic projections are produced (Akhtar et al., 2008; Bergstrom et al., 2001; Graham et al., 2007; Haerter 2011). In statistical bias correction methods, biases in the simulated climate time series are corrected with respect to the observed time series. Among other methods, Quantile Mapping (QM) linear method is better performing method of bias correction. QM equates cumulative distribution functions (CDFs) and is represented mathematically as below:

**Quantile mapping method:**

The model output is represented by $x_m$ . In the first step of Quantile mapping method, the distribution function of model output is calculated. After which the distribution function of observed historical data is calculated and the inverse of this function is implemented to the distribution function of model output data given in equation below:

$$\rho_m = F_m(x_m) \quad (1)$$

$$\rho_o = F_o(x_o) \quad (2)$$

$$\tilde{x}_m = {\rho_o}^{-1}(\rho_m) \quad (3)$$

Where $x_m$ is original model output and $\tilde{x}$ is bias corrected output $F_m$, are the distribution function of model simulated data while ${F_o}^{-1}$ represents the inverse of distribution function of observed climate data,

According to Cannon et al, (2015), QM bias-correction assumes the stationarity in the features of historical data which will persist into the future period data.

Many studies used DQM method (Teutschbein et al., 2010; Lafon et al., 2012). The description and equation of the DQM method is as below:

**Detrended quantile mapping method**

It starts with the ratio of average values of predicted data of model in future to the baseline period.

$$R_{f,h} = \frac{\bar{x}_{m,f}}{\bar{x}_{m,h}} \quad (4)$$

In next step the cumulative distribution function is calculated by taking the ratio of baseline average values of model's simulated data to future period simulations further multiplied with model's simulation in the future.

$$\rho_{m,h} = F_{m,h}\left\{\left(\frac{\bar{x}_{m,h}}{\bar{x}_{m,f}}\right).x_{m,f}(t)\right\} \quad (5)$$

Finally, cumulative distribution function of observed data is implemented to the CDF of model's simulated historical data multiplied with ratio calculated in equation 4.

$$\tilde{x}_{m,f}(t) = {\rho_{o,h}}^{-1}\left[\rho_{m,h}.R_{f,h}\right] \quad (6)$$

Where, $\rho_{o,h} = F\left(x_{o,h}\right)$. The same procedure can be applied for temperature but the difference between mode's future and baseline data is added instead of multiplications.

$$D_{f,h} = \bar{x}_{m,f} - \bar{x}_{m,h} \quad (7)$$

$$\rho_{m,h} = \left\{x_{m,f} + \left(\bar{x}_{m,h} - \bar{x}_{m,f}\right)\right\} \quad (8)$$

$$\tilde{x}_{m,f}(t) = {\rho_{o,h}}^{-1}\left[\rho_{m,h} + \left(\bar{x}_{m,f} - \bar{x}_{m,h}\right)\right] \quad (9)$$

QDM method is also used by some studies (Cannon et al., 2015; Eum and Cannon, 2016).

The equation and description of QDM method is as below:

**Detrended Quantile Mapping (QDM)**

In this method,$x_{m,h}$, $x_{m,p}$ represents model's simulated historical and future data, respectively. Similarly, cumulative distribution function of historical observed data is

represented as $\rho_{o,h}$, model's simulated data for historical time as $\rho_{m,h}$, and future time period as $\rho_{m,f}$ respectively. Further, $x$ and $\rho$ represent data and CDF of the data, respectively.

$$\rho_{m,f}(t) = F_{m,f}(t)\left(x_{m,f}(t)\right) \quad , \quad \rho_{m,f}(t) \in [0,1] \tag{10}$$

The relative change can be calculated as the ratio of inverse CDF of model predicted data and the inverse CDF of historical observed data. Mathematically this can be represented by equation

$$\Delta_m(t) = \frac{{F^{(t)}}_{m,f}{}^{-1}\left(\rho_{m,f}(t)\right)}{{F_{m,h}}^{-1}\left(\rho_{m,f}(t)\right)} = \frac{x_{m,f}(t)}{{F_{m,h}}^{-1}\left(\rho_{m,f}(t)\right)} \tag{11}$$

The bias correction of quantile of model's predicted data $\rho_{m,f}(t)$ can be carried out by the inverse CDF of historical observed data.

$$\tilde{x}_{o,m}(t) = {F_{o,h}}^{-1}\left(\rho_{m,f}(t)\right) \tag{12}$$

The bias corrected future projections can be acquired by implementing relative changes to the historical bias corrected data given in equation 12.

$$\tilde{x}_{m,f}(t) = \hat{x}_{o,m}(t) + \Delta_m(t) \tag{13}$$

$\tilde{x}_{m,f}(t)$ is the final output of the method which is utilized in climate studies.

## 3. Results

### 3.1. Baseline temperature and precipitation changes

Figure (3.10(i(a, b, c)) shows observed climatology over three regions of Punjab for the period 1971-2000. The northern edge of north and central Punjab show lowest annual maximum temperature (fig. 3.10(i(a)) which tends to increase towards Southern region. The south region of Punjab shows highest annual maximum temperature reaching upto 33 ˚C. The western part of study area shows moderate temperature conditions which are higher than northern part but lower than the south region of Punjab. The observed annual maximum temperature in North region for period 1971-2000 is 30.17˚C, in Central region it reached upto 30.5˚C while highest in South region with 32.34˚C average annual maximum

temperature. The observed annual minimum temperature from 1971-2000 (fig. 3.10(i(b)) also displays almost similar temperature distribution where the north region of Punjab shows lowest minimum temperature. It has been observed that highest annual minimum temperature was observed in the south-eastern part of the province. The average minimum temperature observed in North region during 1971-2000 is 15.7˚C, 16.9˚C in Central region while 17.5˚C in South region of Punjab. Figure (3.10(i(c)) shows the observed mean daily precipitation. It can be noted that the north region along with northern edge of central region show highest observed precipitation during the period 1971-2000 reaching up to 3.3 mm/day in Rawalpindi. This region lies in core monsoon region of Pakistan where highest amount of precipitation is recorded. However, it can be seen that the lowest precipitation is observed in the south region which is characterized by dry and hot weather conditions.

### 3.1.1. Observed Changes in 2001-2017 compared to 1971-200

A comprehensive analysis of observed changes in maximum, minimum temperature and precipitation is presented in Figure 3.1, 3.2, 3.4 and Table 3.1(a-c).

**North Punjab:** The average maximum temperature in Jhelum shows a slight increase during 2001-2017 compared to baseline period. However, a decreasing trend in maximum temperature has been observed from 2001-2017. The minimum temperature shows an increase of 0.53 ˚C in 2001-2017 compared to average maximum temperature in baseline. While similar to maximum temperature, minimum temperature also shows decreasing trend from 2001-2017 with 2006 showing the highest minimum temperature. In case of precipitation, average of 2001-2017 show an increase compared to baseline period while similar to temperature, a decreasing trend is observed in precipitation as well from 2001-2017.

In Mianwali, the average maximum temperature observed during 1971-200 is 31.44˚C while it shows a little decrease during 2001-2017 i.e. 31.35 ˚C. Also, a decreasing trend in maximum temperature has been observed during 2001-2017, however, highest maximum temperature is observed in 2002. The average minimum temperature has increased in period 2001-2017 compared to baseline period and show 0.68 ˚C increase. However, a constant trend has been observed during 2001-2017 with year 2006 showing highest observed minimum temperature. With respect to precipitation, the period 2001-2017

shows increase in average daily precipitation during 2001-2017 with highest precipitation observed in 2010.

**Central Punjab:** In Sargodha, the period 2001-2017 shows slightly less average maximum temperature compared to baseline while a decreasing trend has been observed in maximum temperature during 2001-2017 with 2015 showing lowest observed maximum temperature in the period. The opposite of this is observed in minimum temperature in Sargodha which average minimum temperature during 2001-2017 was observed to be higher than average baseline. However, a decreasing trend has been observed during 2001-2017. Precipitation shows an increasing trend from 2001-2017 with only 2009 showing less precipitation compared to baseline. On average, the average precipitation in 2001-2017 is higher compared to baseline.

In Sialkot, the average maximum temperature during 2001-2017 shows 0.7˚C increase compared to baseline. However, from 2001-2017, the maximum temperature is observed to show slight decreasing trend. Minimum temperature also show prominent increase of 2.2 ˚C in average of 2001-2017 compared to baseline average. Also, an increasing trend is observed in minimum temperature during 2001-2017. Opposite of it can be seen in average daily precipitation where less average precipitation is observed in 2001-2017 compared to baseline, however from 2001-2017 slightly increasing trend has been observed in yearly precipitation.

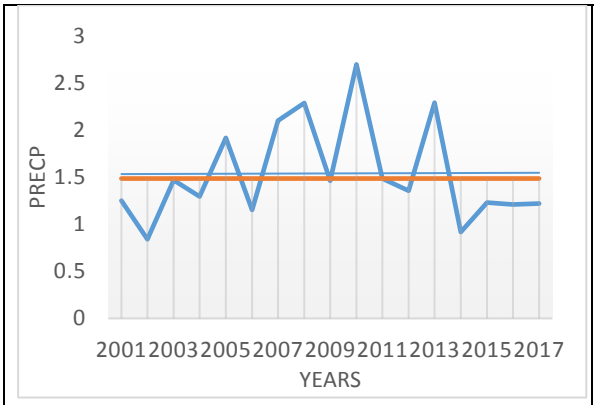
The average maximum temperature in Faisalabad is observed to be higher in 2001-2017 than baseline, however, a decreasing trend has been observed in yearly average from 2001-2017. For minimum temperature, an increase of 1.01˚C has been observed in 2001-2017 average with increasing trend in yearly precipitation. All the years shows higher annual minimum temperature than baseline average minimum temperature in Faisalabad. An increase has also been observed in precipitation in average as well as yearly trend from 2001-2017 shown an increase. The average precipitation also shows an increase from 2001-2017 compared to baseline along with an increasing trend from 2001-2017.

In Lahore, the average maximum temperature in 2001-2017 shows a slight decrease compared to baseline along with decreasing trend observed in maximum temperature from 2001-2017. However, minimum temperature shows an increase of 1˚C in average of 2001-2017 compared to baseline minimum temperature in Lahore. While minimum temperature shows decreasing from 2001-2017 in yearly average minimum temperature. The precipitation shows opposite behaviour as it shows a decrease in average daily temperature from 1.85mm in baseline to 1.65 mm in 2001-2017. However, an increasing trend has been observed in daily precipitation from 2001-2017.

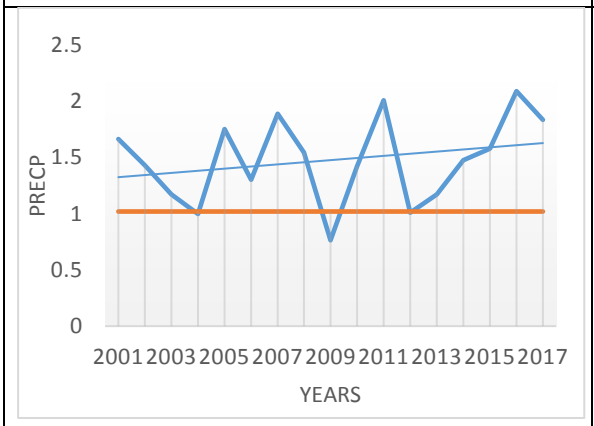
**South Punjab**: In Multan, a slight increase has been observed in 2001-2017 in average maximum temperature compared to baseline with decreasing trend from 2001-2017 yearly maximum temperature. Minimum shows a prominent increase in average of 2001-2017 compared to baseline i.e. 1.39˚C. The observed trend from 2001-2017 is also consistent with average increase in minimum temperature. Precipitation in Multan also shows an increase in average of 2001-2017 as well as in trend from 2001-2017 daily precipitation.

In Bahawalnagar, the maximum and minimum temperature shows an increase of 0.7˚C and 0.8˚C respectively in average of 2001-2017 compared to baseline. However, the trends during 2001-2017 yearly temperature are opposite for both variables where minimum temperature shows an increasing trend while minimum temperature shows decreasing trend. Similar to temperature, precipitation also shows an increase in daily precipitation in 2001-2017 compared to baseline with an increasing trend observe d from 2001-2017.

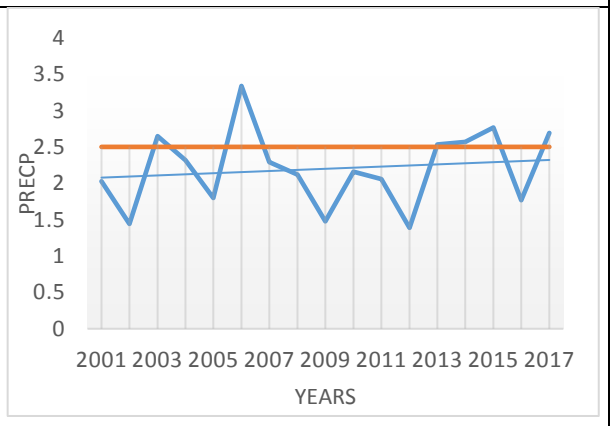
The city of Bahawalpur displays highest increase in maximum temperature among all cities in 2001-2017 compared to baseline i.e. 2.14 ˚C, however, from 2001-2017 a decreasing trend has been observed in yearly maximum temperature. The minimum temperature also shows an increase of 0.61˚C compared to baseline along with increasing trend from 2001-2017. The precipitation also shows an increase in 2001-2017 daily precipitation compared to baseline. The trend from 2001-2017 also shows increasing trend in daily precipitation.



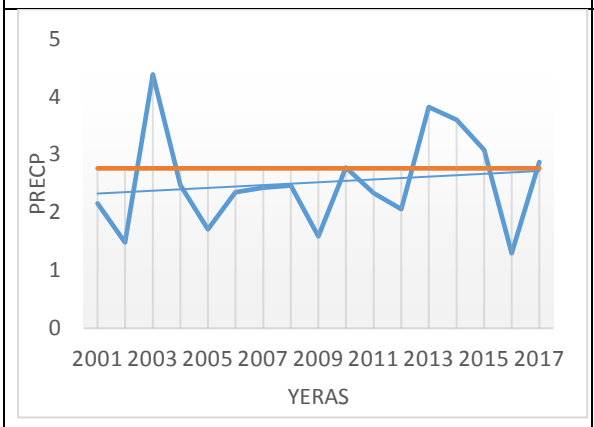

Mianwali



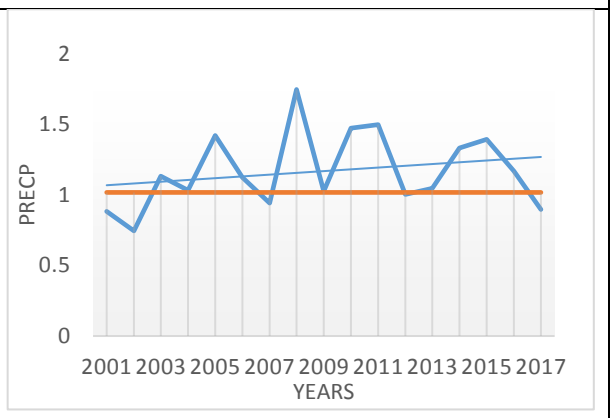

Sargodha



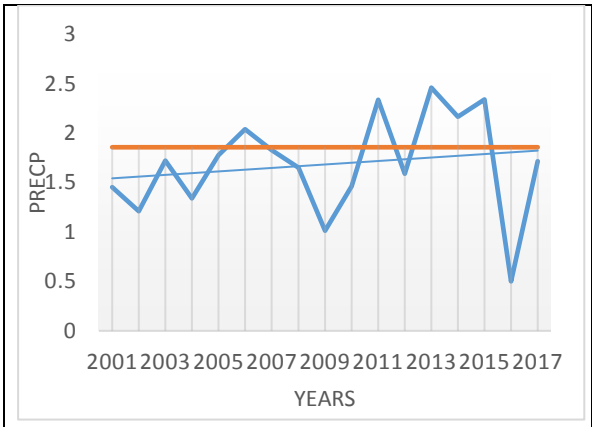

Jhelum



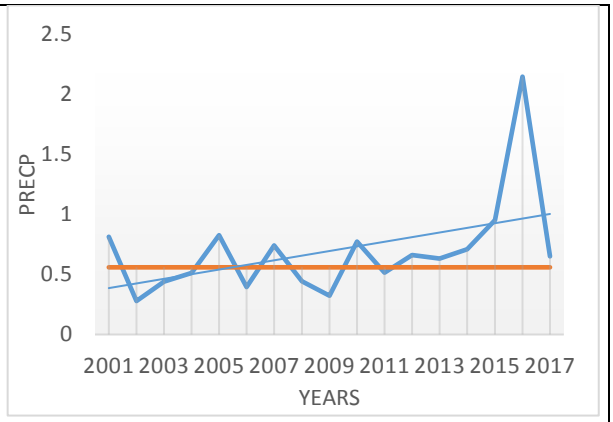

Sialkot



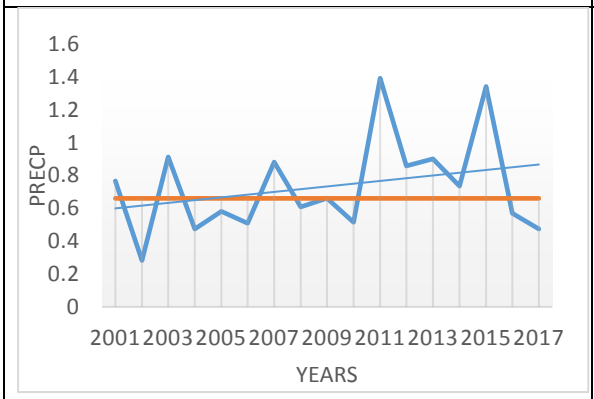

Faisalabad



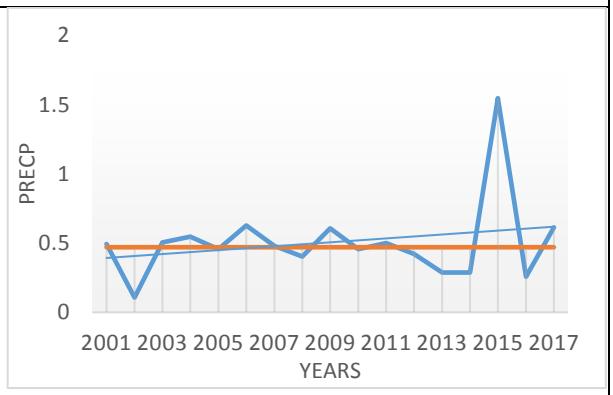

Lahore




Multan

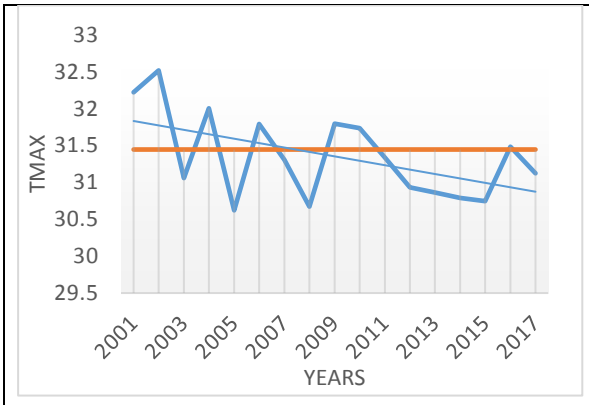



Bahawalnagar

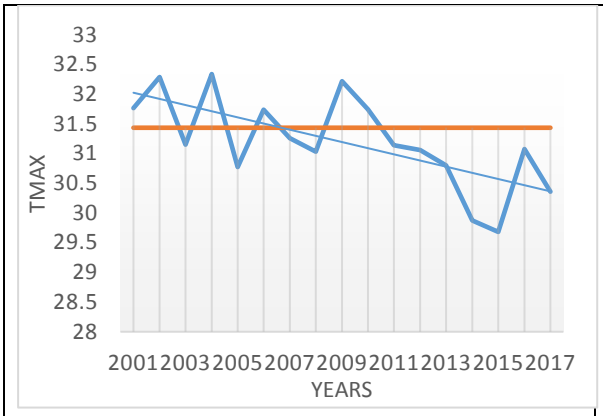



Bahawalpur

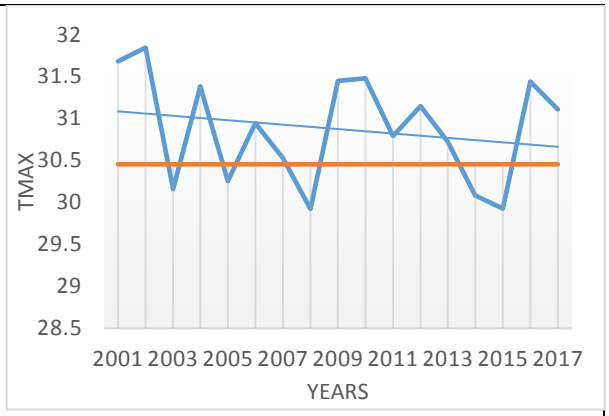
*Figure 3.1: Comparison of precipitation in baseline (1971-2000) and 2001-2017. Brown line represents baseline (1971-2000) and blue curve shows variability in precipitation from 2001-2017.*



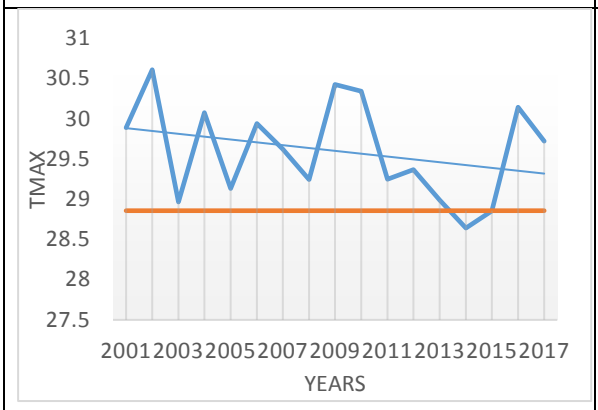

Mianwali



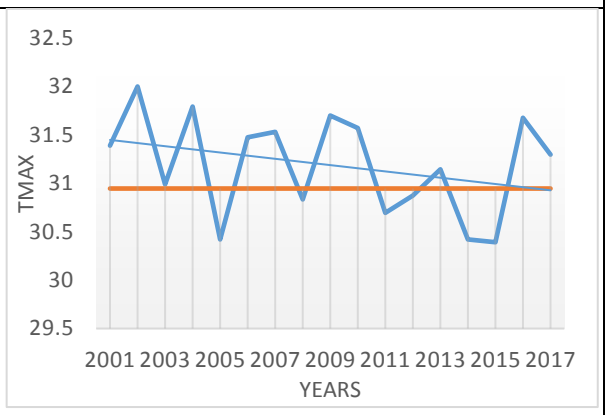

Sargodha



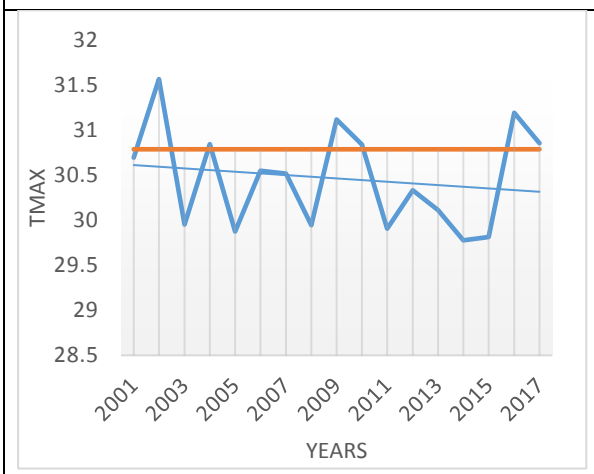

Jhelum



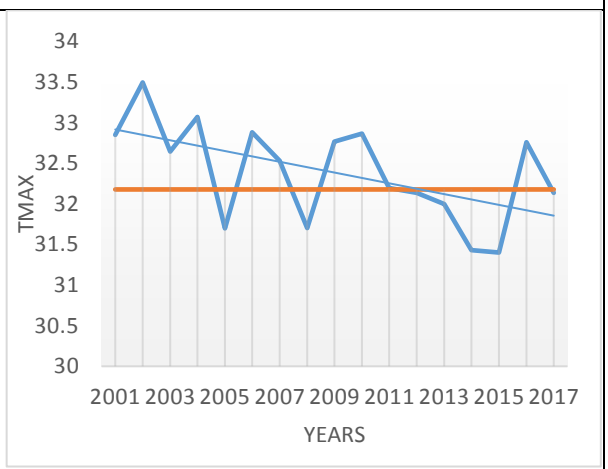

Sialkot



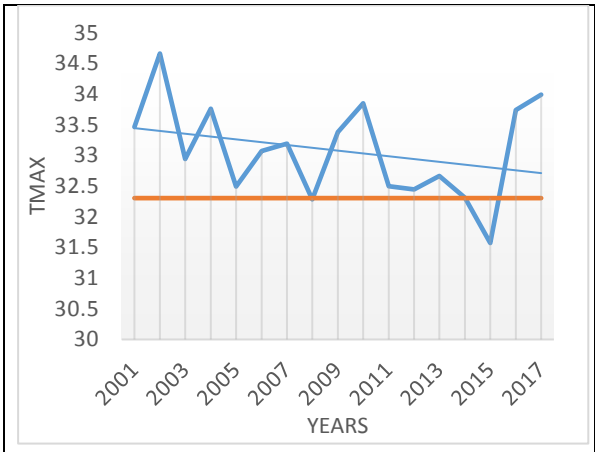

Faisalabad



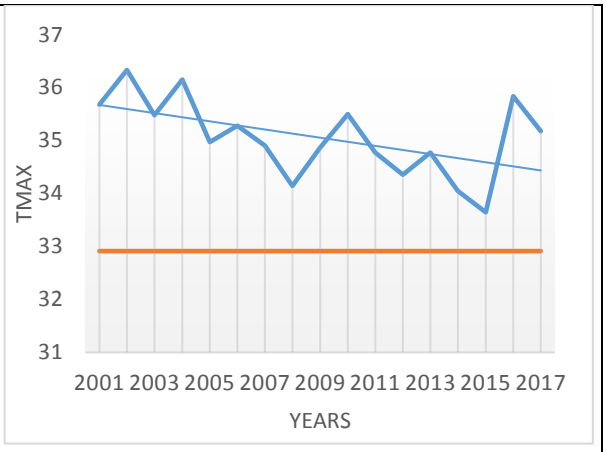

Lahore




Multan

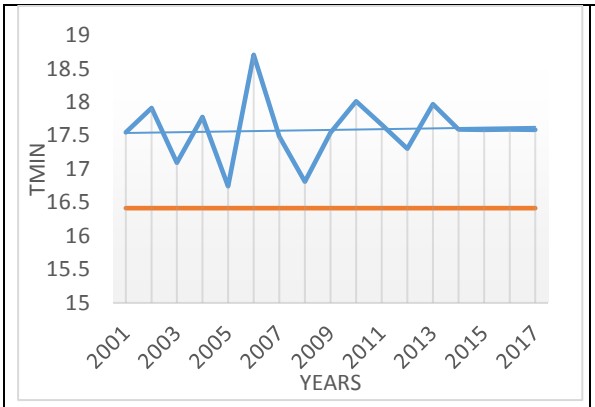



Bahawalnagar

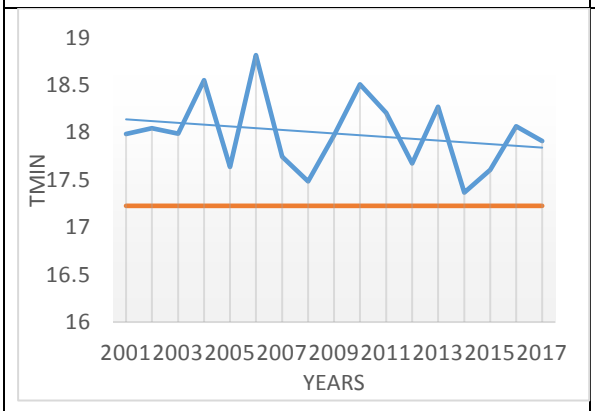



Bahawalpur

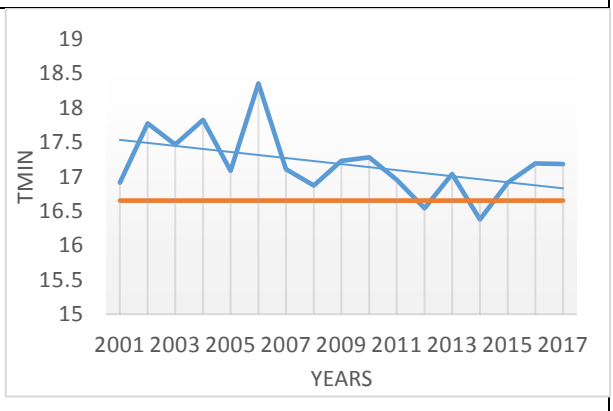
*Figure 3.2: Comparison of maximum temperature in baseline (1971-2000) and 2001-2017. Brown line represents baseline (1971-2000) and blue curve shows variability in max temperature from 2001-2017.*



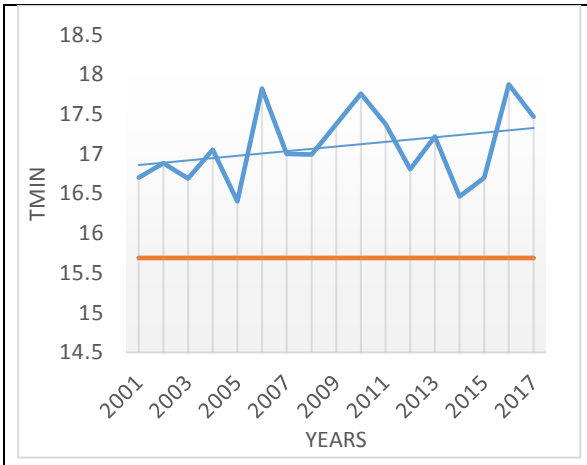

Mianwali



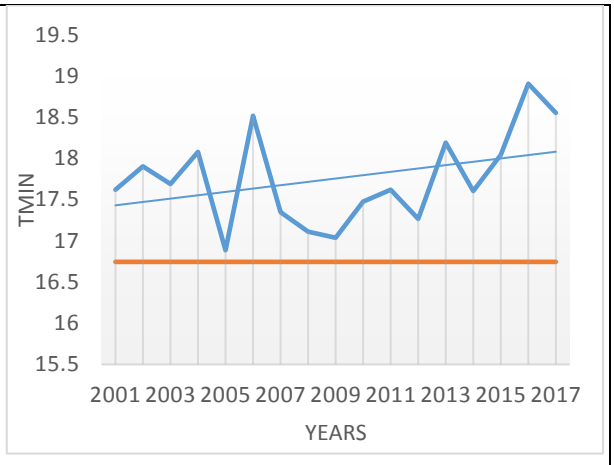

Sargodha



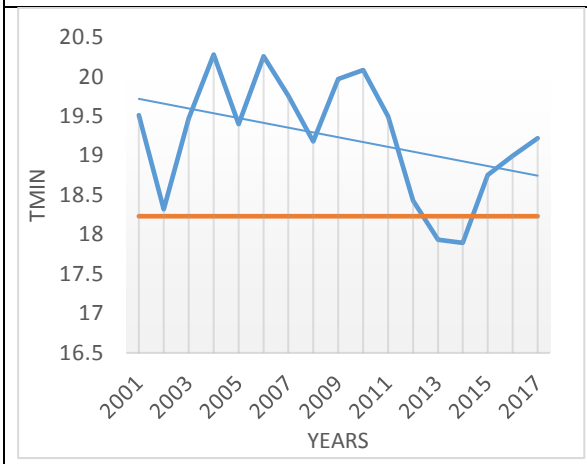

Jhelum



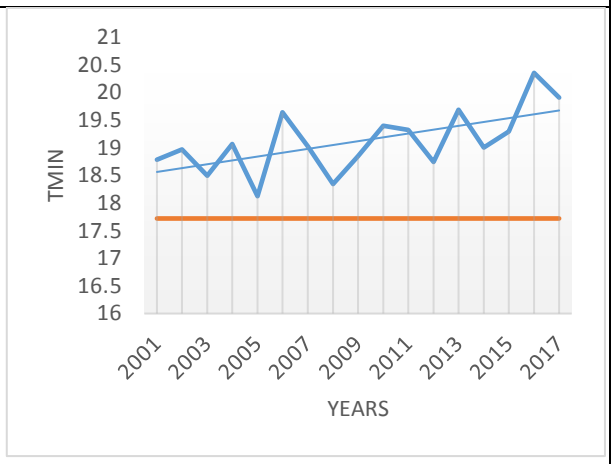

Sialkot



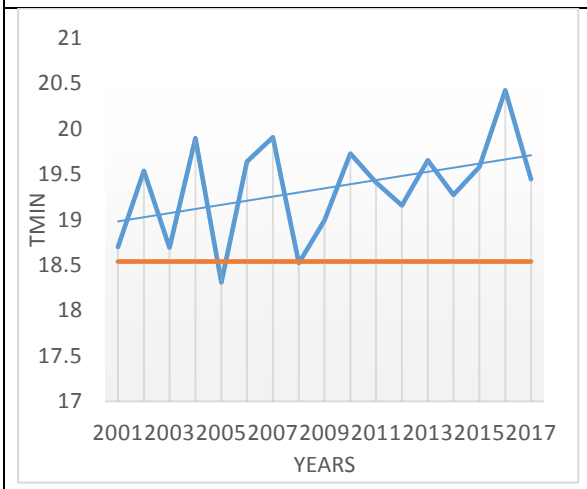

Faisalabad



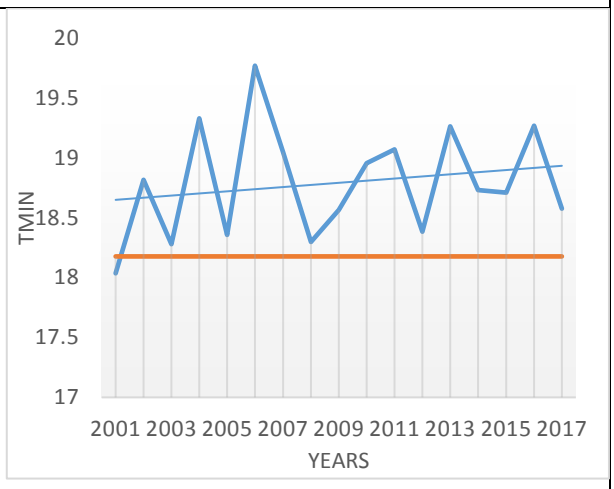

Lahore




Multan




Bahawalnagar




Bahawalpur

*Figure 3.3: Comparison of minimum temperature in baseline (1971-2000) and 2001-2017. Brown line represents baseline (1971-2000) and blue curve shows variability in min temperature from 2001-2017.*

Table3.1 (a): Annual changes in daily precipitation

| Stations | Average of 1971-2000 | Average of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mianwali | 1.49 | 1.54 | 1.25 | 0.84 | 1.47 | 1.30 | 1.92 | 1.15 | 2.10 | 2.29 | 1.46 | 2.70 | 1.48 | 1.36 | 2.29 | 0.92 | 1.23 | 1.21 | 1.22 |
| Sargodha | 1.02 | 1.47 | 1.66 | 1.43 | 1.17 | 1.00 | 1.75 | 1.30 | 1.89 | 1.54 | 0.76 | 1.42 | 2.01 | 1.01 | 1.17 | 1.48 | 1.58 | 2.09 | 1.84 |
| Jhelum | 2.51 | 2.20 | 2.03 | 1.45 | 2.65 | 2.32 | 1.80 | 3.34 | 2.29 | 2.12 | 1.48 | 2.16 | 2.06 | 1.39 | 2.54 | 2.57 | 2.77 | 1.77 | 2.70 |
| Sialkot | 2.76 | 2.52 | 2.16 | 1.48 | 4.38 | 2.47 | 1.71 | 2.35 | 2.43 | 2.47 | 1.59 | 2.78 | 2.33 | 2.06 | 3.82 | 3.60 | 3.08 | 1.30 | 2.87 |
| Faisalabad | 1.02 | 1.16 | 0.88 | 0.75 | 1.13 | 1.03 | 1.42 | 1.12 | 0.94 | 1.75 | 1.03 | 1.47 | 1.50 | 1.00 | 1.05 | 1.33 | 1.39 | 1.17 | 0.90 |
| Lahore | 1.86 | 1.68 | 1.46 | 1.21 | 1.72 | 1.34 | 1.78 | 2.04 | 1.83 | 1.65 | 1.01 | 1.47 | 2.34 | 1.59 | 2.46 | 2.17 | 2.34 | 0.50 | 1.72 |
| Multan | 0.56 | 0.69 | 0.81 | 0.28 | 0.44 | 0.51 | 0.83 | 0.39 | 0.74 | 0.44 | 0.32 | 0.77 | 0.51 | 0.66 | 0.63 | 0.71 | 0.95 | 2.14 | 0.65 |
| B-nagar | 0.66 | 0.73 | 0.77 | 0.28 | 0.91 | 0.48 | 0.58 | 0.51 | 0.88 | 0.61 | 0.66 | 0.52 | 1.39 | 0.86 | 0.90 | 0.74 | 1.34 | 0.57 | 0.47 |
| B-pur | 0.47 | 0.50 | 0.49 | 0.11 | 0.50 | 0.55 | 0.46 | 0.63 | 0.48 | 0.40 | 0.61 | 0.46 | 0.50 | 0.42 | 0.29 | 0.29 | 1.55 | 0.26 | 0.61 |

Table 3.1(b): Annual changes in Maximum Temperature

| Stations | Average of 1971-2000 | Average of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mianwali | 31.45 | 31.35 | 32.22 | 32.52 | 31.06 | 32.00 | 30.62 | 31.79 | 31.30 | 30.67 | 31.80 | 31.74 | 31.34 | 30.93 | 30.86 | 30.79 | 30.75 | 31.48 | 31.12 |
| Sargodha | 31.43 | 31.19 | 31.77 | 32.29 | 31.15 | 32.34 | 30.77 | 31.74 | 31.26 | 31.03 | 32.22 | 31.75 | 31.14 | 31.06 | 30.80 | 29.87 | 29.68 | 31.08 | 30.36 |
| Jhelum | 30.46 | 30.87 | 31.68 | 31.85 | 30.16 | 31.39 | 30.26 | 30.95 | 30.53 | 29.92 | 31.45 | 31.48 | 30.79 | 31.15 | 30.72 | 30.08 | 29.93 | 31.44 | 31.11 |
| Sialkot | 28.86 | 29.60 | 29.89 | 30.61 | 28.97 | 30.07 | 29.13 | 29.94 | 29.62 | 29.25 | 30.42 | 30.34 | 29.25 | 29.37 | 28.99 | 28.64 | 28.85 | 30.14 | 29.72 |
| Faisalabad | 30.95 | 31.80 | 31.39 | 32.00 | 30.99 | 31.79 | 30.42 | 31.48 | 31.53 | 30.84 | 31.70 | 31.57 | 30.70 | 30.87 | 31.15 | 30.42 | 30.39 | 31.68 | 31.30 |
| Lahore | 30.79 | 30.46 | 30.69 | 31.56 | 29.95 | 30.84 | 29.87 | 30.55 | 30.52 | 29.94 | 31.11 | 30.84 | 29.90 | 30.33 | 30.11 | 29.78 | 29.81 | 31.19 | 30.85 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Multan | 32.18 | 32.38 | 32.85 | 33.50 | 32.64 | 33.07 | 31.70 | 32.88 | 32.53 | 31.70 | 32.77 | 32.86 | 32.20 | 32.14 | 32.00 | 31.43 | 31.40 | 32.76 | 32.14 |
| B-nagar | 32.31 | 33.07 | 33.47 | 34.66 | 32.94 | 33.77 | 32.49 | 33.08 | 33.20 | 32.28 | 33.38 | 33.85 | 32.50 | 32.45 | 32.67 | 32.31 | 31.57 | 33.74 | 33.99 |
| B-pur | 32.91 | 35.05 | 33.73 | 34.36 | 33.54 | 34.16 | 32.68 | 33.54 | 33.08 | 32.09 | 33.06 | 33.39 | 32.67 | 32.28 | 32.75 | 32.12 | 31.73 | 33.79 | 33.23 |

Table 3.1 (c): Annual changes in Minimum Temperature

| Stations | Average of 1971-2000 | Average of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mianwali | 16.42 | 17.09 | 17.55 | 17.91 | 17.10 | 17.78 | 16.74 | 18.71 | 17.49 | 16.81 | 17.55 | 18.02 | 17.66 | 17.31 | 17.97 | 17.59 | 17.59 | 17.59 | 17.59 |
| Sargodha | 17.23 | 17.98 | 17.98 | 18.04 | 17.99 | 18.55 | 17.64 | 18.82 | 17.74 | 17.49 | 17.97 | 18.51 | 18.21 | 17.67 | 18.27 | 17.37 | 17.61 | 18.06 | 17.91 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jhelum | 16.65 | 17.18 | 16.91 | 17.77 | 17.47 | 17.82 | 17.08 | 18.35 | 17.11 | 16.87 | 17.23 | 17.28 | 16.96 | 16.54 | 17.04 | 16.38 | 16.91 | 17.19 | 17.18 |
| Sialkot | 15.69 | 17.09 | 16.70 | 16.88 | 16.69 | 17.05 | 16.40 | 17.82 | 17.00 | 16.99 | 17.38 | 17.76 | 17.38 | 16.81 | 17.22 | 16.46 | 16.70 | 17.87 | 17.47 |
| Faisalabad | 16.74 | 17.75 | 17.62 | 17.90 | 17.69 | 18.08 | 16.89 | 18.52 | 17.35 | 17.11 | 17.04 | 17.48 | 17.62 | 17.27 | 18.19 | 17.60 | 18.04 | 18.91 | 18.55 |
| Lahore | 18.23 | 19.23 | 19.51 | 18.32 | 19.47 | 20.28 | 19.40 | 20.26 | 19.76 | 19.18 | 19.97 | 20.08 | 19.50 | 18.43 | 17.93 | 17.89 | 18.75 | 19.00 | 19.22 |
| Multan | 17.72 | 19.11 | 18.78 | 18.97 | 18.50 | 19.07 | 18.12 | 19.64 | 19.03 | 18.34 | 18.85 | 19.40 | 19.32 | 18.74 | 19.69 | 19.01 | 19.29 | 20.36 | 19.91 |
| B-nagar | 18.54 | 19.34 | 18.70 | 19.54 | 18.69 | 19.89 | 18.31 | 19.64 | 19.91 | 18.52 | 18.99 | 19.72 | 19.41 | 19.16 | 19.65 | 19.27 | 19.58 | 20.42 | 19.44 |
| B-pur | 18.18 | 18.78 | 18.04 | 18.82 | 18.28 | 19.33 | 18.35 | 19.77 | 19.04 | 18.30 | 18.56 | 18.95 | 19.07 | 18.38 | 19.26 | 18.73 | 18.71 | 19.27 | 18.58 |

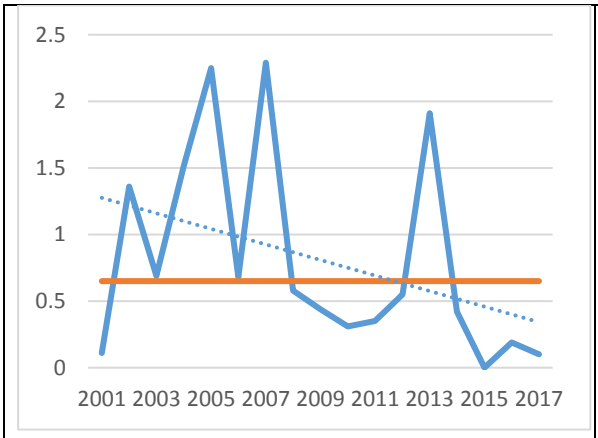
## 3.2. Observed Seasonal Changes

With respect to observed seasonal variations, precipitation in DJF is higher in all cities in 2003 and 2005 than the baseline DJF precipitation and in the other years mostly the baseline is higher (Fig. 3.4, Table 3.2a). Total precipitation in DJF from 2001 to 2017, is observed to be greater than baseline in Mianwali, Sargodha, Faisalabad, Multan, Bahawalnagar and Bahawalpur. Among all the regions, Mianwali gets 0.16 mm increase while cities in south Punjab i.e. Multan, Bahwalnagr and Bahawalpur have approximately the same increase in mm. In comparison of individual years from 2001 to 20017 with baseline, it has been noted that from 2003 to 2007 and in 2013 overall the cities have greater precipitation than baseline. Precipitation decreases in North Punjab for MAM during the averaged 2001-2017 than baseline while Bahawalnagar have same precipitation. In annual MAM precipitation as compared to baseline MAM, most of the stations doesn't show higher MAM precipitation with reference to baseline except for the years (2014 and 2015) (Table 3.3a). JJA precipitation have not shown a prominent increase compared to baseline. In most of the years, JJA precipitation less than baseline have been observed across all stations which indicate that monsoon precipitation has decreased compared to baseline (Fig. 3.7, Table 3.4a). In JJA in comparison of precipitation in 2001-2017 with baseline, the total precipitation increases in Mianwali, Sargodha, Faisalabad, Multan and Bahawalpur. But among these the greater increase of about 1.08 mm is observed in Sargodha station. While in comparison of yearly JJA precipitation, most of the years have less precipitation than baseline. But in those years which have greater precipitation than baseline, Mianwali gets the highest increase of 5.67 mm in 2010 and Multan of 5.19 mm during 2016.

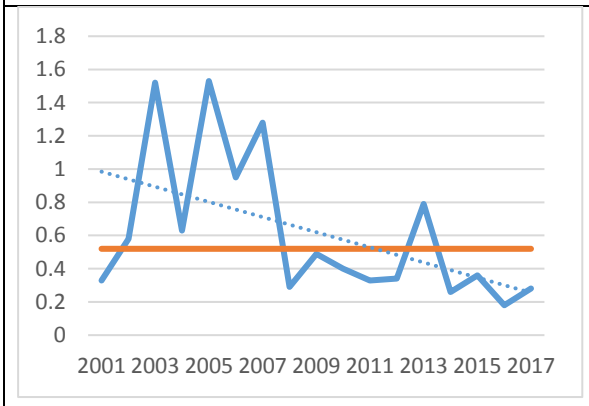
In DJF, maximum temperature during 2001- 2017 shows higher degree of warming only in Jhelum, Sialkot, Multan and Bahawalnagar compared to baseline. But in yearly comparison the years in which all cities have greater temperature increase than baseline in 2001, 2002, 2004, 2006, 2009, 2016 and 2017. While other than these years, mixed variations are shown. Jhelum show average temperature similar to baseline in 2014. Overall the increase by all cities in 2016 is greater than the increase in 2017 in DJF. Maximum temperature in MAM is greater in 2001-2017 than baseline over all the cities. In this season, nearly all years have greater MAM maximum temperature as compared to baseline. None of the regions except Faisalabad

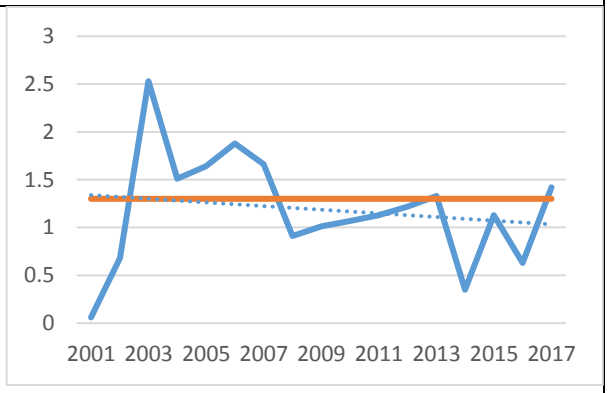
have shown greater MAM seasonal maximum temperature increase in 2005, 2014 and 2015. In case of maximum temperature, Jhelum and Sialkot have shown maximum increase in JJA as compared to baseline (Fig. 3.8) while in Faisalabad it is same. All cities in 2002, 2003, 2009 and 2012 have higher temperature than baseline while remaining years have mixed behaviour. In seasonal variations of SON, Sialkot, Bahawalpur and Bahawalnagar have maximum increase in maximum temperature in all years while other regions have higher increase mostly in 2001 and 2005(Table 3.2b, 3.3b, 3.4b, 3.5b).

Average minimum annual seasonal temperature in almost all cities show higher seasonal increase than the past 30 years average minimum seasonal temperature. In DJF, there is a greater increasing trend in the average minimum temperature from 2001-2017 than baseline in all cities. The highest increase of 4.25˚C is observed in Multan, whereas Mianwali and Lahore have approximately the same increase of 2.77 ˚C and 2.76 ˚C respectively. In comparison of annual DJF min temp to the DJF min temp of baseline, with exception of 2008 in Bahawalnagar, 2013 in Faisalabad all the years in all the cities have greater temperature than baseline. In DJF, 5.81 ˚C and 5.44 ˚C increase is observed in Multan during 2016 and 2017 respectively. Minimum temperature has observed to be increase in all the seasons across all the stations of Punjab (Fig 3.6 and 3.9).In JJA, all cities have greater temp in 2001-2017 with the highest increase of 0.99 ˚C observed in Sialkot. To compare annual with baseline it is noted that with exception of few years in overall cities, all the individual annual JJA min temperature is greater than baseline. This increase has also been observed in the average yearly minimum temperatures (Table 3.2c, 3.3c, 3.4c, 3.5c).

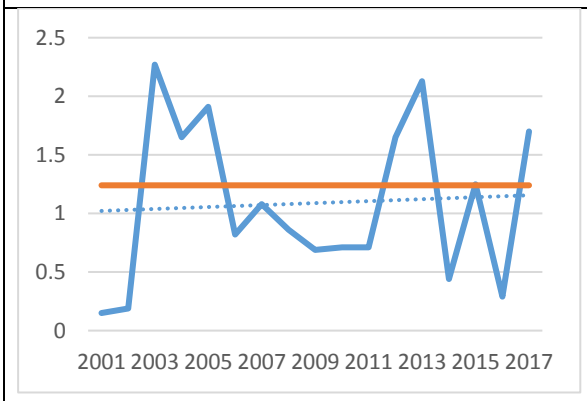



Mianwali

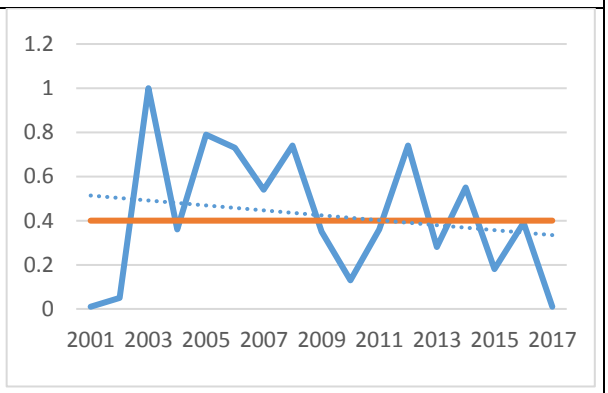


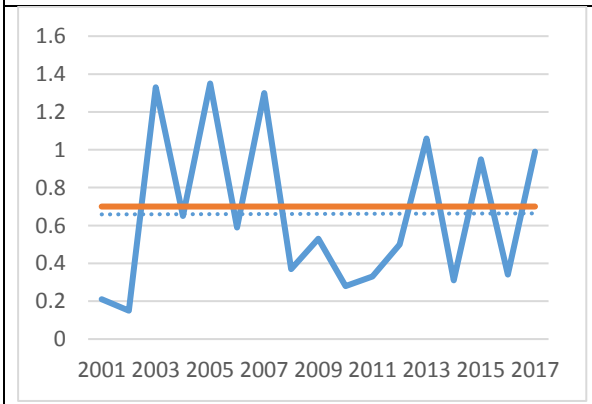

Sargodha



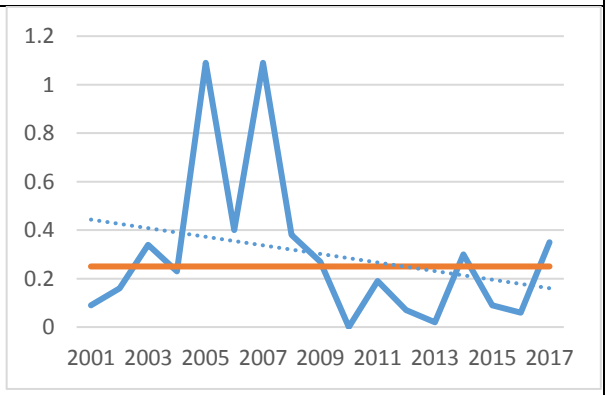

Jhelum




Sialkot




Faisalabad



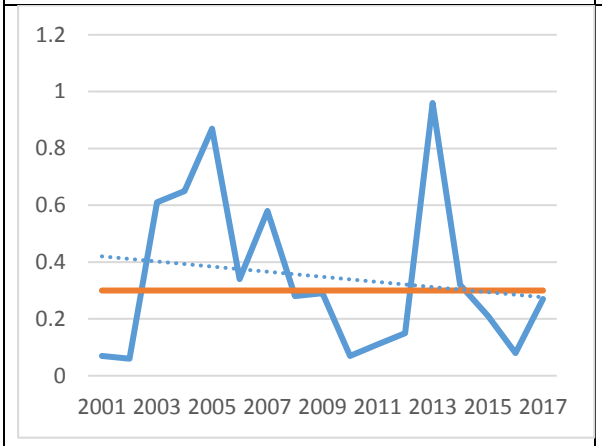
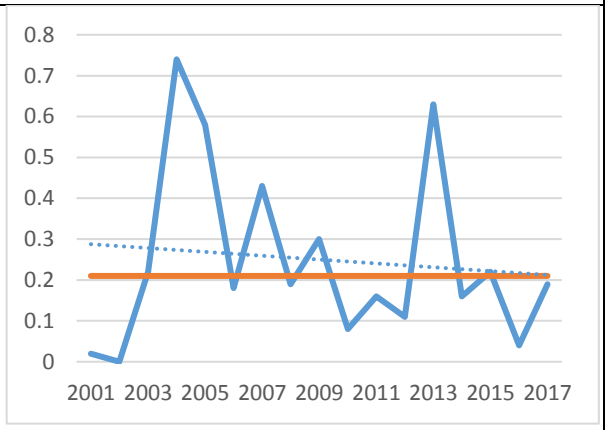
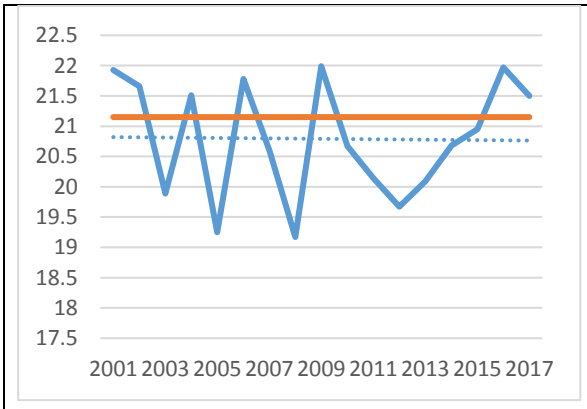
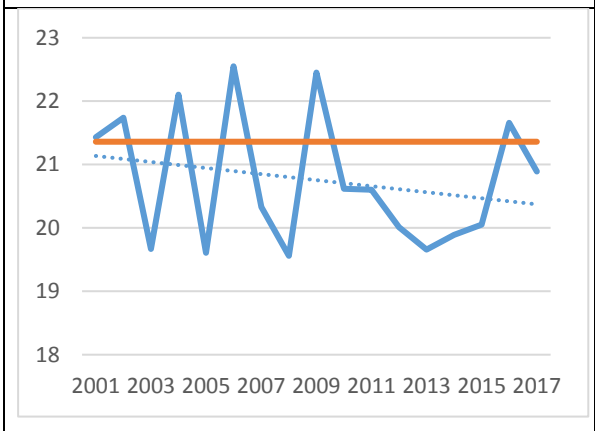
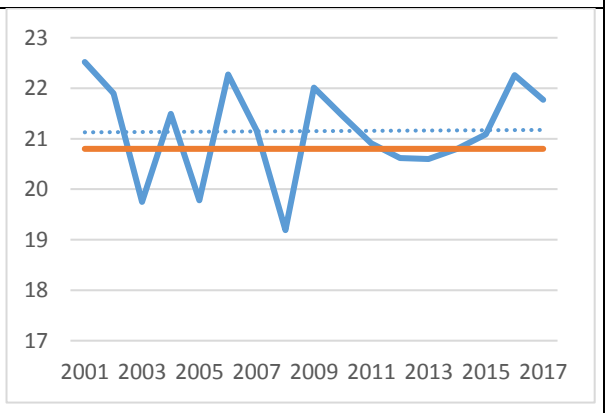
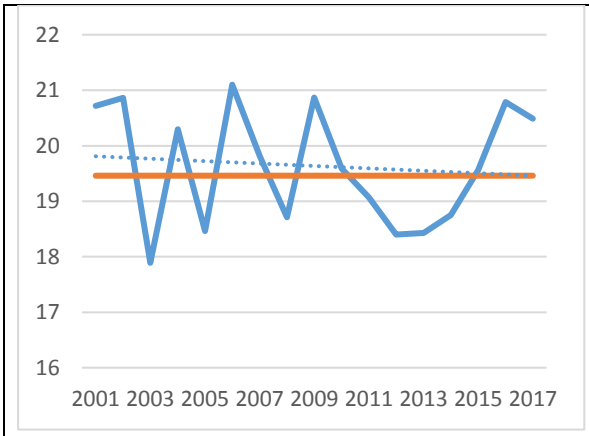
| Lahore | Multan |
|---|---|
|  |  |
| Bahawalnagar | Bahawalpur |

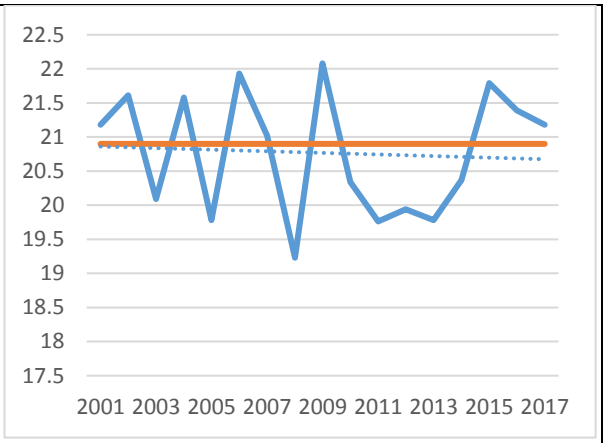


*Figure 3.1: Comparison of seasonal DJF precipitation in baseline (1971-2000) and 2001-2017. Brown line represents baseline (1971-2000) and blue curve shows variability in min temperature from 2001-2017.*

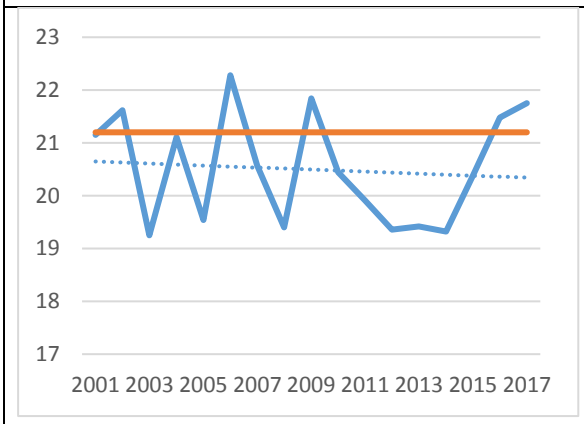
| | |
|---|---|
|  | |
| Mianwali | |
|  |  |
| Sargodha | Jhelum |



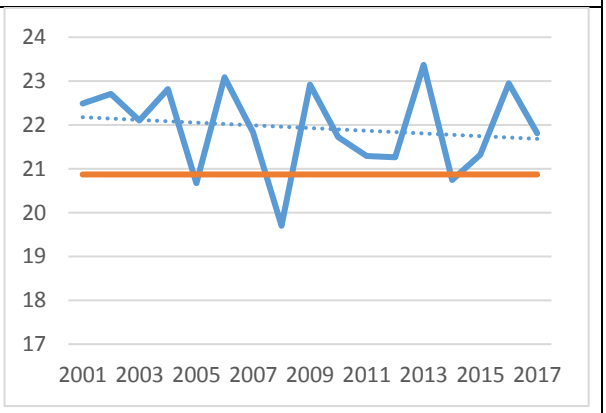

Sialkot



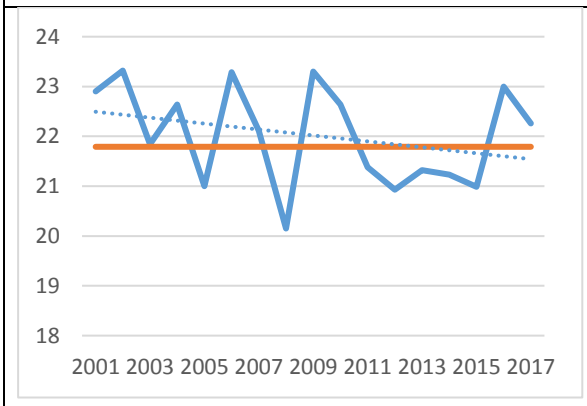

Faisalabad



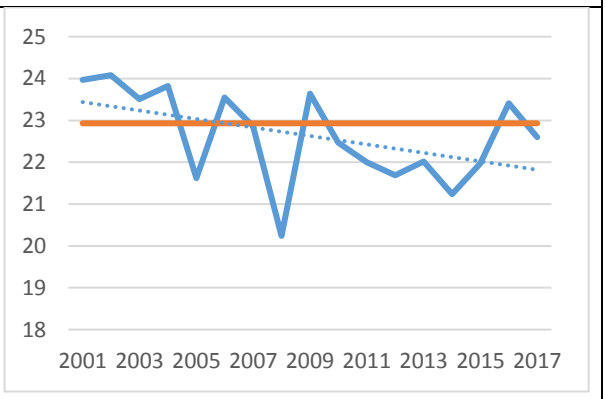

Lahore




Multan

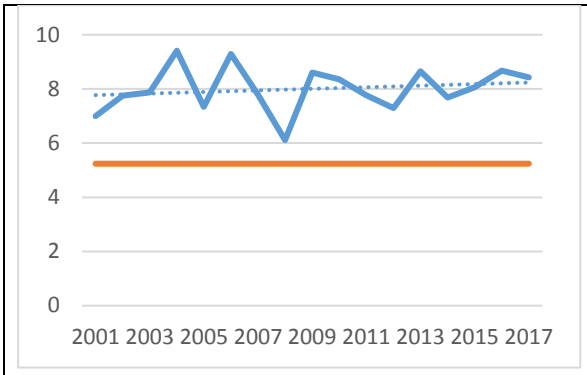



Bahawalnagar

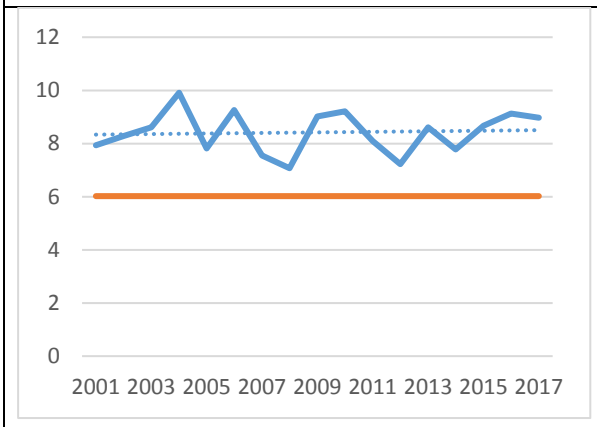



Bahawalpur

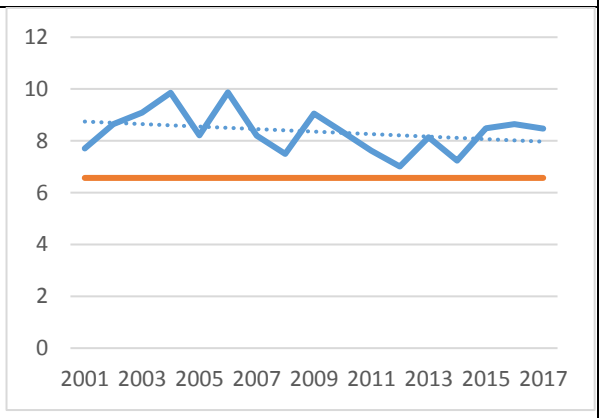
*Figure 3.2: Comparison of seasonal DJF maximum temperature in baseline (1971-2000) and 2001-2017. Brown line represents baseline (1971-2000) and blue curve shows variability in min temperature from 2001-2017.*



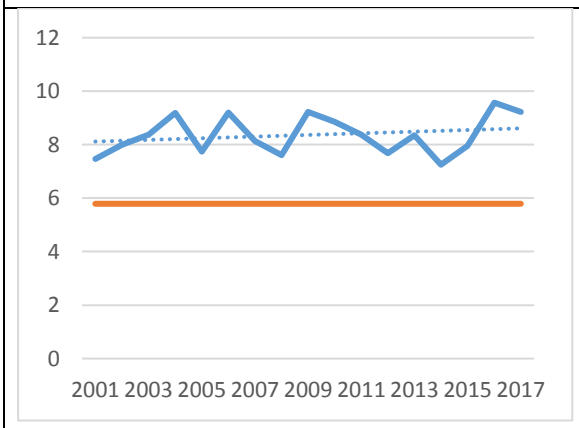

Mianwali



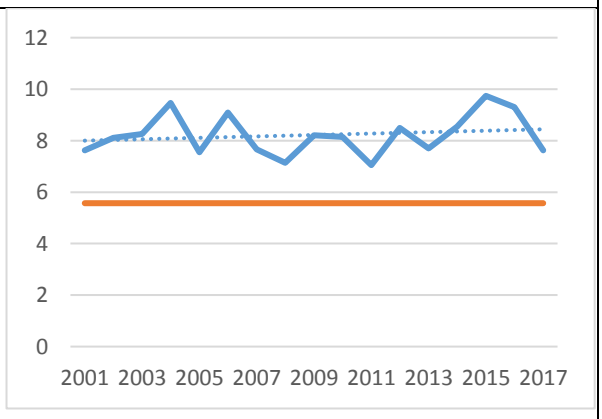

Sargodha



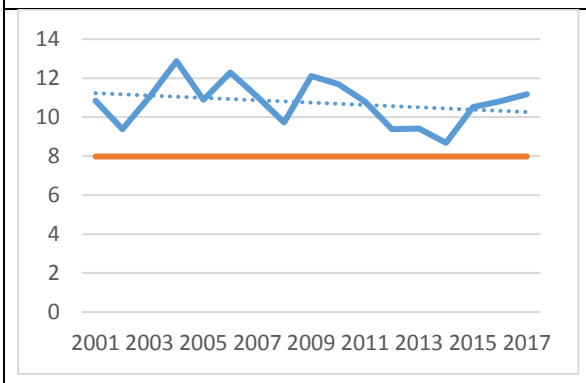

Jhelum



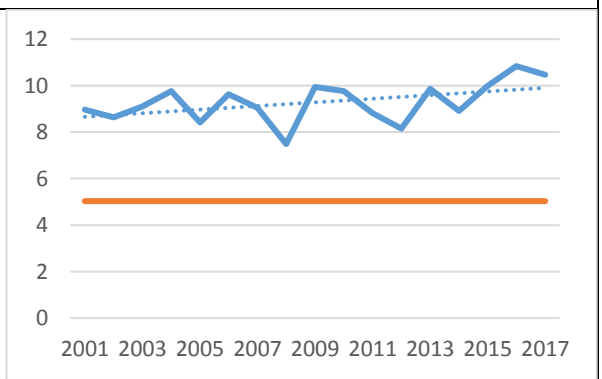

Sialkot



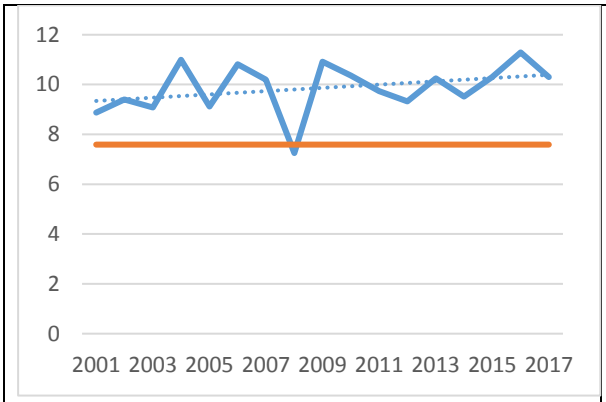

Faisalabad



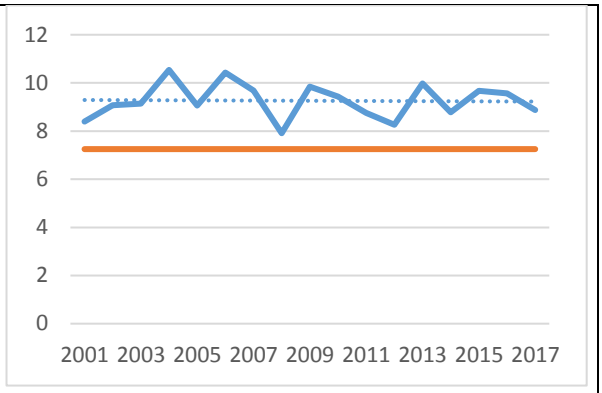

Lahore




Multan

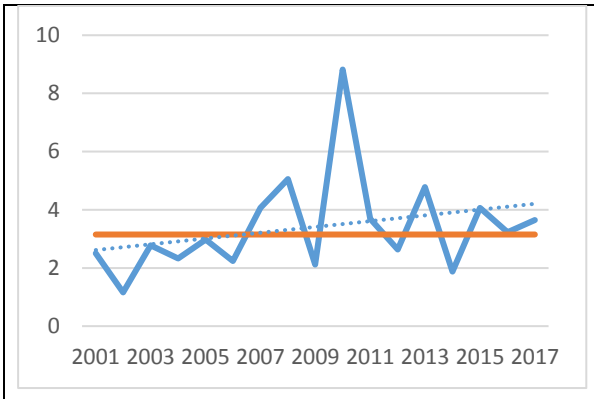



Bahawalnagar

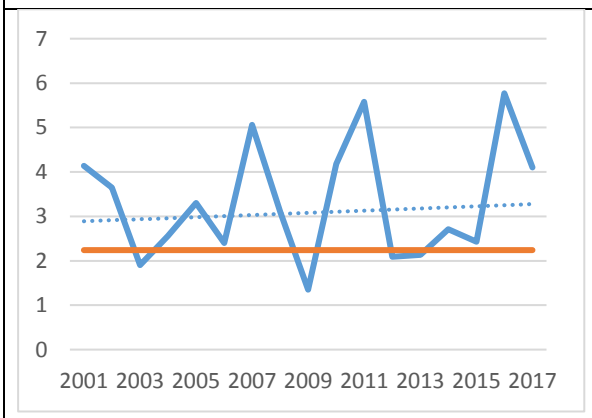



Bahawalpur

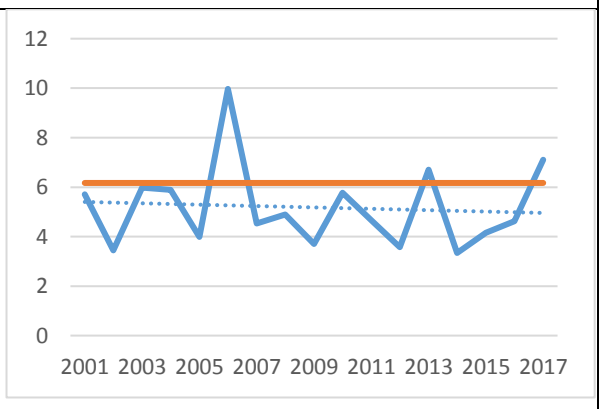
*Figure 3.3: Comparison of seasonal DJF minimum temperature in baseline (1971-2000) and 2001-2017. Brown line represents baseline (1971-2000) and blue curve shows variability in min temperature from 2001-2017.*



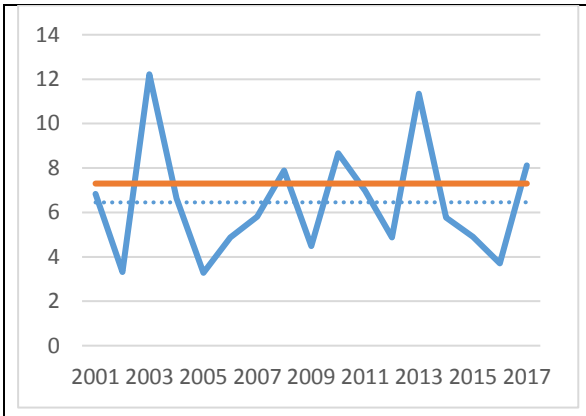

Mianwali



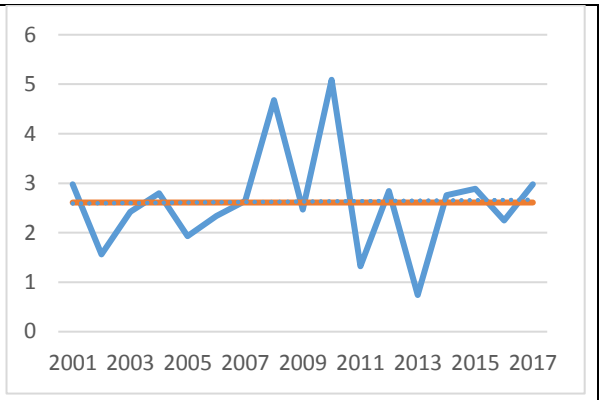

Sargodha



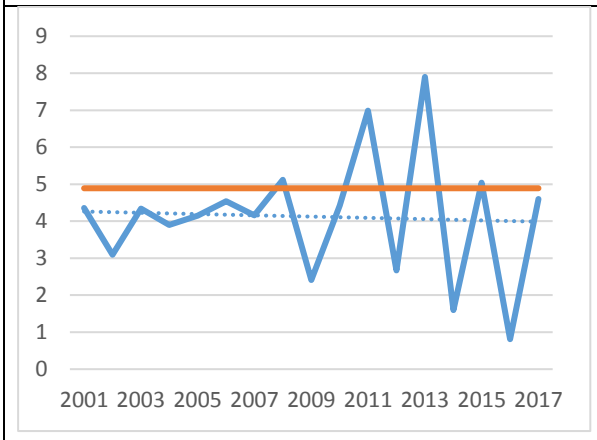

Jhelum



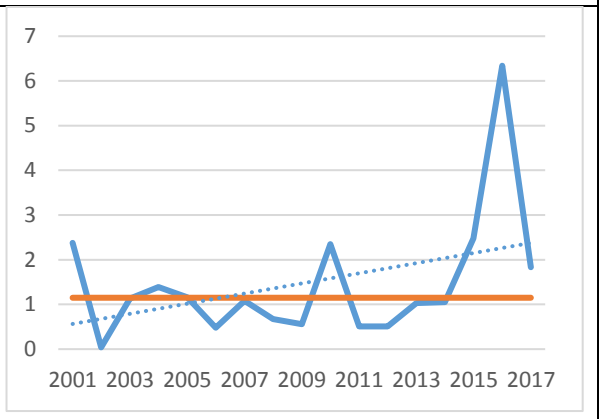

Sialkot



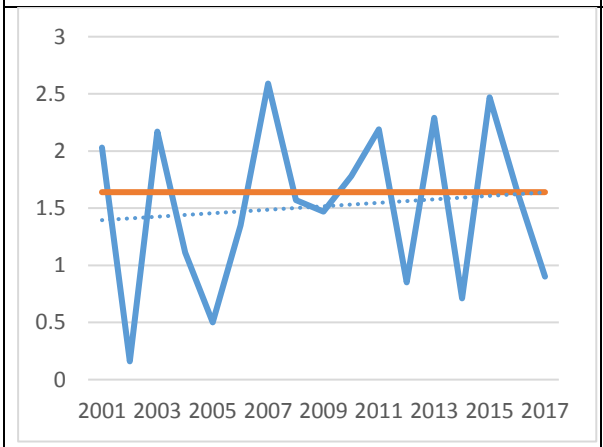

Faisalabad



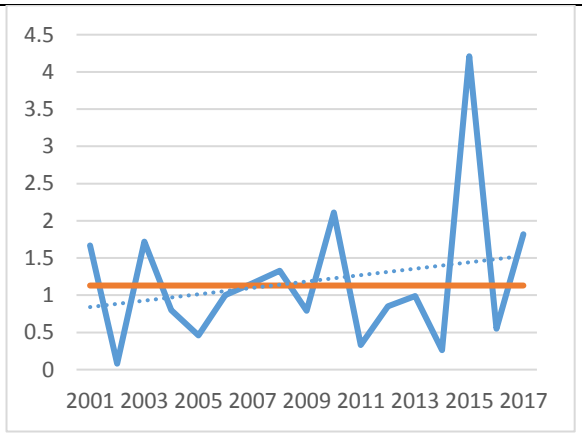

Lahore




Multan

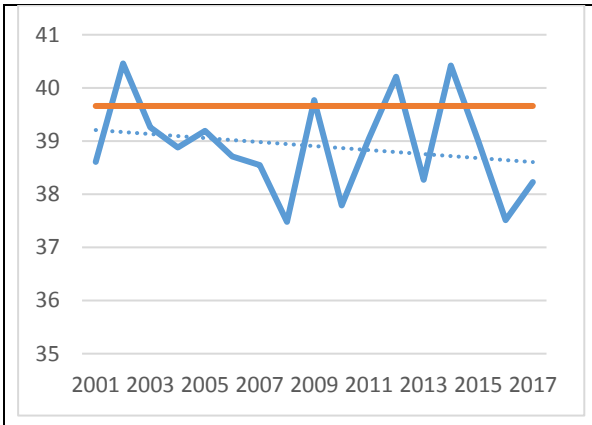



Bahawalnagar

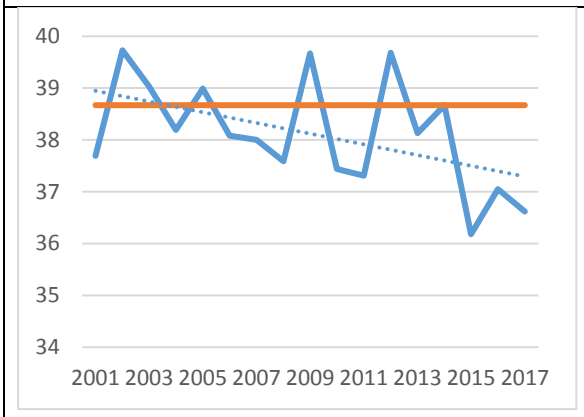



Bahawalpur

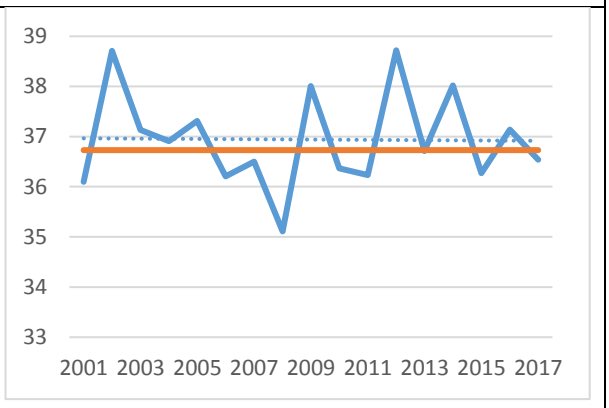
*Figure 3.4: Comparison of seasonal JJA precipitation in baseline (1971-2000) and 2001-2017. Brown line represents baseline (1971-2000) and blue curve shows variability in min temperature from 2001-2017.*



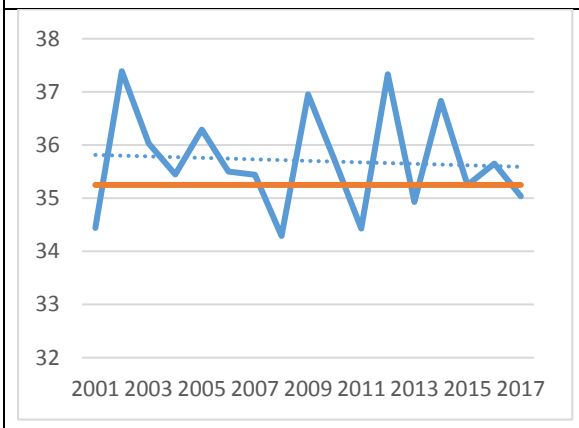

Mianwali



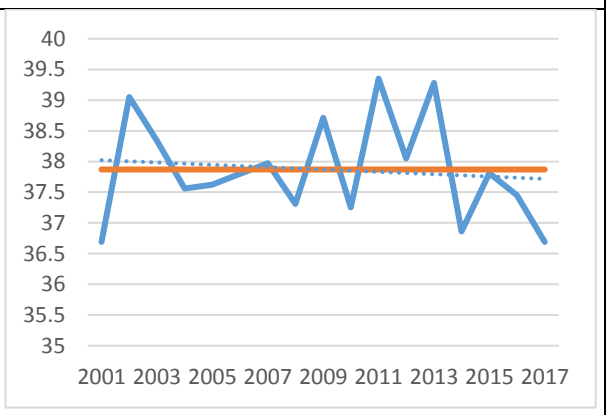

Sargodha



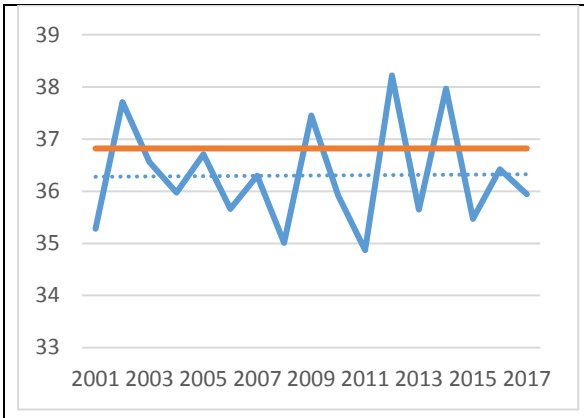

Jhelum



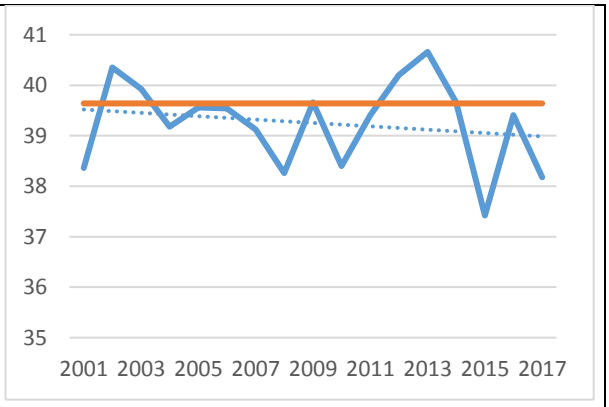

Sialkot



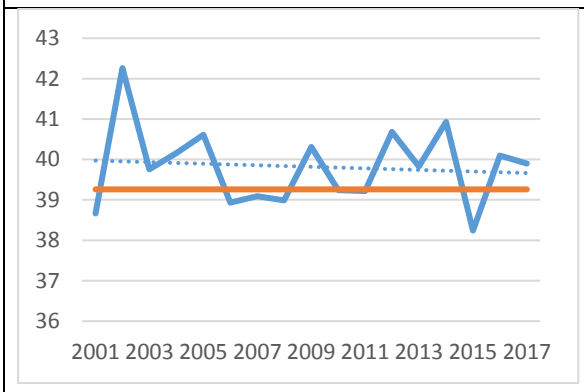

Faisalabad



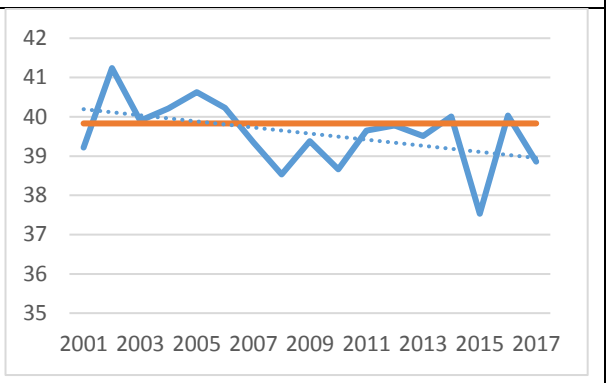

Lahore




Multan

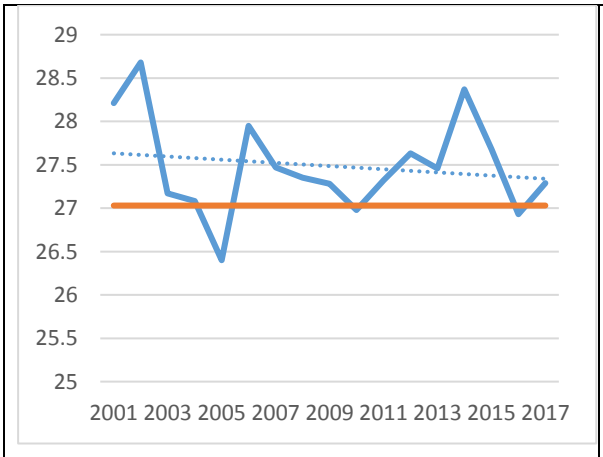



Bahawalnagar

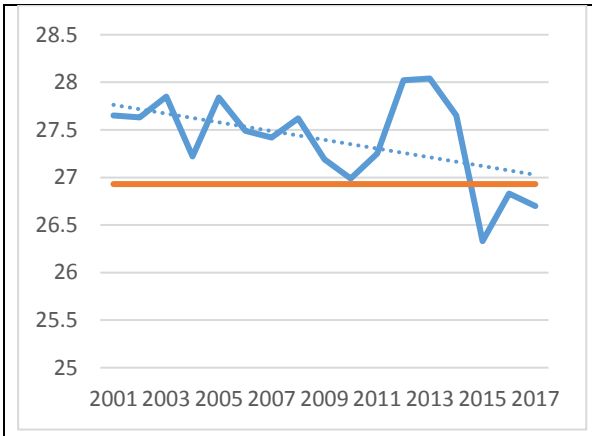


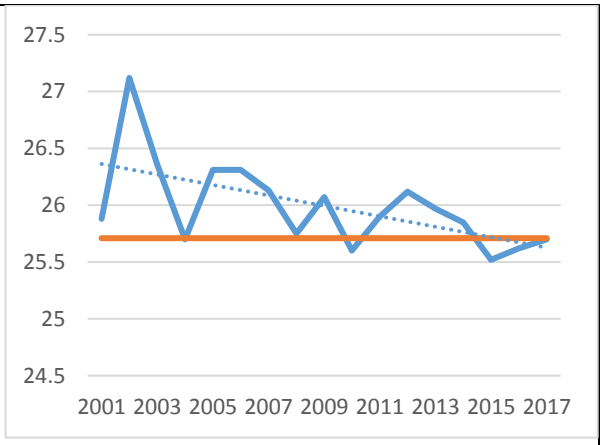

Bahawalpur

*Figure 3.5: Comparison of seasonal JJA maximum temperature in baseline (1971-2000) and 2001-2017. Brown line represents baseline (1971-2000) and blue curve shows variability in min temperature from 2001-2017.*

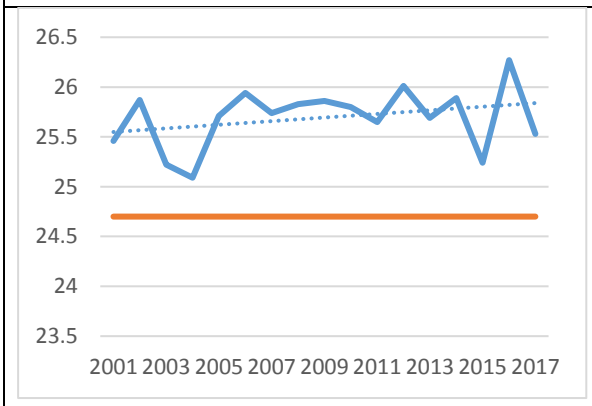



Mianwali

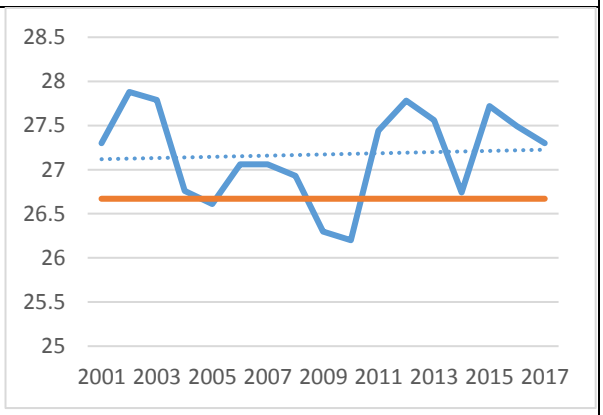


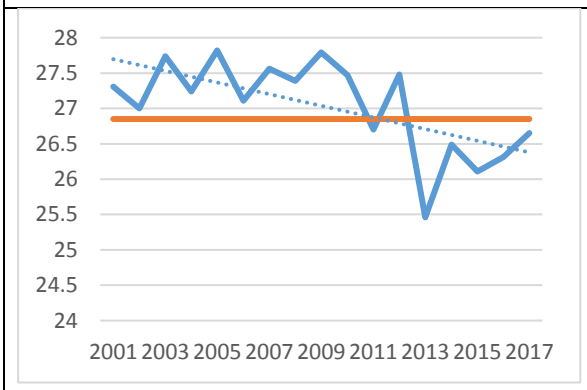

Sargodha



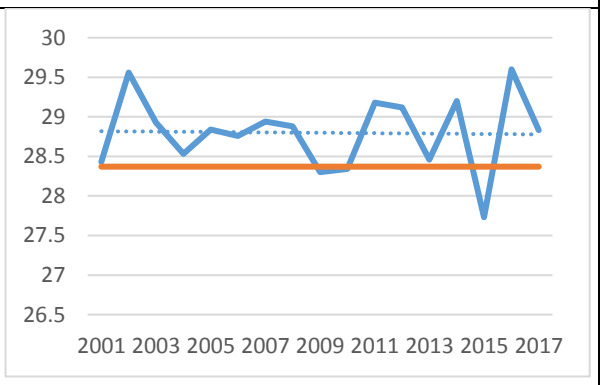

Jhelum



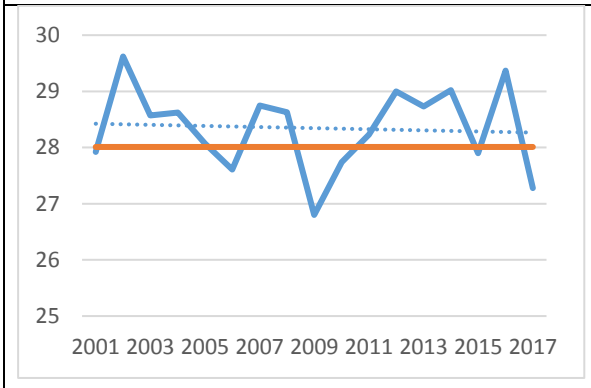

Sialkot



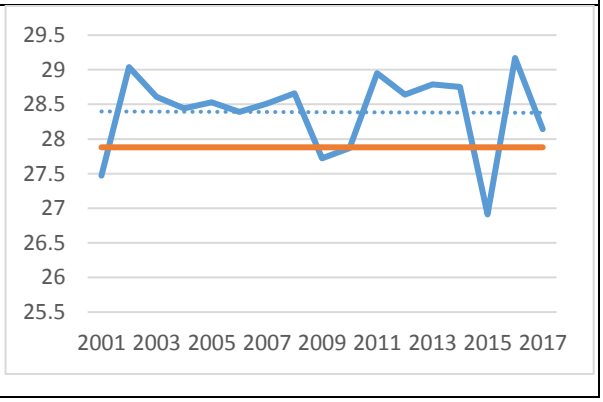

Faisalabad




Lahore




Multan



| Bahawalnagar | Bahawalpur |
|---|---|

*Figure 3.6: Comparison of seasonal JJA minimum temperature in baseline (1971-2000) and 2001-2017. Brown line represents baseline (1971-2000) and blue curve shows variability in min temperature from 2001-2017.*

Table 3.2 (a) Seasonal changes in DJF Precipitation

| Station | Avg of 1971-2000 | Avg of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mainwali | 0.65 | 0.81 | 0.11 | 1.36 | 0.69 | 1.52 | 2.25 | 0.68 | 2.29 | 0.58 | 0.44 | 0.31 | 0.35 | 0.55 | 1.91 | 0.42 | 0.00 | 0.19 | 0.10 |
| Sargodha | 0.52 | 0.62 | 0.33 | 0.58 | 1.52 | 0.63 | 1.53 | 0.95 | 1.28 | 0.29 | 0.49 | 0.40 | 0.33 | 0.34 | 0.79 | 0.26 | 0.36 | 0.18 | 0.28 |
| Jhelum | 1.30 | 1.19 | 0.06 | 0.68 | 2.53 | 1.51 | 1.64 | 1.88 | 1.66 | 0.91 | 1.01 | 1.07 | 1.13 | 1.22 | 1.33 | 0.35 | 1.13 | 0.63 | 1.42 |
| Sialkot | 1.24 | 1.09 | 0.15 | 0.19 | 2.27 | 1.65 | 1.91 | 0.82 | 1.08 | 0.86 | 0.69 | 0.71 | 0.71 | 1.65 | 2.13 | 0.44 | 1.25 | 0.29 | 1.70 |
| Faisalabad | 0.40 | 0.42 | 0.01 | 0.05 | 1.00 | 0.36 | 0.79 | 0.73 | 0.54 | 0.74 | 0.35 | 0.13 | 0.36 | 0.74 | 0.28 | 0.55 | 0.18 | 0.39 | 0.01 |
| Lahore | 0.70 | 0.66 | 0.21 | 0.15 | 1.33 | 0.65 | 1.35 | 0.59 | 1.30 | 0.37 | 0.53 | 0.28 | 0.33 | 0.50 | 1.06 | 0.31 | 0.95 | 0.34 | 0.99 |
| Multan | 0.25 | 0.30 | 0.09 | 0.16 | 0.34 | 0.23 | 1.09 | 0.40 | 1.09 | 0.38 | 0.27 | 0.00 | 0.19 | 0.07 | 0.02 | 0.30 | 0.09 | 0.06 | 0.35 |
| Bahawalnagar | 0.30 | 0.35 | 0.07 | 0.06 | 0.61 | 0.65 | 0.87 | 0.34 | 0.58 | 0.28 | 0.29 | 0.07 | 0.11 | 0.15 | 0.96 | 0.32 | 0.21 | 0.08 | 0.27 |
| Bahawalpur | 0.21 | 0.25 | 0.02 | 0.00 | 0.22 | 0.74 | 0.58 | 0.18 | 0.43 | 0.19 | 0.30 | 0.08 | 0.16 | 0.11 | 0.63 | 0.16 | 0.22 | 0.04 | 0.19 |

Table 3.2 (b) Seasonal changes in DJF Tmax

| Station | Avg of 1971-2000 | Avg of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mainwali | 21.15 | 20.79 | 21.93 | 21.66 | 19.89 | 21.51 | 19.25 | 21.78 | 20.60 | 19.17 | 21.99 | 20.67 | 20.14 | 19.67 | 20.09 | 20.68 | 20.95 | 21.97 | 21.50 |
| Sargodha | 21.36 | 20.75 | 21.43 | 21.74 | 19.67 | 22.10 | 19.61 | 22.55 | 20.33 | 19.56 | 22.45 | 20.62 | 20.60 | 20.01 | 19.66 | 19.89 | 20.05 | 21.66 | 20.89 |
| Jhelum | 20.80 | 21.15 | 22.52 | 21.90 | 19.75 | 21.49 | 19.78 | 22.27 | 21.16 | 19.19 | 22.01 | 21.45 | 20.91 | 20.62 | 20.60 | 20.80 | 21.09 | 22.26 | 21.77 |
| Sialkot | 19.46 | 19.64 | 20.72 | 20.86 | 17.89 | 20.30 | 18.46 | 21.10 | 19.81 | 18.71 | 20.87 | 19.59 | 19.07 | 18.40 | 18.43 | 18.75 | 19.56 | 20.79 | 20.49 |
| Faisalabad | 20.90 | 20.77 | 21.18 | 21.61 | 20.09 | 21.58 | 19.78 | 21.93 | 21.02 | 19.23 | 22.08 | 20.34 | 19.76 | 19.94 | 19.78 | 20.37 | 21.79 | 21.39 | 21.18 |
| Lahore | 21.20 | 20.52 | 21.15 | 21.62 | 19.25 | 21.11 | 19.54 | 22.28 | 20.57 | 19.40 | 21.84 | 20.44 | 19.91 | 19.36 | 19.42 | 19.32 | 20.38 | 21.48 | 21.75 |
| Multan | 20.87 | 21.93 | 22.49 | 22.71 | 22.10 | 22.82 | 20.67 | 23.09 | 21.83 | 19.70 | 22.92 | 21.72 | 21.29 | 21.26 | 23.37 | 20.74 | 21.32 | 22.95 | 21.81 |
| Bahawalnagar | 21.79 | 22.02 | 22.90 | 23.32 | 21.84 | 22.64 | 21.00 | 23.29 | 22.11 | 20.15 | 23.30 | 22.64 | 21.38 | 20.93 | 21.32 | 21.23 | 20.99 | 23.00 | 22.26 |
| Bahawalpur | 22.93 | 22.63 | 23.97 | 24.08 | 23.51 | 23.82 | 21.62 | 23.55 | 22.86 | 20.24 | 23.64 | 22.47 | 22.00 | 21.69 | 22.02 | 21.24 | 21.97 | 23.41 | 22.60 |

Table 3.2 (c) Seasonal changes in DJF Tmin

| Station | Avg of 1971-2000 | Avg of | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | 2001-2017 | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mainwali | 5.24 | 8.00 | 7.00 | 7.75 | 7.87 | 9.41 | 7.34 | 9.29 | 7.78 | 6.11 | 8.60 | 8.35 | 7.77 | 7.29 | 8.65 | 7.68 | 8.06 | 8.68 | 8.43 |
| Sargodha | 6.02 | 8.42 | 7.93 | 8.28 | 8.61 | 9.91 | 7.81 | 9.26 | 7.55 | 7.07 | 9.02 | 9.21 | 8.09 | 7.22 | 8.61 | 7.78 | 8.67 | 9.13 | 8.97 |
| Jhelum | 6.57 | 8.36 | 7.71 | 8.64 | 9.09 | 9.85 | 8.21 | 9.87 | 8.20 | 7.49 | 9.05 | 8.35 | 7.62 | 7.01 | 8.14 | 7.24 | 8.49 | 8.64 | 8.47 |
| Sialkot | 5.79 | 8.36 | 7.46 | 7.99 | 8.37 | 9.19 | 7.74 | 9.20 | 8.13 | 7.61 | 9.23 | 8.85 | 8.37 | 7.68 | 8.35 | 7.25 | 7.95 | 9.57 | 9.23 |
| Faisalabad | 5.57 | 8.22 | 7.63 | 8.11 | 8.26 | 9.47 | 7.55 | 9.09 | 7.66 | 7.14 | 8.21 | 8.15 | 7.05 | 8.50 | 7.70 | 8.55 | 9.74 | 9.30 | 7.63 |
| Lahore | 7.98 | 10.75 | 10.85 | 9.38 | 11.03 | 12.87 | 10.89 | 12.29 | 11.06 | 9.73 | 12.11 | 11.69 | 10.79 | 9.38 | 9.42 | 8.68 | 10.52 | 10.81 | 11.17 |
| Multan | 5.03 | 9.28 | 8.96 | 8.63 | 9.10 | 9.76 | 8.41 | 9.63 | 9.05 | 7.49 | 9.95 | 9.76 | 8.81 | 8.16 | 9.86 | 8.91 | 9.98 | 10.84 | 10.47 |
| Bahawalnagar | 7.59 | 9.87 | 8.88 | 9.40 | 9.08 | 11.00 | 9.12 | 10.82 | 10.20 | 7.25 | 10.92 | 10.36 | 9.73 | 9.33 | 10.25 | 9.52 | 10.30 | 11.29 | 10.30 |
| Bahawalpur | 7.25 | 9.26 | 8.40 | 9.07 | 9.14 | 10.54 | 9.06 | 10.43 | 9.69 | 7.91 | 9.84 | 9.43 | 8.75 | 8.26 | 9.98 | 8.78 | 9.67 | 9.56 | 8.87 |

Table 3.3 (a) Seasonal changes in MAM Precipitation

| Station | Avg of 1971-2000 | Avg of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mainwali | 1.42 | 1.15 | 1.59 | 0.49 | 1.67 | 0.79 | 2.01 | 1.19 | 1.18 | 1.93 | 2.06 | 0.39 | 0.41 | 0.71 | 2.04 | 1.02 | 0.10 | 1.33 | 0.72 |
| Sargodha | 0.81 | 1.15 | 1.25 | 0.50 | 0.67 | 0.38 | 1.46 | 1.08 | 0.86 | 2.35 | 0.96 | 0.26 | 0.59 | 0.24 | 1.14 | 1.18 | 2.15 | 2.33 | 2.23 |
| Jhelum | 1.43 | 1.33 | 1.22 | 0.58 | 0.73 | 1.14 | 1.00 | 0.63 | 2.15 | 1.70 | 0.82 | 0.89 | 0.70 | 0.42 | 0.76 | 3.34 | 3.49 | 1.68 | 1.42 |
| Sialkot | 1.17 | 1.18 | 1.15 | 0.76 | 1.05 | 0.79 | 1.00 | 0.59 | 2.06 | 0.48 | 0.51 | 0.74 | 0.74 | 1.11 | 0.35 | 1.64 | 4.79 | 1.06 | 1.17 |
| Faisalabad | 0.60 | 0.72 | 0.50 | 0.31 | 0.64 | 0.42 | 1.53 | 0.33 | 0.53 | 1.12 | 0.65 | 0.21 | 0.48 | 0.41 | 1.44 | 1.47 | 1.24 | 0.39 | 0.50 |
| Lahore | 0.88 | 0.78 | 0.71 | 1.00 | 0.86 | 0.59 | 0.84 | 0.69 | 0.91 | 0.82 | 0.85 | 0.16 | 0.32 | 0.66 | 0.30 | 1.39 | 1.92 | 0.69 | 0.62 |
| Multan | 0.48 | 0.54 | 0.07 | 0.59 | 0.08 | 0.19 | 0.88 | 0.63 | 0.39 | 0.62 | 0.40 | 0.58 | 0.37 | 0.26 | 1.03 | 1.20 | 1.00 | 0.75 | 0.22 |
| Bahawalnagar | 0.44 | 0.44 | 0.94 | 0.62 | 0.06 | 0.14 | 0.73 | 0.28 | 0.25 | 0.49 | 0.25 | 0.04 | 0.58 | 0.30 | 0.23 | 0.73 | 1.08 | 0.56 | 0.17 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bahawalpur | 0.26 | 0.28 | 0.28 | 0.02 | 0.07 | 0.03 | 0.34 | 0.55 | 0.46 | 0.39 | 0.21 | 0.20 | 0.16 | 0.19 | 0.07 | 0.47 | 0.77 | 0.44 | 0.13 |

Table 3.3 (b) Seasonal changes in MAM Tmax

| Station | Avg of 1971-2000 | Avg of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mainwali | 32.60 | 33.71 | 35.03 | 35.73 | 33.03 | 35.40 | 31.19 | 34.73 | 33.85 | 33.95 | 33.08 | 36.34 | 34.48 | 32.83 | 33.39 | 30.96 | 32.25 | 33.76 | 33.08 |
| Sargodha | 33.27 | 34.15 | 35.13 | 36.23 | 33.99 | 37.25 | 32.00 | 34.89 | 34.57 | 34.55 | 34.40 | 37.04 | 34.35 | 33.65 | 33.53 | 30.65 | 31.87 | 33.58 | 32.80 |
| Jhelum | 32.58 | 33.79 | 34.87 | 35.69 | 33.10 | 35.86 | 31.51 | 34.48 | 33.08 | 33.60 | 33.92 | 35.96 | 33.64 | 33.97 | 34.08 | 31.00 | 31.35 | 33.93 | 34.38 |
| Sialkot | 31.94 | 32.95 | 33.39 | 34.51 | 32.37 | 34.68 | 31.19 | 33.57 | 32.70 | 33.25 | 33.39 | 35.77 | 32.85 | 32.09 | 32.92 | 30.38 | 30.72 | 33.22 | 33.18 |
| Faisalabad | 33.03 | 34.30 | 34.64 | 35.86 | 33.69 | 36.40 | 32.11 | 34.64 | 34.41 | 34.44 | 34.22 | 36.81 | 33.48 | 34.21 | 31.97 | 32.57 | 34.14 | 34.95 | 34.64 |

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| Lahore | 33.25 | 33.95 | 34.21 | 35.89 | 33.10 | 35.52 | 32.03 | 33.98 | 33.91 | 33.98 | 33.82 | 36.22 | 33.58 | 33.29 | 34.12 | 31.70 | 32.47 | 34.72 | 34.58 |
| Multan | 34.88 | 35.33 | 36.80 | 37.42 | 35.72 | 38.00 | 33.53 | 36.36 | 35.82 | 35.66 | 35.48 | 38.20 | 35.34 | 35.09 | 28.28 | 33.23 | 34.22 | 35.16 | 36.28 |
| Bahawalnagar | 34.95 | 36.55 | 36.87 | 38.26 | 36.50 | 38.14 | 34.80 | 37.06 | 36.98 | 36.14 | 36.40 | 39.63 | 36.28 | 35.52 | 35.95 | 33.96 | 34.21 | 36.95 | 37.74 |
| Bahawalpur | 35.28 | 36.40 | 36.90 | 38.02 | 36.69 | 38.95 | 35.05 | 37.15 | 36.22 | 35.93 | 35.79 | 38.44 | 35.70 | 34.82 | 35.73 | 34.23 | 34.70 | 36.72 | 37.80 |

Table 3.3 (c) Seasonal changes in MAM Tmin

| Station | Avg of 1971-2000 | Avg of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mainwali | 17.04 | 18.90 | 18.83 | 19.63 | 18.06 | 18.56 | 17.26 | 19.94 | 18.91 | 18.62 | 18.49 | 21.20 | 19.73 | 18.52 | 18.86 | 17.45 | 18.47 | 19.66 | 19.15 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sargodha | 18.17 | 19.57 | 19.60 | 19.87 | 19.03 | 20.66 | 18.67 | 20.49 | 19.71 | 19.61 | 19.52 | 21.90 | 19.85 | 19.03 | 19.11 | 17.82 | 18.80 | 19.68 | 19.36 |
| Jhelum | 17.63 | 18.61 | 19.04 | 19.56 | 18.51 | 19.67 | 18.18 | 19.81 | 18.53 | 18.86 | 18.45 | 20.03 | 18.44 | 17.83 | 18.21 | 16.85 | 17.64 | 18.41 | 18.29 |
| Sialkot | 17.06 | 18.47 | 18.58 | 18.76 | 17.79 | 18.46 | 17.29 | 18.88 | 18.66 | 19.07 | 18.44 | 20.72 | 18.87 | 17.98 | 18.57 | 16.93 | 17.57 | 19.14 | 18.26 |
| Faisalabad | 17.77 | 19.27 | 19.33 | 19.56 | 18.65 | 20.07 | 17.98 | 19.87 | 18.75 | 19.10 | 18.70 | 20.53 | 18.78 | 19.17 | 18.35 | 18.41 | 20.59 | 20.48 | 19.33 |
| Lahore | 19.56 | 21.11 | 21.19 | 20.56 | 20.98 | 22.85 | 20.89 | 22.06 | 21.94 | 21.77 | 21.70 | 23.42 | 21.35 | 19.96 | 19.92 | 17.91 | 20.08 | 20.93 | 21.37 |
| Multan | 19.26 | 20.54 | 20.74 | 20.87 | 19.94 | 21.28 | 19.20 | 21.44 | 21.01 | 20.58 | 20.32 | 22.33 | 20.95 | 19.99 | 15.51 | 19.69 | 21.01 | 21.92 | 22.41 |
| Bahawalnagar | 19.72 | 21.05 | 20.53 | 21.21 | 19.73 | 22.29 | 19.82 | 21.66 | 21.93 | 19.97 | 21.12 | 22.80 | 20.95 | 20.27 | 20.78 | 20.00 | 20.92 | 22.48 | 21.47 |
| Bahawalpur | 19.26 | 20.31 | 19.35 | 20.19 | 18.85 | 21.63 | 19.32 | 21.36 | 20.89 | 20.26 | 19.72 | 21.48 | 20.16 | 19.38 | 19.90 | 19.56 | 20.41 | 21.51 | 21.22 |

Table 3.4(a) Seasonal changes in JJA Precipitation

| Station | Avg of 1971-2000 | Avg of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mainwali | 3.15 | 3.41 | 2.50 | 1.16 | 2.78 | 2.33 | 2.97 | 2.24 | 4.07 | 5.06 | 2.12 | 8.82 | 3.69 | 2.63 | 4.78 | 1.88 | 4.06 | 3.23 | 3.65 |
| Sargodha | 2.24 | 3.32 | 4.14 | 3.65 | 1.90 | 2.56 | 3.30 | 2.40 | 5.06 | 3.10 | 1.35 | 4.18 | 5.58 | 2.09 | 2.13 | 2.71 | 2.43 | 5.77 | 4.10 |
| Jhelum | 6.17 | 5.18 | 5.71 | 3.44 | 5.98 | 5.89 | 3.99 | 9.97 | 4.53 | 4.89 | 3.71 | 5.77 | 4.66 | 3.58 | 6.71 | 3.34 | 4.16 | 4.62 | 7.11 |
| Sialkot | 7.30 | 6.45 | 6.84 | 3.32 | 12.22 | 6.63 | 3.28 | 4.87 | 5.81 | 7.89 | 4.48 | 8.66 | 6.98 | 4.88 | 11.35 | 5.77 | 4.90 | 3.71 | 8.12 |
| Faisalabad | 2.61 | 2.63 | 2.98 | 1.56 | 2.42 | 2.80 | 1.93 | 2.34 | 2.64 | 4.68 | 2.47 | 5.09 | 1.32 | 2.84 | 0.74 | 2.76 | 2.89 | 2.25 | 2.98 |
| Lahore | 4.89 | 4.12 | 4.36 | 3.09 | 4.34 | 3.90 | 4.15 | 4.54 | 4.16 | 5.12 | 2.41 | 4.43 | 6.99 | 2.67 | 7.90 | 1.60 | 5.04 | 0.81 | 4.60 |
| Multan | 1.15 | 1.47 | 2.38 | 0.04 | 1.13 | 1.39 | 1.16 | 0.48 | 1.08 | 0.67 | 0.56 | 2.35 | 0.51 | 0.51 | 1.03 | 1.05 | 2.48 | 6.34 | 1.83 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bahawalnagar | 1.64 | 1.52 | 2.03 | 0.16 | 2.17 | 1.11 | 0.50 | 1.35 | 2.59 | 1.57 | 1.47 | 1.78 | 2.19 | 0.85 | 2.29 | 0.71 | 2.47 | 1.64 | 0.90 |
| Bahawalpur | 1.13 | 1.18 | 1.67 | 0.08 | 1.72 | 0.80 | 0.46 | 1.00 | 1.16 | 1.33 | 0.79 | 2.11 | 0.33 | 0.85 | 0.99 | 0.26 | 4.21 | 0.55 | 1.82 |

Table 3.4 (b) Seasonal changes in JJA Tmax

| Station | Avg of 1971-2000 | Avg of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mainwali | 39.66 | 38.91 | 38.61 | 40.46 | 39.26 | 38.88 | 39.19 | 38.71 | 38.55 | 37.48 | 39.77 | 37.79 | 39.05 | 40.21 | 38.27 | 40.42 | 39.01 | 37.51 | 38.23 |
| Sargodha | 38.67 | 38.12 | 37.69 | 39.73 | 39.03 | 38.19 | 38.99 | 38.08 | 38.00 | 37.59 | 39.67 | 37.44 | 37.31 | 39.68 | 38.13 | 38.67 | 36.18 | 37.05 | 36.62 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jhelum | 36.73 | 36.94 | 36.10 | 38.71 | 37.13 | 36.91 | 37.31 | 36.21 | 36.50 | 35.11 | 38.01 | 36.37 | 36.23 | 38.72 | 36.71 | 38.02 | 36.27 | 37.14 | 36.54 |
| Sialkot | 35.25 | 35.70 | 34.44 | 37.39 | 36.03 | 35.45 | 36.29 | 35.50 | 35.44 | 34.29 | 36.95 | 35.71 | 34.43 | 37.33 | 34.93 | 36.83 | 35.25 | 35.65 | 35.04 |
| Faisalabad | 37.87 | 37.87 | 36.69 | 39.05 | 38.34 | 37.56 | 37.62 | 37.80 | 37.97 | 37.31 | 38.71 | 37.25 | 39.35 | 38.05 | 39.28 | 36.86 | 37.81 | 37.45 | 36.69 |
| Lahore | 36.82 | 36.30 | 35.28 | 37.71 | 36.56 | 35.97 | 36.71 | 35.66 | 36.30 | 35.01 | 37.45 | 35.92 | 34.87 | 38.22 | 35.65 | 37.97 | 35.47 | 36.42 | 35.94 |
| Multan | 39.64 | 39.25 | 38.36 | 40.35 | 39.93 | 39.18 | 39.56 | 39.54 | 39.12 | 38.26 | 39.66 | 38.40 | 39.41 | 40.20 | 40.66 | 39.66 | 37.42 | 39.41 | 38.18 |
| Bahawalnagar | 39.26 | 39.82 | 38.66 | 42.26 | 39.76 | 40.16 | 40.61 | 38.93 | 39.09 | 38.99 | 40.31 | 39.24 | 39.22 | 40.68 | 39.83 | 40.93 | 38.24 | 40.10 | 39.90 |
| Bahawalpur | 39.83 | 39.57 | 39.22 | 41.24 | 39.90 | 40.21 | 40.63 | 40.23 | 39.35 | 38.53 | 39.38 | 38.66 | 39.65 | 39.78 | 39.51 | 40.01 | 37.53 | 40.03 | 38.86 |

Table 3.4 (c) Seasonal changes in JJA Tmin

| Station | Avg of 1971-2000 | Avg of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mainwali | 27.03 | 27.49 | 28.21 | 28.68 | 27.17 | 27.08 | 26.40 | 27.95 | 27.47 | 27.35 | 27.28 | 26.98 | 27.32 | 27.63 | 27.46 | 28.37 | 27.68 | 26.93 | 27.29 |
| Sargodha | 26.93 | 27.40 | 27.65 | 27.63 | 27.85 | 27.22 | 27.84 | 27.49 | 27.42 | 27.62 | 27.19 | 26.99 | 27.25 | 28.02 | 28.04 | 27.65 | 26.33 | 26.83 | 26.70 |
| Jhelum | 25.71 | 25.99 | 25.88 | 27.12 | 26.36 | 25.70 | 26.31 | 26.31 | 26.13 | 25.75 | 26.07 | 25.60 | 25.90 | 26.12 | 25.97 | 25.85 | 25.52 | 25.62 | 25.70 |
| Sialkot | 24.70 | 25.69 | 25.46 | 25.87 | 25.22 | 25.09 | 25.71 | 25.94 | 25.74 | 25.83 | 25.86 | 25.80 | 25.65 | 26.01 | 25.69 | 25.89 | 25.24 | 26.27 | 25.53 |
| Faisalabad | 26.67 | 27.17 | 27.30 | 27.88 | 27.79 | 26.76 | 26.61 | 27.06 | 27.06 | 26.93 | 26.30 | 26.20 | 27.44 | 27.78 | 27.56 | 26.74 | 27.72 | 27.49 | 27.30 |
| Lahore | 26.85 | 27.04 | 27.31 | 27.00 | 27.74 | 27.24 | 27.82 | 27.11 | 27.56 | 27.39 | 27.79 | 27.47 | 26.70 | 27.48 | 25.46 | 26.49 | 26.11 | 26.31 | 26.65 |
| Multan | 28.37 | 28.80 | 28.43 | 29.56 | 28.93 | 28.53 | 28.84 | 28.76 | 28.94 | 28.88 | 28.30 | 28.34 | 29.18 | 29.12 | 28.46 | 29.20 | 27.73 | 29.60 | 28.83 |

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| Bahawalnagar | 28.01 | 28.34 | 27.92 | 29.62 | 28.57 | 28.62 | 28.07 | 27.61 | 28.75 | 28.63 | 26.80 | 27.74 | 28.23 | 29.00 | 28.73 | 29.02 | 27.90 | 29.37 | 27.28 |
| Bahawalpur | 27.88 | 28.39 | 27.47 | 29.04 | 28.61 | 28.44 | 28.53 | 28.39 | 28.51 | 28.66 | 27.72 | 27.87 | 28.95 | 28.64 | 28.79 | 28.75 | 26.91 | 29.17 | 28.14 |

Table 3.5 (a) Seasonal changes in SON Precipitation

| Station | Avg of 1971-2000 | Avg of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mainwali | 0.72 | 0.79 | 0.79 | 0.34 | 0.72 | 0.55 | 0.43 | 0.49 | 0.86 | 1.58 | 1.21 | 1.28 | 1.50 | 1.54 | 0.44 | 0.36 | 0.76 | 0.09 | 0.43 |
| Sargodha | 0.51 | 0.81 | 0.94 | 0.98 | 0.60 | 0.43 | 0.72 | 0.78 | 0.36 | 0.43 | 0.26 | 0.86 | 1.53 | 1.36 | 0.63 | 1.74 | 1.37 | 0.09 | 0.73 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jhelum | 1.12 | 1.11 | 1.14 | 1.07 | 1.38 | 0.74 | 0.57 | 0.90 | 0.84 | 0.98 | 0.37 | 0.92 | 1.75 | 0.35 | 1.35 | 3.27 | 2.31 | 0.15 | 0.83 |
| Sialkot | 1.32 | 1.36 | 0.48 | 1.64 | 1.99 | 0.81 | 0.66 | 3.12 | 0.77 | 0.63 | 0.66 | 0.99 | 0.90 | 0.58 | 1.43 | 6.54 | 1.38 | 0.12 | 0.49 |
| Faisalabad | 0.46 | 0.76 | 0.03 | 1.06 | 0.48 | 0.55 | 1.44 | 1.09 | 0.06 | 0.45 | 0.64 | 0.45 | 1.84 | 0.20 | 2.88 | 0.80 | 0.36 | 0.55 | 0.03 |
| Lahore | 0.96 | 1.17 | 0.54 | 0.59 | 0.36 | 0.23 | 0.78 | 2.35 | 0.96 | 0.31 | 0.27 | 0.98 | 1.71 | 2.53 | 0.59 | 5.37 | 1.46 | 0.16 | 0.66 |
| Multan | 0.36 | 0.46 | 0.71 | 0.33 | 0.19 | 0.25 | 0.18 | 0.07 | 0.40 | 0.10 | 0.06 | 0.17 | 1.00 | 1.80 | 0.45 | 0.29 | 0.24 | 1.43 | 0.20 |
| Bahawalnagar | 0.27 | 0.63 | 0.03 | 0.29 | 0.81 | 0.00 | 0.23 | 0.08 | 0.11 | 0.10 | 0.63 | 0.17 | 2.69 | 2.14 | 0.12 | 1.19 | 1.61 | 0.00 | 0.56 |
| Bahawalpur | 0.27 | 0.33 | 0.00 | 0.33 | 0.01 | 0.01 | 0.80 | 0.10 | 0.46 | 0.01 | 0.31 | 0.03 | 1.17 | 0.85 | 0.00 | 0.25 | 0.99 | 0.00 | 0.31 |

Table 3.5 (b) Seasonal changes in SON Tmax

| Station | Avg of 1971-2000 | Avg of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mainwali | 32.37 | 32.00 | 33.32 | 32.21 | 32.04 | 32.23 | 32.85 | 31.94 | 32.22 | 32.08 | 32.35 | 32.14 | 31.67 | 31.02 | 31.70 | 31.10 | 30.78 | 32.68 | 31.69 |
| Sargodha | 32.44 | 31.76 | 32.81 | 31.44 | 31.92 | 31.81 | 32.49 | 31.43 | 32.12 | 32.43 | 32.35 | 31.90 | 32.30 | 30.91 | 31.87 | 30.29 | 30.63 | 32.02 | 31.13 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jhelum | 31.72 | 31.62 | 33.23 | 31.08 | 30.66 | 31.29 | 32.42 | 30.83 | 31.38 | 31.80 | 31.86 | 32.14 | 32.38 | 31.27 | 31.50 | 30.51 | 31.00 | 32.44 | 31.75 |
| Sialkot | 28.77 | 30.11 | 31.01 | 29.68 | 29.57 | 29.86 | 30.59 | 29.59 | 30.55 | 30.72 | 30.47 | 30.29 | 30.64 | 29.64 | 29.68 | 28.61 | 29.88 | 30.91 | 30.17 |
| Faisalabad | 31.98 | 31.98 | 33.05 | 31.49 | 31.84 | 31.64 | 32.16 | 31.55 | 32.73 | 32.36 | 31.80 | 31.89 | 30.90 | 32.38 | 30.64 | 31.77 | 32.98 | 31.39 | 33.05 |
| Lahore | 31.87 | 31.08 | 32.14 | 31.05 | 30.89 | 30.77 | 31.22 | 30.27 | 31.28 | 31.38 | 31.34 | 30.77 | 31.26 | 30.45 | 31.25 | 30.10 | 30.94 | 32.13 | 31.13 |
| Multan | 33.33 | 33.06 | 33.75 | 33.50 | 32.83 | 32.28 | 33.03 | 32.53 | 33.37 | 33.19 | 33.01 | 33.13 | 32.73 | 32.00 | 36.22 | 32.09 | 32.63 | 33.51 | 32.28 |
| Bahawalnagar | 33.22 | 33.93 | 35.44 | 34.80 | 33.68 | 34.12 | 33.56 | 33.02 | 34.61 | 33.85 | 33.52 | 33.91 | 33.12 | 32.67 | 33.56 | 33.13 | 32.85 | 34.91 | 36.08 |
| Bahawalpur | 33.61 | 33.67 | 34.82 | 34.09 | 34.06 | 33.65 | 33.41 | 33.21 | 33.88 | 33.65 | 33.43 | 33.99 | 33.33 | 32.84 | 33.72 | 33.01 | 32.71 | 35.03 | 33.64 |

Table 3.5 (c) Seasonal changes in SON Tmin

| Station | Avg of 1971-2000 | Avg of 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mainwali | 16.35 | 17.83 | 17.68 | 17.37 | 16.83 | 17.75 | 18.01 | 19.13 | 17.25 | 17.75 | 17.38 | 17.88 | 17.83 | 17.53 | 18.64 | 18.34 | 17.79 | 18.07 | 17.84 |
| Sargodha | 17.78 | 18.49 | 18.56 | 18.28 | 18.09 | 18.38 | 18.54 | 19.58 | 18.25 | 18.40 | 17.77 | 18.57 | 19.72 | 18.27 | 19.04 | 18.05 | 18.05 | 18.50 | 18.25 |
| Jhelum | 16.70 | 17.52 | 16.79 | 17.44 | 17.52 | 17.73 | 17.77 | 18.84 | 16.98 | 17.90 | 16.90 | 17.59 | 17.76 | 16.74 | 17.67 | 17.18 | 17.46 | 17.92 | 17.58 |
| Sialkot | 15.22 | 17.56 | 16.99 | 16.86 | 16.94 | 17.01 | 17.00 | 18.65 | 17.02 | 17.99 | 17.33 | 18.08 | 18.46 | 17.12 | 17.97 | 17.36 | 17.54 | 18.26 | 17.87 |
| Faisalabad | 16.97 | 18.16 | 17.90 | 17.72 | 17.73 | 17.84 | 17.74 | 19.50 | 17.53 | 17.88 | 16.64 | 17.48 | 17.64 | 19.06 | 18.56 | 19.56 | 19.42 | 18.59 | 17.90 |
| Lahore | 18.53 | 19.83 | 20.33 | 18.27 | 19.78 | 20.23 | 20.05 | 20.86 | 20.06 | 20.73 | 19.85 | 20.26 | 20.97 | 18.57 | 18.75 | 19.93 | 19.58 | 19.63 | 19.21 |
| Multan | 18.21 | 19.74 | 18.63 | 18.80 | 17.69 | 18.59 | 18.46 | 20.43 | 18.90 | 19.18 | 18.46 | 19.77 | 20.46 | 19.52 | 25.86 | 20.03 | 20.02 | 20.93 | 19.86 |
| Bahawalnagar | 18.83 | 19.84 | 19.10 | 19.53 | 18.80 | 19.56 | 18.52 | 19.95 | 20.36 | 20.21 | 18.71 | 20.31 | 20.58 | 19.64 | 20.65 | 20.14 | 20.65 | 20.27 | 20.32 |
| Bahawalpur | 18.32 | 19.00 | 18.46 | 18.79 | 17.98 | 18.57 | 18.75 | 20.26 | 18.68 | 18.99 | 18.45 | 19.31 | 20.20 | 18.78 | 20.01 | 19.44 | 19.30 | 18.96 | 18.06 |

## 3.3. Extreme Weather Events

Table 3.6(a-i) provide comprehensive analysis of observed extreme events in Punjab.

**North Punjab** In Jhelum, all the precipitation indices has decreased compared to baseline, consequently, CDD has increased. For temperature extremes, SU and TR20 have increased while all other indices display no change or a very slight increase compared to baseline. WSDI, on the other hand, has decreased in Jhelum in 2001-2017 compared to baseline. In Mianwali, the warm days have slightly decreased from baseline. Among all the indices the increase in total precipitation over all the regions, Mianwali received higher total precipitation (PRCPTOT) in between 2001 to 2017 and is very prominent in 2010. Heavy rain days and extreme 5-day precipitation also has shown higher increase in Mianwali.

**Central Punjab:** In Lahore, all the precipitation indices except Rx5days have decreased while all the temperature extremes except WSDI show increase in 2001-2017 period compared to baseline. In contrast, all the precipitation indices have increased in 2001-2017 comparatively while all the temperature indices have decreased or show no change compared to baseline period. The temperature indices in Sargodha show no change compared to baseline except for SU and TR20 which have increased while all the precipitation indices have increased in 2001-2017 compared to baseline. In Sialkot, despite decrease in all precipitation indices, CDD has also decreased compared to baseline while all the temperature extremes except WSDI have increased in 2001-2017 compared to baseline. An increase in precipitation indices have been observed in Faisalabad while for temperature extremes, SU, tropical nights and cool days(TX10p) has increased while warm days and nights and cool nights show no change. DTR and WSDI have decreased compared to baseline in Faisalabad.

**South Punjab:** In Bahawalnagar, all the precipitation indices show an increase compared to baseline except R95p which shows decrease while no change has been observed in CWD and R99. Similarly, all the temperature extremes have observed to be increased in 2001-2017 compared to baseline except WSDI which has decreased. TN90, however, shows no change. In Bahawalpur temperature extreme shows similar behaviour with decreased WSDI and increase in all other extremes compared to baseline. For precipitation, all the indices show an increase except CDD which shows decrease. In Multan, all the temperature and precipitation indices have increased, however, a decrease is found in WSDI, DTR and CDD compared to baseline period.

Table 3.6 (a): Observed extreme events in Bahawalnagar

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDD | 104 | 98 | 99 | 75 | 66 | 135 | 71 | 79 | 90 | 83 | 45 | 131 | 138 | 116 | 81 | 90 | 81 | 143 | 149 | days |
| Cwd | 3 | 3 | 2 | 2 | 2 | 3 | 7 | 3 | 4 | 3 | 3 | 3 | 7 | 3 | 3 | 4 | 4 | 4 | 2 | days |
| DTR | 14 | 14 | 15 | 15 | 14 | 14 | 14 | 13 | 13 | 14 | 14 | 14 | 13 | 13 | 13 | 13 | 12 | 13 | 15 | °C |
| PRCPTOP | 239 | 267 | 281 | 104 | 330 | 174 | 210 | 187 | 316 | 223 | 242 | 190 | 505 | 312 | 325 | 265 | 491 | 210 | 173 | mm |
| R10mm | 7 | 9 | 12 | 4 | 10 | 7 | 7 | 7 | 9 | 11 | 7 | 8 | 16 | 7 | 10 | 9 | 13 | 5 | 5 | days |
| R20mm | 3 | 4 | 4 | 1 | 7 | 4 | 2 | 3 | 6 | 2 | 4 | 1 | 9 | 5 | 6 | 5 | 9 | 3 | 4 | days |
| R95p | 21 | 19 | 0 | 0 | 66 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 94 | 83 | 0 | 0 | 78 | 0 | 0 | mm |
| R99p | 67 | 67 | 41 | 0 | 152 | 0 | 0 | 0 | 65 | 0 | 84 | 0 | 138 | 120 | 113 | 60 | 219 | 103 | 39 | mm |
| Rx5day | 72 | 76 | 58 | 30 | 74 | 67 | 42 | 61 | 137 | 54 | 57 | 30 | 119 | 109 | 91 | 98 | 142 | 87 | 44 | mm |
| SU | 278 | 289 | 302 | 301 | 278 | 302 | 273 | 298 | 275 | 286 | 290 | 300 | 280 | 280 | 285 | 283 | 270 | 306 | 297 | days |
| TN10p | 10 | 11 | 17 | 7 | 19 | 9 | 24 | 9 | 5 | 22 | 14 | 5 | 8 | 11 | 6 | 9 | 7 | 1 | 9 | % |
| TN90p | 10 | 10 | 6 | 12 | 5 | 15 | 7 | 15 | 14 | 7 | 7 | 12 | 10 | 8 | 9 | 11 | 8 | 18 | 13 | % |
| TR20 | 176 | 190 | 181 | 195 | 183 | 192 | 181 | 192 | 188 | 189 | 188 | 207 | 181 | 191 | 190 | 184 | 198 | 195 | 192 | days |
| TX10 | 10 | 11 | 7 | 3 | 10 | 11 | 16 | 11 | 7 | 16 | 8 | 8 | 14 | 13 | 12 | 13 | 21 | 5 | 6 | % |
| TX90p | 10 | 11 | 15 | 27 | 7 | 17 | 9 | 11 | 9 | 5 | 8 | 15 | 3 | 5 | 5 | 8 | 4 | 12 | 20 | % |
| WSDI | 5 | 3 | 9 | 15 | 0 | 6 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | days |

Table 3.6 (b): Observed extreme events in Bahawalpur

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDD | 129 | 115 | 55 | 199 | 97 | 135 | 64 | 118 | 77 | 85 | 68 | 133 | 160 | 122 | 51 | 174 | 111 | 149 | 163 | days |
| Cwd | 3 | 3 | 4 | 1 | 3 | 2 | 6 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 4 | 1 | 3 | days |
| DTR | 15 | 14 | 16 | 16 | 15 | 15 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 13 | 13 | 13 | 14 | 15 | °C |
| PRCPTOP | 171 | 186 | 181 | 38 | 183 | 146 | 195 | 168 | 228 | 176 | 149 | 223 | 162 | 182 | 148 | 103 | 561 | 93 | 221 | mm |
| R10mm | 5 | 5 | 4 | 1 | 6 | 3 | 4 | 4 | 8 | 5 | 6 | 5 | 5 | 3 | 5 | 6 | 14 | 4 | 5 | days |
| R20mm | 2 | 3 | 2 | 1 | 4 | 2 | 2 | 1 | 3 | 3 | 2 | 5 | 3 | 2 | 2 | 1 | 5 | 1 | 4 | days |
| R95p | 46 | 53 | 45 | 0 | 0 | 46 | 94 | 66 | 0 | 47 | 0 | 49 | 0 | 113 | 47 | 0 | 278 | 0 | 110 | mm |
| R99p | 14 | 17 | 0 | 0 | 0 | 0 | 0 | 66 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 220 | 0 | 0 | mm |
| Rx5day | 63 | 64 | 49 | 24 | 45 | 50 | 53 | 70 | 46 | 98 | 28 | 86 | 92 | 69 | 55 | 32 | 145 | 25 | 116 | mm |
| SU | 291 | 292 | 309 | 306 | 293 | 312 | 279 | 299 | 278 | 283 | 299 | 294 | 282 | 284 | 291 | 284 | 276 | 303 | 293 | days |
| TN10p | 10 | 11 | 16 | 9 | 13 | 10 | 16 | 7 | 11 | 17 | 11 | 7 | 9 | 8 | 6 | 9 | 15 | 6 | 13 | % |
| TN90p | 10 | 11 | 3 | 7 | 7 | 16 | 8 | 26 | 11 | 8 | 6 | 13 | 14 | 5 | 15 | 9 | 7 | 15 | 9 | % |
| TR20 | 171 | 181 | 171 | 173 | 168 | 185 | 175 | 190 | 177 | 182 | 172 | 195 | 175 | 176 | 184 | 179 | 193 | 185 | 193 | days |
| TX10 | 10 | 11 | 6 | 3 | 7 | 9 | 15 | 9 | 9 | 16 | 7 | 10 | 14 | 13 | 10 | 15 | 23 | 6 | 12 | % |
| TX90p | 10 | 10 | 13 | 19 | 12 | 21 | 10 | 16 | 8 | 5 | 4 | 12 | 5 | 3 | 5 | 3 | 3 | 18 | 17 | % |
| WSDI | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 15 | days |

Table 3.6 (c): Observed extreme events in Faisalabad

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDD | 82 | 72 | 102 | 95 | 53 | 73 | 34 | 100 | 77 | 68 | 45 | 99 | 43 | 111 | 37 | 88 | 67 | 31 | 100 | days |
| Cwd | 3 | 4 | 2 | 2 | 5 | 7 | 3 | 2 | 4 | 4 | 4 | 4 | 4 | 3 | 3 | 5 | 5 | 3 | 4 | days |
| DTR | 14 | 13 | 14 | 14 | 13 | 14 | 14 | 13 | 14 | 14 | 15 | 14 | 13 | 14 | 13 | 13 | 12 | 13 | 13 | °C |
| PRCPTOP | 368 | 425 | 320 | 270 | 409 | 376 | 517 | 412 | 345 | 642 | 374 | 543 | 542 | 364 | 377 | 481 | 506 | 428 | 327 | mm |
| R10mm | 11 | 12 | 8 | 7 | 10 | 14 | 14 | 9 | 7 | 21 | 11 | 13 | 18 | 11 | 11 | 11 | 20 | 13 | 10 | days |
| R20mm | 6 | 7 | 7 | 3 | 6 | 6 | 8 | 5 | 4 | 12 | 6 | 10 | 9 | 4 | 3 | 8 | 9 | 9 | 4 | days |
| R95p | 101 | 113 | 117 | 58 | 139 | 0 | 201 | 148 | 190 | 198 | 67 | 257 | 48 | 49 | 190 | 148 | 0 | 111 | 0 | mm |
| R99p | 34 | 31 | 0 | 0 | 0 | 0 | 74 | 79 | 0 | 78 | 0 | 92 | 0 | 0 | 130 | 77 | 0 | 0 | 0 | mm |
| Rx5day | 98 | 101 | 99 | 75 | 84 | 93 | 74 | 81 | 73 | 142 | 133 | 118 | 89 | 68 | 154 | 228 | 64 | 93 | 46 | mm |
| SU | 264 | 271 | 288 | 280 | 258 | 286 | 260 | 275 | 264 | 272 | 268 | 275 | 268 | 267 | 273 | 269 | 256 | 286 | 267 | days |
| TN10p | 10 | 10 | 10 | 7 | 10 | 11 | 20 | 8 | 12 | 15 | 15 | 9 | 9 | 12 | 5 | 8 | 7 | 3 | 5 | % |
| TN90p | 10 | 10 | 7 | 10 | 10 | 15 | 7 | 20 | 6 | 3 | 3 | 8 | 7 | 5 | 12 | 7 | 13 | 19 | 16 | % |
| TR20 | 156 | 173 | 174 | 172 | 162 | 174 | 162 | 184 | 165 | 174 | 162 | 180 | 170 | 161 | 180 | 168 | 185 | 180 | 193 | days |
| TX10 | 10 | 11 | 9 | 6 | 11 | 12 | 16 | 11 | 7 | 14 | 6 | 8 | 14 | 12 | 11 | 15 | 14 | 7 | 11 | % |
| TX90p | 10 | 10 | 10 | 14 | 6 | 17 | 8 | 13 | 10 | 8 | 9 | 10 | 6 | 8 | 8 | 8 | 6 | 14 | 12 | % |
| WSDI | 5 | 4 | 0 | 0 | 0 | 14 | 13 | 7 | 0 | 9 | 0 | 0 | 0 | 6 | 0 | 0 | 8 | 6 | 7 | days |

Table 3.6 (d): Observed extreme events in Jhelum

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDD | 55 | 57 | 50 | 103 | 38 | 64 | 75 | 27 | 67 | 45 | 58 | 79 | 37 | 74 | 53 | 25 | 67 | 37 | 64 | days |
| Cwd | 5 | 5 | 4 | 4 | 5 | 6 | 7 | 7 | 6 | 4 | 4 | 5 | 4 | 4 | 5 | 5 | 4 | 5 | 6 | days |
| DTR | 14 | 14 | 15 | 14 | 13 | 14 | 13 | 13 | 13 | 13 | 14 | 14 | 14 | 15 | 14 | 14 | 13 | 14 | 14 | °C |
| PRCPTOP | 916 | 805 | 746 | 528 | 961 | 854 | 659 | 1237 | 830 | 772 | 542 | 789 | 747 | 510 | 923 | 938 | 1009 | 652 | 988 | mm |
| R10mm | 25 | 24 | 21 | 18 | 22 | 29 | 19 | 33 | 24 | 26 | 20 | 22 | 22 | 19 | 27 | 31 | 27 | 21 | 28 | days |
| R20mm | 14 | 13 | 12 | 9 | 17 | 12 | 10 | 21 | 16 | 16 | 8 | 11 | 12 | 6 | 18 | 14 | 14 | 10 | 14 | days |
| R95p | 265 | 217 | 234 | 56 | 369 | 274 | 57 | 593 | 123 | 64 | 60 | 220 | 216 | 125 | 226 | 304 | 289 | 130 | 339 | mm |
| R99p | 86 | 66 | 0 | 0 | 93 | 222 | 0 | 89 | 0 | 0 | 0 | 92 | 0 | 0 | 102 | 135 | 239 | 0 | 155 | mm |
| Rx5day | 172 | 138 | 147 | 88 | 171 | 151 | 97 | 259 | 86 | 90 | 127 | 151 | 84 | 86 | 146 | 220 | 128 | 111 | 198 | mm |
| SU | 264 | 275 | 304 | 283 | 260 | 285 | 263 | 274 | 266 | 279 | 272 | 283 | 273 | 273 | 277 | 267 | 257 | 283 | 277 | days |
| TN10p | 10 | 10 | 13 | 5 | 10 | 8 | 14 | 6 | 9 | 15 | 11 | 9 | 11 | 14 | 7 | 15 | 7 | 7 | 11 | % |
| TN90p | 10 | 10 | 8 | 16 | 11 | 19 | 10 | 25 | 9 | 9 | 10 | 12 | 6 | 7 | 8 | 4 | 7 | 8 | 10 | % |
| TR20 | 152 | 165 | 162 | 166 | 157 | 174 | 165 | 177 | 162 | 166 | 161 | 182 | 163 | 155 | 165 | 156 | 158 | 160 | 172 | days |
| TX10 | 10 | 11 | 8 | 6 | 15 | 11 | 13 | 11 | 8 | 16 | 6 | 8 | 10 | 7 | 11 | 17 | 17 | 8 | 11 | % |
| TX90p | 10 | 11 | 21 | 19 | 5 | 14 | 7 | 10 | 5 | 7 | 11 | 12 | 9 | 11 | 6 | 8 | 9 | 11 | 14 | % |
| WSDI | 7 | 2 | 0 | 9 | 0 | 9 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | days |

Table 3.6 (e): Observed extreme events in Lahore

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDD | 65 | 71 | 90 | 70 | 48 | 72 | 42 | 100 | 65 | 55 | 34 | 126 | 38 | 108 | 43 | 31 | 67 | 79 | 136 | days |
| Cwd | 4 | 4 | 4 | 4 | 3 | 2 | 4 | 5 | 4 | 3 | 4 | 3 | 3 | 4 | 10 | 6 | 4 | 2 | 3 | days |
| DTR | 13 | 11 | 11 | 13 | 10 | 11 | 10 | 10 | 11 | 11 | 11 | 11 | 10 | 12 | 12 | 12 | 11 | 12 | 12 | °C |
| PRCPTOP | 678 | 613 | 535 | 443 | 622 | 493 | 646 | 747 | 657 | 606 | 367 | 537 | 855 | 580 | 901 | 779 | 852 | 181 | 626 | mm |
| R10mm | 18 | 18 | 20 | 11 | 18 | 16 | 19 | 23 | 28 | 16 | 12 | 9 | 26 | 17 | 28 | 14 | 26 | 7 | 22 | days |
| R20mm | 10 | 10 | 9 | 10 | 10 | 8 | 9 | 10 | 10 | 11 | 4 | 7 | 15 | 7 | 12 | 10 | 16 | 3 | 12 | days |
| R95p | 193 | 166 | 87 | 67 | 200 | 162 | 137 | 237 | 99 | 206 | 49 | 328 | 198 | 186 | 255 | 379 | 128 | 0 | 105 | mm |
| R99p | 62 | 54 | 0 | 0 | 0 | 0 | 137 | 115 | 0 | 0 | 0 | 122 | 0 | 110 | 113 | 323 | 0 | 0 | 0 | mm |
| Rx5day | 143 | 146 | 103 | 121 | 109 | 78 | 186 | 156 | 107 | 131 | 63 | 235 | 148 | 140 | 217 | 416 | 166 | 39 | 75 | mm |
| SU | 266 | 271 | 291 | 280 | 254 | 284 | 262 | 278 | 264 | 274 | 266 | 273 | 269 | 262 | 274 | 262 | 259 | 285 | 268 | days |
| TN10p | 10 | 11 | 6 | 22 | 8 | 9 | 8 | 5 | 4 | 17 | 5 | 4 | 4 | 17 | 21 | 22 | 12 | 8 | 9 | % |
| TN90p | 10 | 11 | 11 | 6 | 9 | 24 | 10 | 23 | 11 | 13 | 15 | 17 | 11 | 5 | 2 | 4 | 3 | 5 | 10 | % |
| TR20 | 173 | 189 | 195 | 178 | 186 | 198 | 187 | 200 | 194 | 197 | 188 | 217 | 188 | 176 | 178 | 173 | 187 | 182 | 197 | days |
| TX10 | 10 | 11 | 9 | 5 | 14 | 12 | 15 | 10 | 7 | 15 | 7 | 8 | 11 | 10 | 14 | 17 | 17 | 7 | 12 | % |
| TX90p | 10 | 11 | 12 | 21 | 6 | 15 | 5 | 12 | 8 | 9 | 14 | 9 | 5 | 11 | 7 | 11 | 7 | 13 | 20 | % |
| WSDI | 7 | 6 | 0 | 17 | 0 | 15 | 0 | 8 | 0 | 9 | 7 | 6 | 0 | 0 | 0 | 6 | 0 | 6 | 23 | days |

Table 3.6 (f): Observed extreme events in Mianwali

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDD | 129 | 68 | 86 | 64 | 52 | 72 | 99 | 41 | 61 | 35 | 33 | 91 | 44 | 57 | 38 | 62 | 170 | 69 | 90 | days |
| Cwd | 3 | 4 | 3 | 6 | 3 | 4 | 7 | 3 | 4 | 4 | 4 | 3 | 5 | 3 | 3 | 2 | 2 | 4 | 3 | days |
| DTR | 15 | 14 | 15 | 15 | 14 | 14 | 14 | 13 | 14 | 14 | 14 | 14 | 14 | 14 | 13 | 13 | 13 | 14 | 13 | °C |
| PRCPTOP | 171 | 562 | 458 | 302 | 538 | 474 | 696 | 424 | 753 | 837 | 535 | 996 | 538 | 498 | 828 | 334 | 456 | 444 | 445 | mm |
| R10mm | 5 | 16 | 14 | 7 | 19 | 21 | 24 | 12 | 20 | 24 | 15 | 22 | 17 | 11 | 22 | 9 | 5 | 14 | 12 | days |
| R20mm | 2 | 8 | 10 | 4 | 6 | 8 | 10 | 7 | 12 | 14 | 9 | 14 | 9 | 4 | 14 | 6 | 5 | 7 | 4 | days |
| R95p | 46 | 159 | 65 | 69 | 93 | 0 | 143 | 63 | 155 | 276 | 60 | 510 | 84 | 245 | 252 | 94 | 340 | 90 | 172 | mm |
| R99p | 14 | 61 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 369 | 0 | 99 | 129 | 0 | 340 | 0 | 102 | mm |
| Rx5day | 63 | 137 | 96 | 80 | 101 | 66 | 106 | 80 | 139 | 105 | 95 | 271 | 145 | 171 | 139 | 96 | 340 | 95 | 200 | mm |
| SU | 291 | 269 | 288 | 275 | 254 | 287 | 257 | 268 | 264 | 272 | 263 | 273 | 270 | 270 | 275 | 256 | 259 | 275 | 275 | days |
| TN10p | 10 | 10 | 13 | 8 | 15 | 11 | 22 | 5 | 13 | 21 | 8 | 10 | 4 | 10 | 7 | 9 | 3 | 6 | 3 | % |
| TN90p | 10 | 10 | 12 | 16 | 7 | 16 | 6 | 23 | 11 | 6 | 9 | 17 | 4 | 8 | 9 | 7 | 2 | 8 | 2 | % |
| TR20 | 171 | 167 | 166 | 163 | 154 | 160 | 159 | 176 | 168 | 166 | 163 | 188 | 180 | 157 | 168 | 161 | 161 | 173 | 172 | days |
| TX10 | 10 | 10 | 9 | 6 | 13 | 11 | 15 | 11 | 11 | 19 | 8 | 9 | 5 | 12 | 13 | 12 | 8 | 6 | 5 | % |
| TX90p | 10 | 9 | 15 | 18 | 7 | 15 | 9 | 12 | 10 | 10 | 13 | 14 | 3 | 9 | 3 | 6 | 0 | 9 | 2 | % |
| WSDI | 7 | 2 | 7 | 0 | 0 | 8 | 7 | 14 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | days |

Table 3.6 (g): Observed extreme events in Multan

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDD | 104 | 97 | 90 | 95 | 77 | 131 | 64 | 122 | 94 | 76 | 46 | 167 | 145 | 99 | 59 | 90 | 98 | 77 | 114 | days |
| Cwd | 3 | 3 | 2 | 2 | 4 | 2 | 4 | 3 | 4 | 3 | 3 | 5 | 2 | 5 | 3 | 3 | 2 | 5 | 3 | days |
| DTR | 14 | 13 | 14 | 15 | 14 | 14 | 14 | 13 | 14 | 13 | 14 | 13 | 13 | 13 | 12 | 12 | 12 | 12 | 12 | °C |
| PRCPTOP | 203 | 252 | 295 | 100 | 160 | 188 | 299 | 144 | 261 | 160 | 117 | 286 | 183 | 237 | 225 | 256 | 347 | 785 | 237 | mm |
| R10mm | 6 | 7 | 7 | 2 | 6 | 5 | 9 | 5 | 7 | 5 | 4 | 7 | 7 | 5 | 6 | 7 | 10 | 21 | 6 | days |
| R20mm | 3 | 4 | 5 | 2 | 1 | 2 | 4 | 1 | 4 | 2 | 2 | 3 | 2 | 2 | 3 | 5 | 7 | 14 | 4 | days |
| R95p | 63 | 71 | 133 | 0 | 50 | 48 | 71 | 50 | 91 | 0 | 0 | 120 | 0 | 128 | 91 | 62 | 52 | 314 | 0 | mm |
| R99p | 22 | 22 | 83 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 120 | 0 | 77 | 0 | 0 | 0 | 97 | 0 | mm |
| Rx5day | 71 | 78 | 86 | 40 | 59 | 54 | 108 | 55 | 69 | 54 | 30 | 141 | 66 | 156 | 57 | 65 | 63 | 162 | 68 | mm |
| SU | 281 | 284 | 303 | 289 | 277 | 305 | 272 | 291 | 273 | 281 | 282 | 286 | 279 | 283 | 279 | 284 | 273 | 293 | 272 | days |
| TN10p | 10 | 11 | 12 | 8 | 16 | 10 | 23 | 9 | 11 | 22 | 13 | 7 | 8 | 11 | 6 | 8 | 10 | 2 | 5 | % |
| TN90p | 10 | 10 | 5 | 6 | 6 | 10 | 7 | 18 | 11 | 5 | 6 | 14 | 14 | 6 | 14 | 9 | 8 | 21 | 18 | % |
| TR20 | 172 | 186 | 180 | 183 | 176 | 184 | 173 | 191 | 177 | 182 | 172 | 208 | 187 | 185 | 195 | 183 | 197 | 192 | 199 | days |
| TX10 | 10 | 11 | 9 | 4 | 8 | 10 | 15 | 8 | 8 | 16 | 6 | 10 | 13 | 10 | 13 | 18 | 18 | 5 | 15 | % |
| TX90p | 10 | 10 | 16 | 18 | 10 | 15 | 7 | 14 | 10 | 8 | 7 | 13 | 9 | 9 | 8 | 5 | 4 | 12 | 9 | % |
| WSDI | 4 | 2 | 0 | 0 | 0 | 6 | 0 | 8 | 6 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | days |

Table 3.6 (h): Observed extreme events in Sargodha

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDD | 102 | 62 | 77 | 50 | 48 | 53 | 33 | 81 | 67 | 46 | 37 | 115 | 37 | 82 | 36 | 91 | 67 | 70 | 61 | days |
| Cwd | 3 | 4 | 4 | 3 | 5 | 4 | 3 | 2 | 4 | 4 | 4 | 3 | 4 | 3 | 3 | 5 | 4 | 3 | 4 | days |
| DTR | 14 | 13 | 14 | 14 | 13 | 14 | 13 | 13 | 14 | 14 | 14 | 13 | 13 | 13 | 13 | 12 | 12 | 13 | 12 | °C |
| PRCPTOP | 371 | 540 | 612 | 526 | 424 | 367 | 643 | 481 | 683 | 566 | 280 | 523 | 733 | 370 | 424 | 538 | 577 | 771 | 668 | mm |
| R10mm | 11 | 17 | 18 | 14 | 14 | 15 | 19 | 16 | 18 | 17 | 8 | 16 | 19 | 13 | 15 | 16 | 22 | 22 | 23 | days |
| R20mm | 6 | 9 | 14 | 9 | 8 | 8 | 11 | 7 | 12 | 12 | 3 | 7 | 14 | 5 | 6 | 8 | 13 | 10 | 8 | days |
| R95p | 101 | 140 | 158 | 213 | 128 | 0 | 160 | 170 | 301 | 109 | 45 | 161 | 226 | 126 | 0 | 177 | 0 | 347 | 61 | mm |
| R99p | 31 | 44 | 0 | 118 | 76 | 0 | 0 | 0 | 200 | 0 | 0 | 95 | 0 | 69 | 0 | 0 | 0 | 188 | 0 | mm |
| Rx5day | 87 | 102 | 112 | 124 | 100 | 51 | 99 | 75 | 152 | 121 | 77 | 148 | 125 | 87 | 65 | 81 | 86 | 148 | 84 | mm |
| SU | 268 | 270 | 292 | 277 | 265 | 296 | 260 | 275 | 262 | 275 | 270 | 278 | 272 | 267 | 271 | 250 | 248 | 276 | 257 | days |
| TN10p | 10 | 9 | 9 | 10 | 11 | 9 | 16 | 8 | 9 | 16 | 11 | 6 | 7 | 9 | 6 | 14 | 11 | 6 | 3 | % |
| TN90p | 9 | 9 | 8 | 13 | 9 | 16 | 9 | 19 | 7 | 6 | 7 | 15 | 12 | 7 | 8 | 5 | 8 | 6 | 3 | % |
| TR20 | 162 | 175 | 177 | 178 | 164 | 181 | 170 | 182 | 177 | 174 | 171 | 202 | 176 | 168 | 177 | 159 | 165 | 174 | 175 | days |
| TX10 | 10 | 10 | 9 | 5 | 9 | 10 | 12 | 10 | 9 | 13 | 6 | 7 | 9 | 9 | 12 | 18 | 19 | 7 | 6 | % |
| TX90p | 10 | 10 | 12 | 16 | 9 | 23 | 10 | 13 | 10 | 12 | 15 | 13 | 9 | 8 | 5 | 3 | 3 | 5 | 1 | % |
| WSDI | 5 | 4 | 0 | 0 | 6 | 30 | 0 | 11 | 6 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | days |

Table 3.6 (i): Observed extreme events in Sialkot

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CDD | 61 | 56 | 49 | 71 | 48 | 53 | 33 | 81 | 67 | 57 | 65 | 67 | 35 | 71 | 53 | 24 | 66 | 40 | 70 | days |
| Cwd | 5 | 5 | 4 | 3 | 6 | 3 | 6 | 3 | 5 | 8 | 4 | 6 | 5 | 4 | 6 | 6 | 6 | 5 | 5 | days |
| DTR | 13 | 12 | 13 | 14 | 12 | 13 | 13 | 12 | 13 | 12 | 13 | 13 | 12 | 13 | 12 | 12 | 12 | 12 | 12 | °C |
| PRCPTOP | 1011 | 923 | 787 | 542 | 1600 | 911 | 622 | 862 | 887 | 908 | 582 | 1025 | 853 | 756 | 1397 | 1311 | 1123 | 474 | 1051 | mm |
| R10mm | 27 | 24 | 18 | 19 | 29 | 28 | 23 | 22 | 26 | 26 | 15 | 28 | 20 | 21 | 35 | 26 | 33 | 14 | 33 | days |
| R20mm | 15 | 15 | 13 | 5 | 22 | 20 | 10 | 17 | 14 | 18 | 10 | 19 | 10 | 11 | 21 | 15 | 18 | 6 | 21 | days |
| R95p | 299 | 265 | 144 | 129 | 828 | 124 | 0 | 243 | 103 | 276 | 89 | 311 | 252 | 128 | 726 | 768 | 247 | 61 | 80 | mm |
| R99p | 104 | 88 | 0 | 0 | 335 | 0 | 0 | 0 | 0 | 0 | 0 | 251 | 0 | 128 | 407 | 373 | 0 | 0 | 0 | mm |
| Rx5day | 203 | 195 | 169 | 91 | 371 | 124 | 96 | 172 | 156 | 148 | 129 | 253 | 138 | 163 | 383 | 523 | 157 | 88 | 150 | mm |
| SU | 244 | 259 | 276 | 264 | 249 | 270 | 258 | 269 | 251 | 268 | 256 | 270 | 263 | 249 | 249 | 242 | 241 | 270 | 250 | days |
| TN10p | 10 | 11 | 15 | 11 | 15 | 13 | 20 | 7 | 10 | 13 | 10 | 5 | 6 | 9 | 6 | 19 | 10 | 4 | 7 | % |
| TN90p | 10 | 11 | 9 | 10 | 6 | 11 | 7 | 22 | 7 | 10 | 13 | 18 | 14 | 8 | 9 | 6 | 7 | 15 | 12 | % |
| TR20 | 144 | 165 | 164 | 159 | 150 | 159 | 156 | 169 | 170 | 164 | 163 | 188 | 169 | 157 | 171 | 157 | 163 | 168 | 174 | days |
| TX10 | 10 | 11 | 10 | 5 | 18 | 10 | 11 | 10 | 7 | 13 | 6 | 9 | 11 | 9 | 16 | 18 | 12 | 8 | 12 | % |
| TX90p | 10 | 10 | 15 | 17 | 5 | 15 | 5 | 15 | 9 | 11 | 12 | 15 | 8 | 8 | 4 | 7 | 6 | 13 | 12 | % |
| WSDI | 8 | 3 | 0 | 7 | 0 | 6 | 0 | 6 | 0 | 6 | 0 | 0 | 0 | 6 | 7 | 0 | 0 | 7 | 6 | days |

## 3.4. Observed Heatwaves in Punjab

Heatwaves are generally referred as a period of consecutive days where conditions are excessively hotter than normal (Perkins and Alexander, 2013) with intensity depending on the period and temperature during the heat-event. Any heat wave event with extremely high temperature has the potential to adversely affect human health (Anderson and Bell, 2011). Exposure to such extreme heat lead to a variety of clinical conditions, ranging from heat-stroke and dehydration to malfunctioning of vital body systems such as cardiovascular and respiratory systems and can even result in death (Wilker et al.,2012; S. Hajat, et al.,2007). IPCC (2014) and numerous other studies demonstrated a significantly increased intensity and frequency of heat waves particularly over large localities in Europe, Asia, and Australia. (Meehl and Tebaldi, 2004; Schär et al., 2004; Clark et al., 2006; Rasul et al., 2008; Diffenbaugh et al.,2010; Seneviratne et al.,2012;Perkins and Alexander, 2013; Keellings and Waylen, 2014).

Heat wave indices manly magnitude and amplitude that are based on maximum temperature (TX90p) are greater in 2001-2017 in Bahawalnagar, Faisalabad, Jhelum, Mianwali and Sialkot (Table 3.7 (a-i)). In these cities the heat waves indices from minimum temperature have higher tendency in baseline as compared to 2001-2017. In Bahawalpur and Sargodha both maximum and minimum temperature based heatwaves indices are higher in baseline than 2001-2017. In Multan the maximum temperature heatwaves are less in 2001-2017 than baseline while minimum temperature heat wave indices are same in both periods. Over all regions the maximum and minimum temperature heat events (HWN) are same in both the periods except few stations. Overall the difference in heat wave frequency individually from TX90p and TN90p over all the regions is 1 to 2 days and 1-day difference in heat wave duration in their respective periods. Years that possess heat waves have shown greater heat wave indices mostly the amplitude and magnitude of heat waves in both TX90p and TN90p of all regions. In maximum temperature, Bahawalnagar have the highest amplitude of heatwaves during 2001-2017 and in minimum temperature Jhelum have the highest amplitude heat wave during baseline.

Table 3.7(a): Observed heatwaves in Bahawalnagar

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Heat waves Based on TX90p | | | | | | | | | | | | | | | | | | |
| HWM | 31 | 42 | 44 | 44 | 47 | 42 | 44 | 47 | 47 | 40 | 43 | 48 | 0 | 46 | 44 | 44 | 41 | 49 | 41 |
| HWA | 33 | 44 | 49 | 50 | 48 | 44 | 49 | 47 | 47 | 41 | 46 | 50 | 0 | 47 | 48 | 48 | 41 | 50 | 43 |
| HWN | 2 | 2 | 4 | 5 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 0 | 1 | 2 | 3 | 1 | 1 | 2 |
| HWD | 3 | 4 | 3 | 10 | 3 | 6 | 10 | 3 | 1 | 3 | 3 | 3 | 0 | 5 | 3 | 3 | 3 | 4 | 4 |
| HWF | 7 | 7 | 12 | 27 | 3 | 9 | 15 | 3 | 1 | 3 | 6 | 6 | 0 | 5 | 6 | 9 | 3 | 4 | 7 |
| | Heat waves Based on TN90p | | | | | | | | | | | | | | | | | | |
| HWM | 19 | 16 | 32 | 31 | 0 | 0 | 33 | 0 | 30 | 0 | 0 | 29 | 31 | 32 | 0 | 30 | 0 | 29 | 0 |
| HWA | 20 | 17 | 32 | 31 | 0 | 0 | 33 | 0 | 34 | 0 | 0 | 29 | 31 | 34 | 0 | 33 | 0 | 34 | 0 |
| HWN | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 5 | 0 | 0 | 1 | 1 | 1 | 0 | 2 | 0 | 2 | 0 |
| HWD | 3 | 2 | 3 | 4 | 0 | 0 | 3 | 0 | 7 | 0 | 0 | 3 | 4 | 4 | 0 | 5 | 0 | 7 | 0 |
| HWF | 5 | 4 | 3 | 4 | 0 | 0 | 3 | 0 | 22 | 0 | 0 | 3 | 4 | 4 | 0 | 9 | 0 | 12 | 0 |

Table 3.7 (b): Observed heatwaves in Bahawalpur

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Heat waves Based on TX90p | | | | | | | | | | | | | | | | | | |
| HWM | 34 | 31 | 47 | 44 | 45 | 44 | 43 | 44 | 0 | 0 | 45 | 45 | 47 | 0 | 43 | 0 | 0 | 42 | 40 |
| HWA | 35 | 33 | 49 | 49 | 47 | 47 | 43 | 47 | 0 | 0 | 46 | 47 | 47 | 0 | 43 | 0 | 0 | 49 | 41 |
| HWN | 2 | 2 | 2 | 4 | 3 | 2 | 1 | 4 | 0 | 0 | 1 | 2 | 1 | 0 | 1 | 0 | 0 | 5 | 3 |
| HWD | 3 | 3 | 4 | 6 | 5 | 4 | 3 | 5 | 0 | 0 | 3 | 3 | 3 | 0 | 3 | 0 | 0 | 8 | 4 |
| HWF | 7 | 6 | 7 | 15 | 11 | 7 | 3 | 15 | 0 | 0 | 3 | 6 | 3 | 0 | 3 | 0 | 0 | 24 | 11 |
| | Heat waves Based on TN90p | | | | | | | | | | | | | | | | | | |
| HWM | 19 | 14 | 0 | 0 | 0 | 0 | 31 | 31 | 28 | 0 | 0 | 30 | 29 | 29 | 26 | 0 | 0 | 32 | 0 |
| HWA | 20 | 15 | 0 | 0 | 0 | 0 | 32 | 33 | 29 | 0 | 0 | 33 | 31 | 31 | 26 | 0 | 0 | 33 | 0 |
| HWN | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 4 | 2 | 0 | 0 | 3 | 2 | 3 | 1 | 0 | 0 | 2 | 0 |
| HWD | 3 | 2 | 0 | 0 | 0 | 0 | 3 | 5 | 4 | 0 | 0 | 4 | 5 | 4 | 3 | 0 | 0 | 3 | 0 |
| HWF | 6 | 4 | 0 | 0 | 0 | 0 | 9 | 15 | 7 | 0 | 0 | 10 | 9 | 11 | 3 | 0 | 0 | 6 | 0 |

Table 3.7(c) : Observed heatwaves in Faisalabad

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Heat waves Based on TX90p | | | | | | | | | | | | | | | | | | |
| HWM | 34 | 41 | 45 | 42 | 46 | 40 | 42 | 46 | 47 | 41 | 41 | 46 | 46 | 43 | 47 | 42 | 39 | 42 | 0 |
| HWA | 35 | 43 | 48 | 46 | 46 | 41 | 48 | 47 | 48 | 44 | 45 | 47 | 46 | 47 | 48 | 46 | 39 | 46 | 0 |
| HWN | 2 | 2 | 2 | 5 | 2 | 2 | 2 | 1 | 1 | 2 | 4 | 1 | 1 | 3 | 1 | 3 | 1 | 2 | 0 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HWD | 3 | 4 | 4 | 4 | 3 | 4 | 7 | 3 | 3 | 3 | 4 | 3 | 3 | 5 | 4 | 5 | 8 | 5 | 0 |
| HWF | 7 | 7 | 7 | 17 | 6 | 7 | 13 | 3 | 3 | 6 | 13 | 3 | 3 | 11 | 4 | 11 | 8 | 9 | 0 |
| | Heat waves Based on TN90p | | | | | | | | | | | | | | | | | | |
| HWM | 18 | 17 | 0 | 29 | 27 | 0 | 31 | 32 | 31 | 0 | 0 | 0 | 27 | 29 | 28 | 0 | 0 | 29 | 30 |
| HWA | 19 | 18 | 0 | 30 | 28 | 0 | 32 | 33 | 32 | 0 | 0 | 0 | 28 | 31 | 31 | 0 | 0 | 32 | 30 |
| HWN | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 3 | 1 |
| HWD | 3 | 2 | 0 | 3 | 4 | 0 | 4 | 3 | 3 | 0 | 0 | 0 | 3 | 3 | 4 | 0 | 0 | 7 | 3 |
| HWF | 4 | 3 | 0 | 3 | 4 | 0 | 4 | 3 | 3 | 0 | 0 | 0 | 3 | 6 | 10 | 0 | 0 | 14 | 3 |

Table 3.7(d): Observed heatwaves in Jhelum

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Heat waves Based on TX90p | | | | | | | | | | | | | | | | | | |
| HWM | 31 | 41 | 42 | 43 | 42 | 42 | 46 | 44 | 46 | 39 | 42 | 46 | 0 | 44 | 46 | 45 | 38 | 45 | 38 |
| HWA | 33 | 43 | 47 | 46 | 48 | 45 | 47 | 46 | 47 | 40 | 47 | 48 | 0 | 47 | 48 | 46 | 40 | 46 | 39 |
| HWN | 2 | 2 | 2 | 5 | 2 | 4 | 1 | 1 | 1 | 1 | 6 | 2 | 0 | 5 | 1 | 1 | 1 | 2 | 2 |
| HWD | 4 | 4 | 4 | 9 | 5 | 5 | 5 | 3 | 3 | 4 | 3 | 4 | 0 | 5 | 6 | 6 | 7 | 3 | 3 |
| HWF | 8 | 9 | 7 | 25 | 8 | 16 | 5 | 3 | 3 | 4 | 18 | 7 | 0 | 19 | 6 | 6 | 7 | 6 | 6 |
| | Heat waves Based on TN90p | | | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HWM | 29 | 21 | 0 | 31 | 28 | 29 | 31 | 30 | 31 | 25 | 28 | 0 | 0 | 31 | 32 | 0 | 0 | 27 | 29 |
| HWA | 30 | 22 | 0 | 32 | 28 | 31 | 35 | 32 | 31 | 25 | 31 | 0 | 0 | 31 | 34 | 0 | 0 | 27 | 29 |
| HWN | 1 | 1 | 0 | 2 | 1 | 2 | 2 | 3 | 1 | 1 | 2 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 1 |
| HWD | 4 | 3 | 0 | 5 | 6 | 5 | 5 | 4 | 3 | 6 | 5 | 0 | 0 | 3 | 4 | 0 | 0 | 3 | 3 |
| HWF | 4 | 4 | 0 | 8 | 6 | 8 | 8 | 10 | 3 | 6 | 9 | 0 | 0 | 3 | 8 | 0 | 0 | 3 | 3 |

Table 3.7 (e): Observed heatwaves in Lahore

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Heat waves Based on TX90p | | | | | | | | | | | | | | | | | | |
| HWM | 29 | 37 | 0 | 41 | 45 | 37 | 41 | 43 | 46 | 43 | 39 | 44 | 0 | 42 | 45 | 40 | 38 | 45 | 37 |
| HWA | 31 | 39 | 0 | 46 | 45 | 38 | 45 | 44 | 47 | 43 | 44 | 44 | 0 | 46 | 47 | 46 | 38 | 46 | 39 |
| HWN | 2 | 2 | 0 | 7 | 1 | 1 | 2 | 1 | 1 | 1 | 6 | 1 | 0 | 5 | 1 | 4 | 1 | 1 | 2 |
| HWD | 4 | 4 | 0 | 10 | 5 | 4 | 5 | 3 | 3 | 3 | 4 | 3 | 0 | 5 | 5 | 6 | 3 | 4 | 7 |
| HWF | 8 | 8 | 0 | 34 | 5 | 4 | 10 | 3 | 3 | 3 | 19 | 3 | 0 | 17 | 5 | 20 | 3 | 4 | 10 |
| | Heat waves Based on TN90p | | | | | | | | | | | | | | | | | | |
| HWM | 18 | 22 | 29 | 0 | 29 | 30 | 31 | 32 | 31 | 29 | 30 | 32 | 30 | 31 | 0 | 0 | 0 | 0 | 33 |
| HWA | 19 | 23 | 30 | 0 | 29 | 32 | 34 | 32 | 33 | 32 | 34 | 34 | 31 | 32 | 0 | 0 | 0 | 0 | 34 |
| HWN | 1 | 1 | 1 | 0 | 1 | 2 | 3 | 1 | 2 | 4 | 5 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| HWD | 2 | 3 | 4 | 0 | 4 | 6 | 5 | 3 | 6 | 7 | 4 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 3 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HWF | 5 | 5 | 4 | 0 | 4 | 11 | 13 | 3 | 9 | 17 | 16 | 6 | 3 | 3 | 0 | 0 | 0 | 0 | 3 |

Table 3.7 (f): Observed heatwaves in Mianwali

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Heat waves Based on TX90p | | | | | | | | | | | | | | | | | | |
| HWM | 34 | 36 | 43 | 46 | 43 | 41 | 43 | 45 | 49 | 39 | 42 | 47 | 0 | 46 | 46 | 45 | 0 | 46 | 0 |
| HWA | 35 | 39 | 48 | 47 | 49 | 43 | 50 | 46 | 51 | 40 | 47 | 49 | 0 | 47 | 47 | 47 | 0 | 47 | 0 |
| HWN | 2 | 2 | 3 | 1 | 2 | 2 | 3 | 1 | 1 | 1 | 5 | 1 | 0 | 2 | 1 | 2 | 0 | 1 | 0 |
| HWD | 3 | 4 | 4 | 5 | 5 | 4 | 7 | 4 | 4 | 3 | 8 | 3 | 0 | 4 | 3 | 3 | 0 | 5 | 0 |
| HWF | 7 | 6 | 10 | 5 | 10 | 8 | 16 | 4 | 4 | 3 | 23 | 3 | 0 | 7 | 3 | 6 | 0 | 5 | 0 |
| | Heat waves Based on TN90p | | | | | | | | | | | | | | | | | | |
| HWM | 19 | 18 | 30 | 31 | 27 | 27 | 31 | 33 | 32 | 0 | 29 | 0 | 0 | 32 | 0 | 30 | 0 | 0 | 0 |
| HWA | 19 | 19 | 32 | 34 | 28 | 27 | 32 | 34 | 33 | 0 | 31 | 0 | 0 | 33 | 0 | 33 | 0 | 0 | 0 |
| HWN | 19 | 1 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 0 | 4 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 |
| HWD | 19 | 2 | 4 | 3 | 6 | 3 | 3 | 3 | 4 | 0 | 4 | 0 | 0 | 3 | 0 | 5 | 0 | 0 | 0 |
| HWF | 19 | 4 | 7 | 9 | 6 | 3 | 3 | 3 | 4 | 0 | 15 | 0 | 0 | 3 | 0 | 8 | 0 | 0 | 0 |

Table 3.7 (g) : Observed heatwaves in Multan

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Heat waves Based on TX90p | | | | | | | | | | | | | | | | | | |
| HWM | 37 | 33 | 46 | 43 | 45 | 47 | 42 | 46 | 40 | 0 | 44 | 46 | 0 | 42 | 40 | 0 | 39 | 47 | 0 |
| HWA | 39 | 35 | 47 | 49 | 49 | 48 | 46 | 46 | 40 | 0 | 46 | 50 | 0 | 45 | 40 | 0 | 40 | 48 | 0 |
| HWN | 2 | 1 | 1 | 3 | 3 | 1 | 3 | 1 | 1 | 0 | 1 | 3 | 0 | 2 | 2 | 0 | 1 | 1 | 0 |
| HWD | 4 | 4 | 5 | 5 | 8 | 4 | 7 | 3 | 6 | 0 | 4 | 4 | 0 | 3 | 4 | 0 | 5 | 3 | 0 |
| HWF | 8 | 6 | 5 | 13 | 14 | 4 | 13 | 3 | 6 | 0 | 4 | 11 | 0 | 6 | 7 | 0 | 5 | 3 | 0 |
| | Heat waves Based on TN90p | | | | | | | | | | | | | | | | | | |
| HWM | 20 | 20 | 0 | 32 | 32 | 0 | 32 | 31 | 31 | 0 | 0 | 31 | 32 | 30 | 32 | 0 | 0 | 31 | 32 |
| HWA | 21 | 21 | 0 | 33 | 33 | 0 | 34 | 33 | 33 | 0 | 0 | 33 | 32 | 31 | 33 | 0 | 0 | 33 | 34 |
| HWN | 1 | 1 | 0 | 2 | 1 | 0 | 2 | 2 | 3 | 0 | 0 | 2 | 1 | 1 | 1 | 0 | 0 | 3 | 4 |
| HWD | 3 | 3 | 0 | 4 | 3 | 0 | 7 | 4 | 6 | 0 | 0 | 4 | 3 | 3 | 3 | 0 | 0 | 8 | 3 |
| HWF | 5 | 5 | 0 | 7 | 3 | 0 | 11 | 7 | 16 | 0 | 0 | 7 | 3 | 3 | 3 | 0 | 0 | 14 | 12 |

Table 3.7 (h): Observed heatwaves in Sargodha

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Heat waves Based on TX90p | | | | | | | | | | | | | | | | | |
| HWM | 33 | 31 | 45 | 44 | 44 | 43 | 44 | 45 | 49 | 40 | 41 | 47 | 0 | 44 | 47 | 0 | 0 | 0 | 0 |
| HWA | 35 | 33 | 45 | 48 | 49 | 48 | 50 | 46 | 50 | 40 | 48 | 49 | 0 | 48 | 48 | 0 | 0 | 0 | 0 |
| HWN | 2 | 2 | 1 | 4 | 3 | 3 | 2 | 1 | 1 | 1 | 7 | 2 | 0 | 3 | 1 | 0 | 0 | 0 | 0 |
| HWD | 3 | 3 | 3 | 8 | 6 | 4 | 6 | 4 | 4 | 4 | 7 | 4 | 0 | 4 | 3 | 0 | 0 | 0 | 0 |
| HWF | 7 | 7 | 3 | 20 | 14 | 10 | 11 | 4 | 4 | 4 | 28 | 7 | 0 | 10 | 3 | 0 | 0 | 0 | 0 |
| | Heat waves Based on TN90p | | | | | | | | | | | | | | | | | |
| HWM | 18 | 14 | 30 | 31 | 28 | 0 | 30 | 32 | 32 | 0 | 27 | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| HWA | 19 | 15 | 31 | 31 | 30 | 0 | 33 | 33 | 34 | 0 | 27 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| HWN | 1 | 1 | 1 | 1 | 4 | 0 | 3 | 2 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| HWD | 2 | 2 | 3 | 3 | 4 | 0 | 5 | 3 | 6 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| HWF | 5 | 3 | 3 | 3 | 13 | 0 | 11 | 6 | 6 | 0 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 3.7 (i): Observed heatwaves in Sialkot

| Indices | Baseline | Avg 2001-2017 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Heat waves Based on TX90p | | | | | | | | | | | | | | | | | | |
| HWM | 29 | 38 | 43 | 43 | 0 | 40 | 41 | 44 | 43 | 36 | 41 | 45 | 37 | 43 | 45 | 45 | 36 | 36 | 36 |
| HWA | 31 | 40 | 45 | 45 | 0 | 44 | 47 | 45 | 47 | 37 | 45 | 46 | 37 | 46 | 47 | 45 | 36 | 36 | 36 |
| HWN | 2 | 2 | 1 | 5 | 0 | 3 | 2 | 1 | 2 | 1 | 4 | 2 | 1 | 5 | 1 | 1 | 2 | 1 | 1 |
| HWD | 4 | 4 | 4 | 11 | 0 | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 3 | 5 | 7 | 4 | 5 | 3 | 3 |
| HWF | 8 | 7 | 4 | 26 | 0 | 11 | 7 | 3 | 4 | 3 | 15 | 7 | 3 | 18 | 7 | 4 | 8 | 3 | 3 |
| | Heat waves Based on TN90p | | | | | | | | | | | | | | | | | | |
| HWM | 17 | 19 | 29 | 0 | 0 | 0 | 29 | 28 | 0 | 27 | 29 | 30 | 0 | 30 | 30 | 30 | 0 | 27 | 29 |
| HWA | 18 | 20 | 30 | 0 | 0 | 0 | 32 | 29 | 0 | 29 | 31 | 31 | 0 | 31 | 31 | 32 | 0 | 28 | 31 |
| HWN | 1 | 1 | 1 | 0 | 0 | 0 | 3 | 1 | 0 | 2 | 3 | 2 | 0 | 3 | 1 | 2 | 0 | 2 | 2 |
| HWD | 2 | 2 | 3 | 0 | 0 | 0 | 3 | 3 | 0 | 6 | 3 | 3 | 0 | 3 | 4 | 5 | 0 | 4 | 3 |
| HWF | 4 | 4 | 3 | 0 | 0 | 0 | 9 | 3 | 0 | 9 | 9 | 6 | 0 | 9 | 4 | 9 | 0 | 8 | 6 |

## 3.5. Future Climate Change

**Temperature Changes:** Under RCP4.5, the North region of Punjab shows highest increase in maximum and minimum temperature till 2050 (fig. 3.10(ii(a,b)).The maximum temperature is projected to increase by 1.72˚C while minimum temperature is likely to increase by 1.74˚C on average in the region by 2050. As seen in the observed, the region shows lowest maximum and minimum temperature during the period 1971-2000, however, in future the highest increase in temperature is projected in North region of Punjab under RCP4.5. Almost similar trend can be seen in case of RCP8.5, in which North Pakistan shows highest increase in maximum and minimum temperature of about 2.04˚C and 2.16˚C respectively compared to baseline (1975-2005) by 2050 (fig. 3.10(iii(a,b)). Among all the stations located on North region, Rawalpindi shows highest increase in maximum and minimum temperature under both emission scenarios i.e. RCP4.5 and RCP8.5.

The Central region also show increase in minimum and maximum temperature by 2050 under both RCPs but the rate of increase is less than North region. The maximum temperature is projected to increase by 1.66˚C while minimum temperature by 1.64˚C under RCP4.5. The highest increase in maximum temperature is projected is Faisalabad while Sargodha shows highest increase in minimum temperature. Under RCP8.5, the maximum temperature is projected to increase by 2.07˚C while minimum temperature by 2.11˚C. However, it can be noted that the areas lying at the border of central and north region show less increase in minimum temperature compared to adjacent areas.

The South region, characterized by hot and dry conditions also shows increase in maximum and minimum temperature in future but the rate of increase is less compared to north and central region. Under RCP4.5, the average increase in maximum temperature is projected to be 1.52˚C while minimum temperature shows an increase of 1.60˚C. Among all the stations of south region, D.G Khan shows highest projected increase in maximum and minimum temperature under RCP4.5. RCP8.5 also show projected increase in temperature of about 1.95˚C in maximum and 2.11˚C in minimum temperature by 2050 in the South. Similar to RCP4.5, D.G Khan show highest increase in maximum and minimum temperature in the region in future.

**Precipitation Changes:**

Similar to temperature, precipitation also shows projected increase in all the three regions under both emission scenarios, however, there exist spatial variability between two scenarios (fig. 3.10(ii(c), iii(c)). It can be seen in the figure that under RCP4.5, the highest increase is projected in the western edge of North and Central region while lowest increase is projected over north eastern part of Central region. The South region, which showed relatively dry conditions in observed precipitation, also show highest projected increase in precipitation under RCP 4.5. On average, the north region shows 5.64%, central 4.84% and south 7.63% increase in precipitation under RCP4.5.

Under RCP8.5, it can be seen that highest increase in precipitation is projected in the South part while, the north and central region which lie in core monsoon region of Pakistan show less increase comparatively. On average, the north region show 6.61% increase in precipitation by 2050, central region shows 6.35% increase while highest increase of about 9.28% in average annual daily precipitation.

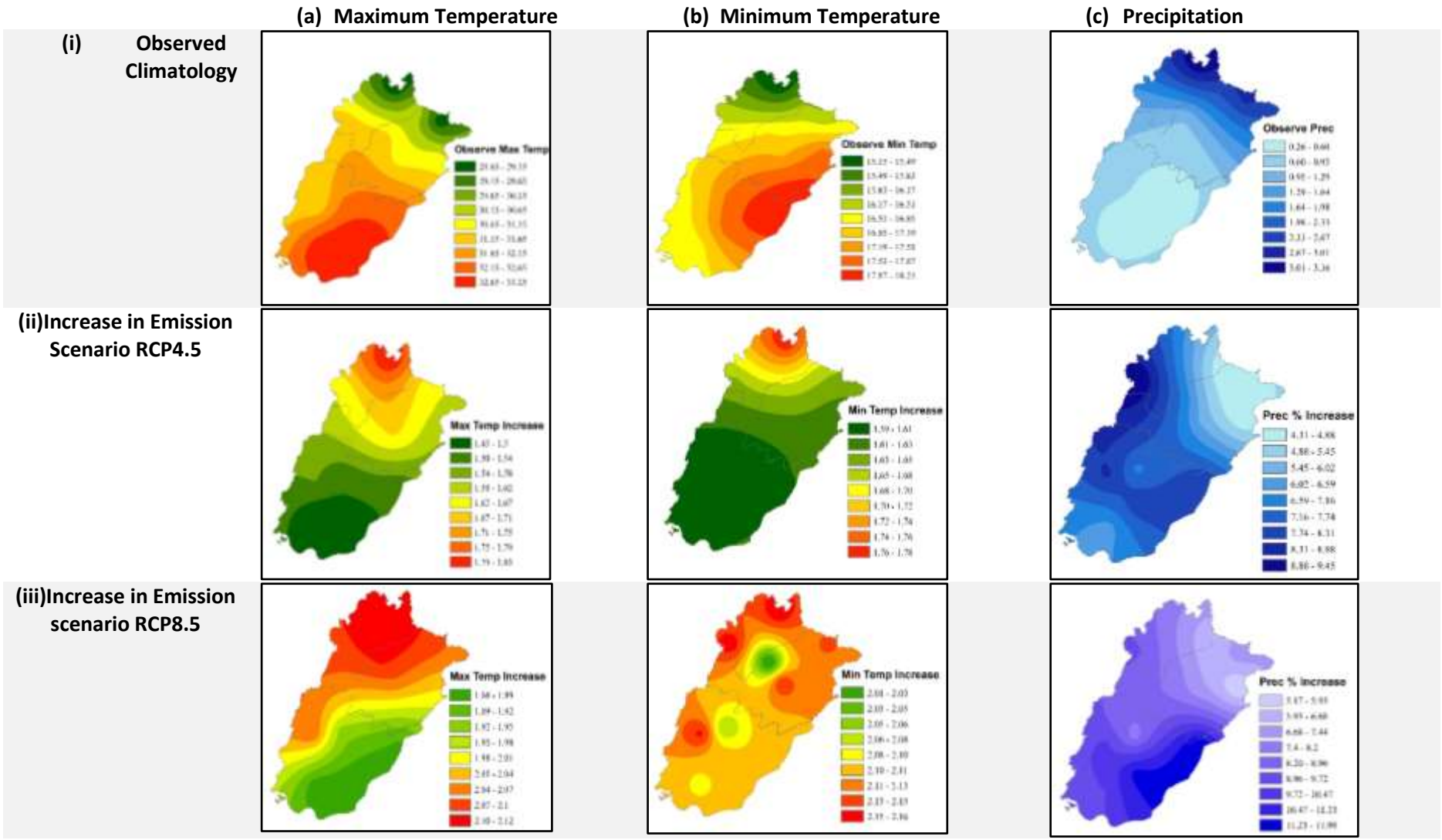



Figure 3.10: Observed (1971-2000) and future (2050) changes in maximum, minimum temperature and precipitation under RCP4.5 and RCP8.5.

**Station wise analysis:**

**North Punjab:** The North region of Punjab shows highest increase in average temperature compared to central and southern part by 2050 (Table 3.8). Under RCP4.5 the region shows 1.73 ˚C increase in average annual temperature by mid-century with 1.72 ˚C increase in maximum and 1.74 ˚C increase in minimum temperature. Compared to 1976-2005 level. The average temperature is likely to reach 24.86 ˚C while the maximum temperature during 2006-2050 is projected to be 32.04 ˚C and minimum temperature as 17.69˚C. It can also be note that among all the four seasons, the highest increase in temperature is likely to occur in spring season (MAM) both in the case of minimum as well as maximum temperature. Among the cities located in North Punjab, Rawalpindi shows the highest increase in average as well as maximum and minimum temperature under RCP4.5. The average temperature in the city is likely to reach 23.56 ˚C with 1.93˚C increase compared to 1976-2005 level. The minimum temperature show more increase (1.95˚C) compared to increase in maximum temperature (1.91˚C). The highest increase of 2˚C is projected in the season of spring which shows the hot conditions in spring and earlier onset of summer season in the city. Similarly, in Jhelum, the average temperature is projected to increase by 1.65˚C against the 1976-2005 level. The average temperature is projected to reach by 25.33˚C by 2050 in Jhelum. However, the increase in minimum and maximum temperature is expected to be similar in the city with maximum increase in MAM. The third city of the North Punjab, Mianwali, shows average temperature higher than other two cities i.e. 25.71˚C, however, the increase in temperature compared to baseline period is less compared to other two cities and shows 1.61˚C increase in average temperature. Similar to the other two cities, the highest increase in temperature on seasonal scale is also projected in MAM by 2.50˚C.

Under most intense scenario, RCP8.5, the average temperature over the North Punjab is projected to reach by 25.26˚C with 2.13 ˚C increase against the baseline level. The maximum temperature shows an increase of 2.04˚C while minimum temperature is projected to increase by 2.16 ˚C by 2050. Hence, the maximum and minimum temperature will reach by 33.49˚C and 18.10 ˚C on average in the North part by 2050. Similar to RCP4.5, the months of spring (MAM) show highest increase in maximum as well as minimum temperature in the future. Under RCP8.5 also, Rawalpindi shows highest increase in temperature i.e. 2.15˚C

compared to other cities in the region despite lower projected average temperature than others. The average temperature is likely to reach by 23.78 ˚C with 32.21˚C maximum and 16.60˚C minimum temperature respectively. The city of Jhelum shows higher average temperature of 25.80˚C in future, however, the increase compared to baseline level is likely to be 2.12˚C. Similar to other stations, the minimum temperature shows higher increase compared to maximum temperature in the future with 2.14 ˚C increase by 2050. The increase in average temperature over Mianwali is similar to Jhelum i.e. 2.13˚C however, the projected average temperature is higher than Jhelum i.e. 26.22˚C by 2050. The months of MAM shows highest increase in temperature in future with highest increase in maximum temperature in MAM i.e. 2.38˚C. This high increase in temperature can have important implications for heatwave in the region and can cause adverse impacts on agriculture as well.

Table 3.8: Maximum and Minimum temperature change in North Punjab under RCP4.5 and 8.5

| | **SEASONAL MAX TEMP** | | | | | **SEASONAL MIN TEMP** | | | | | **ANNUAL MEAN** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DJF | MAM | JJA | SON | Average | DJF | MAM | JJA | SON | Average | |
| | | | | | **RCP4.5** | | | | | | |
| **RAWALPINDI** | | | | | | | | | | | |
| **1976-2005** | **19.27** | **30.08** | **35.79** | **30.14** | **28.82** | **4.29** | **15.19** | **23.89** | **14.34** | **14.43** | **21.63** |
| **2006-2050** | **21.16** | **32.14** | **37.63** | **32.01** | **30.74** | **6.23** | **17.19** | **25.79** | **16.31** | **16.38** | **23.56** |
| **CHANGE** | **1.89** | **2.05** | **1.84** | **1.87** | **1.91** | **1.94** | **2.00** | **1.90** | **1.97** | **1.95** | **1.93** |
| **JHELUM** | | | | | | | | | | | |
| **1976-2005** | **20.92** | **32.71** | **36.93** | **31.66** | **30.55** | **6.71** | **17.72** | **25.86** | **16.92** | **16.80** | **23.68** |
| **2006-2050** | **22.49** | **34.52** | **38.53** | **33.28** | **32.21** | **8.24** | **19.43** | **27.51** | **18.61** | **18.45** | **25.33** |
| **CHANGE** | **1.58** | **1.82** | **1.61** | **1.61** | **1.65** | **1.53** | **1.72** | **1.64** | **1.68** | **1.64** | **1.65** |
| **MIANWALI** | | | | | | | | | | | |
| **1976-2005** | **21.15** | **32.99** | **39.62** | **32.55** | **31.58** | **5.31** | **17.26** | **27.21** | **16.66** | **16.61** | **24.09** |
| **2006-2050** | **22.71** | **34.77** | **41.10** | **34.13** | **33.18** | **6.82** | **18.94** | **28.84** | **18.33** | **18.23** | **25.71** |
| **CHANGE** | **1.57** | **1.79** | **1.48** | **1.57** | **1.60** | **1.51** | **1.69** | **1.63** | **1.67** | **1.62** | **1.61** |
| **NORTH** | | | | | | | | | | | |
| **1976-2005** | **20.45** | **31.93** | **37.45** | **31.45** | **30.32** | **5.44** | **16.72** | **25.65** | **15.97** | **15.95** | **23.13** |
| **2006-2050** | **22.12** | **33.81** | **39.09** | **33.14** | **32.04** | **7.10** | **18.52** | **27.38** | **17.75** | **17.69** | **24.86** |
| **CHANGE** | **1.68** | **1.89** | **1.64** | **1.69** | **1.72** | **1.66** | **1.80** | **1.72** | **1.77** | **1.74** | **1.73** |

| | RCP8.5 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **RAWALPINDI** | | | | | | | | | | | |
| **1976-2005** | 19.27 | 30.08 | 35.79 | 30.14 | 28.82 | 4.29 | 15.19 | 23.89 | 14.34 | 14.43 | 21.63 |
| **2006-2050** | 21.39 | 32.47 | 37.75 | 32.21 | 30.95 | 6.48 | 17.42 | 25.97 | 16.53 | 16.60 | 23.78 |
| **CHANGE** | 2.11 | 2.38 | 1.96 | 2.07 | 2.13 | 2.19 | 2.23 | 2.08 | 2.18 | 2.17 | 2.15 |
| **JHELUM** | | | | | | | | | | | |
| **1976-2005** | 20.92 | 32.71 | 36.93 | 31.66 | 30.55 | 6.71 | 17.72 | 25.86 | 16.92 | 16.80 | 23.68 |
| **2006-2050** | 23.01 | 35.09 | 38.84 | 33.69 | 32.66 | 8.79 | 19.93 | 27.92 | 19.11 | 18.94 | 25.80 |
| **CHANGE** | 2.10 | 2.38 | 1.91 | 2.03 | 2.10 | 2.08 | 2.22 | 2.06 | 2.19 | 2.14 | 2.12 |
| **MIANWALI** | | | | | | | | | | | |
| **1976-2005** | 21.15 | 32.99 | 39.62 | 32.55 | 31.58 | 5.31 | 17.26 | 27.21 | 16.66 | 16.61 | 24.09 |
| **2006-2050** | 23.25 | 35.34 | 41.50 | 34.58 | 33.67 | 7.39 | 19.48 | 29.32 | 18.88 | 18.77 | 26.22 |
| **CHANGE** | 2.11 | 2.35 | 1.88 | 2.03 | 2.09 | 2.08 | 2.22 | 2.11 | 2.22 | 2.16 | 2.13 |
| **NORTH** | | | | | | | | | | | |
| **1976-2005** | 20.45 | 31.93 | 37.45 | 31.45 | 30.32 | 5.44 | 16.72 | 25.65 | 15.97 | 15.95 | 23.13 |
| **2006-2050** | 22.55 | 34.30 | 39.36 | 33.49 | 32.43 | 7.55 | 18.95 | 27.74 | 18.17 | 18.10 | 25.26 |
| **CHANGE** | 2.11 | 2.37 | 1.92 | 2.04 | 2.11 | 2.12 | 2.22 | 2.08 | 2.20 | 2.16 | 2.13 |

**Central Punjab:** The Central Punjab which is hub of industrial activities in Punjab is also likely to show prominent changes in temperature under changing climate scenario by 2050 (Table 3.9). Under RCP4.5 the region on average is likely to show increase in average temperature by 1.64 ˚C with 25.54˚C average temperature projected in 2006-2050 period. Unlike northern region, the central Punjab shows an overall higher increase in maximum temperature than the minimum temperature with MAM showing highest increase. The maximum temperature is likely to be 32.18˚C and minimum temperature to 18.90˚C on average in future period. The cities located in central Punjab also show a prominent increase till mid-century. In Faisalabad, The average temperature is likely to reach 25.31˚C during 2006-2050 with 1.68˚C increase compared to baseline period. The maximum and minimum temperature shows an increase of 1.72˚C and 1.63˚C respectively under RCP4.5. The highest increase in temperature at seasonal level is projected in MAM followed by SON (autumn) period which indicate the prolonged summer season in the city. The capital of Punjab, Lahore, shows the average temperature higher than Faisalabad i.e. 26.24 VC while the increase is temperature is less comparatively. The city is likely to experience 1.6˚C temperature higher than baseline level during 2006-2050 on average while the increase in maximum and minimum temperature is projected as 1.59˚C

and 1.61˚C respectively. In Sargodha, the increase in temperature is quite close to Faisalabad yet higher than Lahore although the average temperature projected is less than that of Lahore i.e. 26.15˚C. On average, an increase of 1.67˚C is projected in mean temperature over the city in future with maximum temperature showing increase higher then minimum temperature increase i.e. 1.70˚C compared to 1.64 ˚C respectively. In case of Sialkot, an increase of 1.63˚C is projected during 2006-2050 period with average temperature likely to reach by 24.45˚C the increase in minimum and maximum temperature is projected to be almost similar in the future. However, in MAM the maximum and minimum temperature show prominent high increase compared to other months of the year.

Under RCP8.5, the central Punjab show higher increase in temperature during 2006-2050 period with 2.09˚C increase and 26.07˚C average temperature. Unlike RCP4.5, the minimum temperature in the region show higher increase compared to maximum temperature. In Faisalabad, the increase in temperature is projected to be 2.11˚C with average temperature likely to reach by 26.09˚C. In case of maximum temperature, the increase is projected as 2.05˚C while minimum temperature shows an increase of 2.15˚C. A higher average temperature of 26.54˚C is projected in provincial capital, Lahore, against the increase of 2.08˚C compared to 1976-2005 level. The minimum temperature shows increase higher than maximum temperature in the city i.e. 2.13˚C compared to 1.94˚C respectively. Similar to other cities, Lahore too is likely to experience highest increase in temperature during spring and autumn season of the year. The city of Jhelum shows higher average temperature of 26.54˚C in future, however, the increase compared to baseline level is likely to be 2.06˚C. The maximum temperature shows higher increase compared to minimum temperature in the future with 2.11 ˚C increase by 2050. The increase in average temperature over Sialkot is similar to Faisalabad i.e. 2.11C however, the projected average temperature is lower than other cities i.e. 24.93˚C by 2050. The months of MAM shows highest increase in temperature in future with highest increase in maximum temperature in MAM i.e. 2.36˚C.

Table 3.9: Maximum and Minimum temperature change in Central Punjab under RCP4.5 and 8.5

| | **SEASONAL MAX TEMP** | | | | | **SEASONAL MIN TEMP** | | | | | **ANNUAL MEAN** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DJF | MAM | JJA | SON | Average | DJF | MAM | JJA | SON | Average | |
| | | | | | **RCP4.5** | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **FAISALABAD** | | | | | | | | | | | |
| **1976-2005** | 20.93 | 33.17 | 38.01 | 31.96 | 30.32 | 5.79 | 17.94 | 26.89 | 17.19 | 16.95 | 23.64 |
| **2006-2050** | 22.50 | 35.01 | 39.58 | 33.58 | 32.04 | 7.26 | 19.65 | 28.55 | 18.90 | 18.59 | 25.31 |
| **CHANGE** | 1.57 | 1.84 | 1.58 | 1.61 | 1.72 | 1.47 | 1.71 | 1.65 | 1.70 | 1.63 | 1.68 |
| **LAHORE** | | | | | | | | | | | |
| **1976-2005** | 21.21 | 33.30 | 36.88 | 31.78 | 30.79 | 8.37 | 19.76 | 27.03 | 18.83 | 18.50 | 24.65 |
| **2006-2050** | 22.77 | 35.06 | 38.39 | 33.30 | 32.38 | 9.88 | 21.45 | 28.62 | 20.48 | 20.11 | 26.24 |
| **CHANGE** | 1.55 | 1.75 | 1.51 | 1.53 | 1.59 | 1.51 | 1.69 | 1.59 | 1.65 | 1.61 | 1.60 |
| **SARGODHA** | | | | | | | | | | | |
| **1976-2005** | 21.32 | 33.69 | 38.78 | 32.46 | 31.56 | 6.11 | 18.40 | 27.15 | 17.89 | 17.39 | 24.48 |
| **2006-2050** | 22.91 | 35.59 | 40.44 | 34.12 | 33.27 | 7.58 | 20.12 | 28.83 | 19.59 | 19.03 | 26.15 |
| **CHANGE** | 1.59 | 1.90 | 1.66 | 1.66 | 1.70 | 1.47 | 1.72 | 1.68 | 1.69 | 1.64 | 1.67 |
| **SIALKOT** | | | | | | | | | | | |
| **1976-2005** | 19.81 | 31.97 | 35.73 | 30.06 | 29.40 | 6.21 | 17.15 | 25.14 | 16.48 | 16.24 | 22.82 |
| **2006-2050** | 21.39 | 33.76 | 37.29 | 31.63 | 31.02 | 7.75 | 18.86 | 26.75 | 18.13 | 17.87 | 24.45 |
| **CHANGE** | 1.58 | 1.79 | 1.55 | 1.57 | 1.62 | 1.54 | 1.71 | 1.61 | 1.66 | 1.63 | 1.63 |
| **CENTRAL** | | | | | | | | | | | |
| **1976-2005** | **20.82** | **33.04** | **37.35** | **31.57** | **30.52** | **6.62** | **18.31** | **26.55** | **17.60** | **17.27** | **23.89** |
| **2006-2050** | **22.39** | **34.86** | **38.92** | **33.16** | **32.18** | **8.12** | **20.02** | **28.19** | **19.27** | **18.90** | **25.54** |
| **CHANGE** | **1.57** | **1.82** | **1.57** | **1.59** | **1.66** | **1.50** | **1.71** | **1.64** | **1.68** | **1.63** | **1.64** |
| | | | | | | | | | | | |
| | | | | | **RCP8.5** | | | | | | |
| **FAISALABAD** | | | | | | | | | | | |
| **1976-2005** | 20.93 | 33.17 | 38.01 | 31.96 | 31.02 | 5.79 | 17.94 | 26.89 | 17.19 | 16.95 | 23.99 |
| **2006-2050** | 23.00 | 35.54 | 39.84 | 33.95 | 33.08 | 7.82 | 20.16 | 28.98 | 19.45 | 19.10 | 26.09 |
| **CHANGE** | 2.07 | 2.37 | 1.83 | 1.98 | 2.06 | 2.04 | 2.22 | 2.08 | 2.26 | 2.15 | 2.11 |
| **LAHORE** | | | | | | | | | | | |
| **1976-2005** | 21.21 | 33.30 | 36.88 | 31.78 | 30.79 | 8.37 | 19.76 | 27.03 | 18.83 | 18.50 | 24.65 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2006-2050** | 23.27 | 35.61 | 38.67 | 33.72 | 32.82 | 10.45 | 21.97 | 29.05 | 21.03 | 20.62 | 26.72 |
| **CHANGE** | 2.06 | 2.31 | 1.79 | 1.94 | 2.02 | 2.07 | 2.22 | 2.03 | 2.20 | 2.13 | 2.08 |
| **SARGODHA** | | | | | | | | | | | |
| **1976-2005** | 21.32 | 33.69 | 38.78 | 32.46 | 31.56 | 6.11 | 18.40 | 27.15 | 17.89 | 17.39 | 24.48 |
| **2006-2050** | 23.40 | 36.11 | 40.69 | 34.48 | 33.67 | 8.01 | 20.50 | 29.14 | 19.98 | 19.41 | 26.54 |
| **CHANGE** | 2.08 | 2.42 | 1.91 | 2.02 | 2.11 | 1.90 | 2.10 | 1.99 | 2.09 | 2.02 | 2.06 |
| **SIALKOT** | | | | | | | | | | | |
| **1976-2005** | 19.81 | 31.97 | 35.73 | 30.06 | 29.40 | 6.21 | 17.15 | 25.14 | 16.48 | 16.24 | 22.82 |
| **2006-2050** | 21.91 | 34.33 | 37.61 | 32.07 | 31.48 | 8.31 | 19.38 | 27.18 | 18.66 | 18.38 | 24.93 |
| **CHANGE** | 2.10 | 2.36 | 1.87 | 2.00 | 2.09 | 2.10 | 2.22 | 2.04 | 2.18 | 2.14 | 2.11 |
| **CENTRAL** | | | | | | | | | | | |
| **1976-2005** | **20.82** | **33.04** | **37.35** | **31.57** | **30.69** | **6.62** | **18.31** | **26.55** | **17.60** | **17.27** | **23.98** |
| **2006-2050** | **22.90** | **35.40** | **39.20** | **33.55** | **32.76** | **8.65** | **20.50** | **28.59** | **19.78** | **19.38** | **26.07** |
| **CHANGE** | **2.08** | **2.36** | **1.85** | **1.99** | **2.07** | **2.03** | **2.19** | **2.04** | **2.18** | **2.11** | **2.09** |

**South Punjab:** The Southern part of Punjab which is characterized by hot condition also show projected increase in temperature in future. However, despite higher average temperature projected in the region, the increase in future temperature compared to baseline level is lower as compared to North and Central Punjab (Table 3.10). The region shows an increase of 1.56˚C in mean temperature with average temperature likely to reach by 26.78˚C on overall region. Like many other cities in Punjab, the region is likely to show higher increase in minimum temperature as compared to maximum temperature compared to baseline temperature level. The hottest city of southern Punjab, Bahwalnagar show highest average temperature in future i.e. 27.21 ˚C with 1.57˚C increase compared to baseline level. The minimum temperature is likely to increase by 1.62˚C while maximum temperature shows an increase of 1.51˚C compared to 1976-2005 level. Similarly, in Bahwalpur, the average temperature is projected to increase by 1.55˚C against the 1976-2005 level. The average temperature is projected to reach by 27.12 ˚C by 2050 in the city. However, the increase in minimum and maximum temperature is expected to be 1.60˚C and 1.50˚C respectively in the city with maximum increase in MAM. In Multan, the increase in temperature is projected to

be 1.53˚C with average temperature likely to reach by 26.98˚C. In case of maximum temperature, the increase is projected as 1.49 ˚C while minimum temperature shows an increase of 1.58 ˚C. The fourth city of the South Punjab, D.G Khan, shows average temperature lower than other cities i.e. 25.83˚C, however, the increase in temperature compared to baseline period is highest compared to other cities and shows 1.58˚C increase in average temperature. Similar to the other two cities, the highest increase in temperature on seasonal scale is also projected in MAM by 2050.

Under RCP8.5, the southern Punjab show higher increase in temperature during 2006-2050 period with 2.03˚C increase and 27.26˚C average temperature. Similar RCP4.5, the minimum temperature in the region show higher increase compared to maximum temperature. In Bahawalnagar, the increase in temperature is projected to be 2.0˚C with average temperature likely to reach by 27.65˚C. In case of maximum temperature, the increase is projected as 1.76˚C while minimum temperature shows an increase of 2.11˚C. A higher average temperature of 27.57˚C is projected in Bahawalpur against the increase of 2.0˚C compared to 1976-2005 level. The minimum temperature shows increase higher than maximum temperature in the city i.e. 2.11˚C compared to 1.81˚C respectively. Similar to other cities, Bahawalpur too is likely to experience highest increase in temperature during spring and autumn season of the year. The city of Multan also shows higher average temperature of 27.44˚C in future, however, the increase compared to baseline level is likely to be 2.0˚C. The minimum temperature shows higher increase compared to maximum temperature in the future with 2.07 ˚C increase by 2050. The increase in average temperature over D.G Khan is higher than other cities i.e. 2.12˚C however, the projected average temperature is lower than other cities i.e. 26.37˚C by 2050. The months of MAM shows highest increase in temperature in future similar to other cities of the province.

Table 1.10: Maximum and Minimum temperature change in South Punjab under RCP4.5 and 8.5

| | **SEASONAL MAX TEMP** | | | | | **SEASONAL MIN TEMP** | | | | | **ANNUAL MEAN** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | DJF | MAM | JJA | SON | Average | DJF | MAM | JJA | SON | Average | |
| | | | | | **RCP4.5** | | | | | | |
| **B-NAGAR** | | | | | | | | | | | |
| **1976-2005** | 22.02 | 35.14 | 39.49 | 33.42 | 32.51 | 7.88 | 19.95 | 28.14 | 19.12 | 18.78 | 25.65 |
| **2006-2050** | 23.56 | 36.87 | 40.84 | 34.83 | 34.02 | 9.43 | 21.69 | 29.67 | 20.81 | 20.40 | 27.21 |
| **CHANGE** | 1.03 | 1.19 | 0.91 | 0.94 | 1.51 | 1.05 | 1.20 | 0.99 | 1.18 | 1.62 | 1.57 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **B-PUR** | | | | | | | | | | | |
| **1976-2005** | 22.92 | 35.45 | 39.92 | 33.52 | 32.95 | 7.23 | 19.24 | 27.91 | 18.34 | 18.18 | 25.57 |
| **2006-2050** | 24.47 | 37.10 | 41.28 | 34.95 | 34.45 | 8.76 | 20.93 | 29.39 | 20.05 | 19.78 | 27.12 |
| **CHANGE** | 1.55 | 1.64 | 1.36 | 1.43 | 1.50 | 1.53 | 1.68 | 1.47 | 1.71 | 1.60 | 1.55 |
| **MULTAN** | | | | | | | | | | | |
| **1976-2005** | 22.44 | 35.06 | 39.67 | 33.27 | 32.61 | 7.03 | 19.86 | 28.37 | 17.83 | 18.27 | 25.44 |
| **2006-2050** | 23.93 | 36.73 | 41.03 | 34.70 | 34.10 | 8.52 | 21.51 | 29.88 | 19.49 | 19.85 | 26.98 |
| **CHANGE** | 1.50 | 1.68 | 1.36 | 1.44 | 1.49 | 1.49 | 1.66 | 1.51 | 1.66 | 1.58 | 1.53 |
| **D.G KHAN** | | | | | | | | | | | |
| **1976-2005** | 21.63 | 33.19 | 39.14 | 32.65 | 31.65 | 5.91 | 18.02 | 26.25 | 17.22 | 16.85 | 24.25 |
| **2006-2050** | 23.18 | 34.92 | 40.60 | 34.17 | 33.22 | 7.38 | 19.67 | 27.85 | 18.91 | 18.45 | 25.83 |
| **CHANGE** | 1.55 | 1.73 | 1.46 | 1.52 | 1.57 | 1.47 | 1.65 | 1.60 | 1.69 | 1.60 | 1.58 |
| **SOUTH** | | | | | | | | | | | |
| **1976-2005** | **22.25** | **34.71** | **39.55** | **33.21** | **32.43** | **7.01** | **19.27** | **27.67** | **18.13** | **18.02** | **25.23** |
| **2006-2050** | **23.78** | **36.41** | **40.94** | **34.66** | **33.95** | **8.52** | **20.95** | **29.20** | **19.81** | **19.62** | **26.78** |
| **CHANGE** | **1.53** | **1.70** | **1.38** | **1.45** | **1.52** | **1.51** | **1.68** | **1.53** | **1.69** | **1.60** | **1.56** |
| | | | | | | | | | | | |
| | | | | | **RCP8.5** | | | | | | |
| **B-NAGAR** | | | | | | | | | | | |
| **1976-2005** | 22.02 | 35.14 | 39.49 | 33.42 | 32.51 | 7.88 | 19.95 | 28.14 | 19.12 | 18.78 | 25.65 |
| **2006-2050** | 24.01 | 37.35 | 41.08 | 35.18 | 34.40 | 9.97 | 22.18 | 30.05 | 21.36 | 20.89 | 27.65 |
| **CHANGE** | 1.99 | 2.21 | 1.59 | 1.76 | 1.89 | 2.08 | 2.23 | 1.91 | 2.23 | 2.11 | 2.00 |
| **B-PUR** | | | | | | | | | | | |
| **1976-2005** | 22.92 | 35.45 | 39.92 | 33.52 | 32.95 | 7.23 | 19.24 | 27.91 | 18.34 | 18.18 | 25.57 |
| **2006-2050** | 24.91 | 37.62 | 41.54 | 35.33 | 34.85 | 9.32 | 21.47 | 29.79 | 20.57 | 20.29 | 27.57 |
| **CHANGE** | 1.99 | 2.17 | 1.62 | 1.81 | 1.90 | 2.09 | 2.23 | 1.87 | 2.24 | 2.11 | 2.00 |
| **MULTAN** | | | | | | | | | | | |
| **1976-2005** | 22.44 | 35.06 | 39.67 | 33.27 | 32.61 | 7.03 | 19.86 | 28.37 | 17.83 | 18.27 | 25.44 |
| **2006-2050** | 24.45 | 37.26 | 41.35 | 35.12 | 34.54 | 8.72 | 21.62 | 30.43 | 20.62 | 20.34 | 27.44 |
| **CHANGE** | 2.02 | 2.20 | 1.68 | 1.85 | 1.94 | 1.68 | 1.76 | 2.06 | 2.78 | 2.07 | 2.00 |
| **D.G KHAN** | | | | | | | | | | | |
| **1976-2005** | 21.63 | 33.19 | 39.14 | 32.65 | 31.65 | 5.91 | 18.02 | 26.25 | 17.22 | 16.85 | 24.25 |
| **2006-2050** | 23.75 | 35.51 | 41.01 | 34.66 | 33.73 | 7.96 | 20.22 | 28.34 | 19.50 | 19.00 | 26.37 |
| **CHANGE** | 2.12 | 2.32 | 1.87 | 2.01 | 2.08 | 2.05 | 2.20 | 2.09 | 2.28 | 2.15 | 2.12 |
| **SOUTH** | | | | | | | | | | | |
| **1976-2005** | **22.25** | **34.71** | **39.55** | **33.21** | **32.43** | **7.01** | **19.27** | **27.67** | **18.13** | **18.02** | **25.23** |
| **2006-2050** | **24.28** | **36.94** | **41.24** | **35.07** | **34.38** | **8.99** | **21.37** | **29.65** | **20.51** | **20.13** | **27.26** |
| **CHANGE** | **2.03** | **2.23** | **1.69** | **1.86** | **1.95** | **1.98** | **2.10** | **1.98** | **2.38** | **2.11** | **2.03** |

## 3.6. Precipitation Projection

**North Punjab:** The precipitation changes in future show variability across cities and regions of the province under both emission scenarios i.e. RCP4.5 and RCP8.5. The North region of Punjab shows 5.64% increase in daily precipitation on annual scale under RCP4.5 by 2006-2050 (Table 3.11). However, all the seasons show different percent changes during the period.

Compared to highest temperature increase in MAM, the projected increase in precipitation in MAM is minimal or negligible in the region. The highest increase of 10.52% is projected in winter (DJF) months in overall region while JJA and SON shows increase of 5.5% and 6.97% respectively. The city of Rawalpindi shows 5.8% increase in daily precipitation at annual scale. The summer season which is characterized by monsoon in the region shows an increase of 5.39% increase in daily precipitation. The highest increase is projected in DJF i.e. 10.29% while SON shows an increase of 8% with negligible increase in MAM. The increase in Jhelum is lowest as compared to other cities and shows an increase of 3.5% increase on annual scale. While seasons also show variability in increase with 11.5% increase in DJF, 0.8% in MAM, 1.94% in JJA and 5.81% in SON. This shows that monsoon precipitation show no prominent change in future precipitation. Among other cities of North Punjab, Mianwali shows highest increase in precipitation with 10.3% increase at annual scale. However, it can also be seen that despite high increase during other season, precipitation show negative increase during MAM and shows a reduction of -1% during 2006-2050. The city show prominent increase during winter as well as in monsoon season i.e. 15.7% and 14.9% respectively while during SON, an increase of 8.8% is projected.

Under RCP8.5, the precipitation in north region is expected to increase by 6.6% with highest increase in DJF i.e. 10.45%. All the cities under RCP8.5 show negative change in precipitation during MAM while the increase during monsoon is higher than RCP4.5. In Rawalpindi, the increase in precipitation is projected to be 7.1% annually. Contrary to RCP4.5, the highest increase is projected in SON of 11.5% while during DJF the increase of 10.7% is projected. The monsoon precipitation shows an increase of 7.4% in the city. Jhelum shows an overall increase of 5.8% in annual daily precipitation. The highest increase is projected in DJF of around 10.4% while JJA and SON shows increase of 5.7% and 9.46% respectively. MAM on other hand shows negligible negative change in precipitation during 2006-2050. Similar to RCP4.5 the highest increase is projected in the city of Mianwali, however, the increase is less as compared to that of RCP4.5 i.e. 9%. MAM shows negative change of -2% in precipitation with highest increase in DJF i.e. 16%. SON and JJA also show prominent increase in precipitation under RCP8.5 i.e. 12.4% and 11.7% respectively.

Table 3.11: Precipitation changes in North Punjab under RCP4.5 and 8.5

| | DJF | MAM | JJA | SON | AVERAGE |
|---|---|---|---|---|---|
| | | **RCP4.5** | | | |
| **RAWALPINDI** | | | | | |
| **1976-2005** | 1.87 | 2.02 | 7.44 | 1.76 | 3.27 |
| **2006-2050** | 2.06 | 2.05 | 7.84 | 1.90 | 3.46 |
| **CHANGE(%)** | 10.29 | 1.51 | 5.39 | 8.01 | 5.85 |
| **JHELUM** | | | | | |
| **1976-2005** | 1.24 | 1.42 | 5.76 | 1.14 | 2.39 |
| **2006-2050** | 1.39 | 1.43 | 5.87 | 1.21 | 2.47 |
| **CHANGE(%)** | 11.59 | 0.87 | 1.94 | 5.81 | 3.50 |
| **MIANWALI** | | | | | |
| **1976-2005** | 0.73 | 1.42 | 2.92 | 0.73 | 1.45 |
| **2006-2050** | 0.85 | 1.41 | 3.36 | 0.79 | 1.60 |
| **CHANGE(%)** | 15.77 | -1.01 | 14.94 | 8.89 | 10.38 |
| **NORTH** | | | | | |
| **1976-2005** | **1.28** | **1.62** | **5.37** | **1.21** | **2.37** |
| **2006-2050** | **1.43** | **1.63** | **5.69** | **1.30** | **2.51** |
| **CHANGE(%)** | **10.52** | **0.58** | **5.56** | **6.97** | **5.64** |
| | | | | | |
| | | | **RCP8.5** | | |
| **RAWALPINDI** | | | | | |
| **1976-2005** | 1.87 | 2.02 | 7.44 | 1.76 | 3.27 |
| **2006-2050** | 2.07 | 1.99 | 7.99 | 1.96 | 3.50 |
| **CHANGE(%)** | 10.71 | -1.57 | 7.49 | 11.56 | 7.10 |
| **JHELUM** | | | | | |
| **1976-2005** | 1.24 | 1.42 | 5.76 | 1.14 | 2.39 |
| **2006-2050** | 1.37 | 1.41 | 6.09 | 1.25 | 2.53 |
| **CHANGE(%)** | 10.22 | -0.32 | 5.70 | 9.46 | 5.84 |
| **MIANWALI** | | | | | |
| **1976-2005** | 0.73 | 1.42 | 2.92 | 0.73 | 1.45 |
| **2006-2050** | 0.86 | 1.39 | 3.26 | 0.82 | 1.58 |
| **CHANGE(%)** | 16.53 | -2.09 | 11.79 | 12.46 | 9.08 |
| **NORTH** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **1976-2005** | **1.28** | **1.62** | **5.37** | **1.21** | **2.37** |
| **2006-2050** | **1.43** | **1.60** | **5.78** | **1.34** | **2.54** |
| **CHANGE(%)** | **10.45** | **-1.37** | **7.09** | **9.97** | **6.61** |

**Central Punjab:** The region of Central Punjab show increase in precipitation lower than the northern region under RCP4.5 (Table 3.12). On annual scale, the region shows an overall increase of 4.84% increase with highest increase during DJF and minimal change during MAM. Faisalabad shows an increase of 5.6% in annual daily precipitation compared to 1976-2005 level. The highest increase is projected in DJF of 12.13% with 3.9%, 4.5% and 8.4% increase in MAM, JJA and SON respectively. In Lahore, the precipitation increase is projected to be minimal compared to 1976-2005 level and shows an increase of 3.70% on annual daily precipitation. The increase in monsoon precipitation in Lahore is projected to be minimal i.e. 2.52% in future while the increase in DJF, MAM and SON is projected as 8.2%, 3.4% and 6.4% respectively. The highest increase in central Punjab is projected in the city of Sargodha and show an increase of 7.37% in annual daily precipitation. The highest increase is projected in DJF of around 14% followed by SON i.e. 11%. In monsoon season, the precipitation shows an increase of 6.54% with negligible change in MAM. In Sialkot, the annual daily precipitation is likely to increase by 4.8% compared to 1976-2005 level with no change in MAM. The DJF, JJA and SON shows increase of 9%, 5.3% and 2.8% respectively.

Under RCP8.5, the precipitation in central region is expected to increase by 6.3% with highest increase in SON i.e. 8.7%. All the cities under RCP8.5 show negative or no change in precipitation during MAM while the increase during monsoon is higher than RCP4.5. In Faisalabad, the increase in precipitation is projected to be 7.3% annually. Contrary to RCP4.5, the highest increase is projected in SON of 9.4% while during DJF the increase of 9.0% is projected. The monsoon precipitation shows an increase of 8.1% in the city. Lahore shows an overall increase of 5.1% in annual daily precipitation. The highest increase is projected in SON of around 9.1% while DJF and SON shows increase of 6.4% and 9.1% respectively. MAM on other hand shows negligible negative change in precipitation during 2006-2050. Similar to RCP4.5 the highest increase is projected in the city of Sargodha, i.e. 7.6%. MAM shows no change in future precipitation while 12.8% and 13.4% increase is projected in DJF and SON. In Sialkot, the annual precipitation is projected to increase by 7.3% while MAM is projected to

decrease by 2.3% in future, DJF and SON show almost similar increase in precipitation of around 8% compared to 1976-2005 level.

Table 3.12: Precipitation changes in Central Punjab under RCP4.5 and 8.5

| | DJF | MAM | JJA | SON | AVERAGE |
|---|---|---|---|---|---|
| | | | **RCP4.5** | | |
| **FAISALABAD** | | | | | |
| **1976-2005** | 0.37 | 0.63 | 2.34 | 0.49 | 0.96 |
| **2006-2050** | 0.41 | 0.65 | 2.45 | 0.53 | 1.01 |
| **CHANGE(%)** | 12.13 | 3.92 | 4.56 | 8.41 | 5.67 |
| **LAHORE** | | | | | |
| **1976-2005** | 0.71 | 0.86 | 4.63 | 0.94 | 1.78 |
| **2006-2050** | 0.76 | 0.89 | 4.74 | 1.00 | 1.85 |
| **CHANGE(%)** | 8.21 | 3.43 | 2.52 | 6.43 | 3.70 |
| **SARGODHA** | | | | | |
| **1976-2005** | 0.58 | 0.86 | 2.44 | 0.62 | 1.12 |
| **2006-2050** | 0.66 | 0.88 | 2.60 | 0.69 | 1.21 |
| **CHANGE(%)** | 14.87 | 1.93 | 6.54 | 11.16 | 7.37 |
| **SIALKOT** | | | | | |
| **1976-2005** | 1.21 | 1.19 | 6.69 | 1.37 | 2.61 |
| **2006-2050** | 1.32 | 1.19 | 7.05 | 1.41 | 2.74 |
| **CHANGE(%)** | 9.02 | -0.05 | 5.35 | 2.87 | 4.83 |
| **CENTRAL** | | | | | |
| **1976-2005** | **0.71** | **0.88** | **4.02** | **0.85** | **1.62** |
| **2006-2050** | **0.79** | **0.90** | **4.21** | **0.91** | **1.70** |
| **CHANGE(%)** | **9.42** | **1.94** | **4.40** | **5.80** | **4.84** |
| | | | | | |
| | | | **RCP8.5** | | |
| **FAISALABAD** | | | | | |
| **1976-2005** | 0.37 | 0.63 | 2.34 | 0.49 | 0.96 |
| **2006-2050** | 0.40 | 0.63 | 2.53 | 0.54 | 1.03 |
| **CHANGE(%)** | 9.01 | 1.31 | 8.19 | 9.40 | 7.30 |
| **LAHORE** | | | | | |
| **1976-2005** | 0.71 | 0.86 | 4.63 | 0.94 | 1.78 |

| | | | | | |
|---|---|---|---|---|---|
| **2006-2050** | 0.75 | 0.87 | 4.86 | 1.02 | 1.87 |
| **CHANGE(%)** | 6.47 | 0.58 | 5.02 | 9.10 | 5.17 |
| **SARGODHA** | | | | | |
| **1976-2005** | 0.58 | 0.86 | 2.44 | 0.62 | 1.12 |
| **2006-2050** | 0.65 | 0.86 | 2.62 | 0.70 | 1.21 |
| **CHANGE(%)** | 12.86 | 0.11 | 7.61 | 13.40 | 7.65 |
| **SIALKOT** | | | | | |
| **1976-2005** | 1.21 | 1.19 | 6.69 | 1.37 | 2.61 |
| **2006-2050** | 1.31 | 1.16 | 7.28 | 1.48 | 2.81 |
| **CHANGE(%)** | 8.11 | -2.37 | 8.72 | 8.14 | 7.32 |
| **CENTRAL** | | | | | |
| **1976-2005** | **0.71** | **0.88** | **4.02** | **0.85** | **1.62** |
| **2006-2050** | **0.78** | **0.88** | **4.32** | **0.94** | **1.73** |
| **CHANGE(%)** | **8.07** | **-0.40** | **6.90** | **8.71** | **6.35** |

**South Punjab:** The region of Southern Punjab shows an increase of around 7.6% on annual basis under RCP4.5 (Table 3.13). The highest increase is projected in DJF of around 13% and 12.3% increase during SON. The precipitation is likely to increase by 4.5% and 6% respectively in MAM and JJA respectively. Bahawalnagar shows an increase of 8.6% on annual daily basis with no change in DJF precipitation. The highest increase is projected in 15.4% in SON with 8.2% and 9.5% increase in MAM and JJA respectively. Bahawalpur shows an increase of 9% in annual daily precipitation compared to 1976-2005 level. The highest increase is projected in DJF of 22% with 6%, 4.8% and 16% increase in MAM, JJA and SON respectively. In Multan, the precipitation increase is projected to be minimal compared to 1976-2005 level and shows an increase of 5.7% on annual daily precipitation. The increase in monsoon precipitation is projected to be minimal i.e. 2.3% in future while the increase in DJF, MAM and SON is projected as 16%, 2.5% and 12.88% respectively. The highest increase in central Punjab is projected in the city of D.G Khan and show an increase of 9.37% in annual daily precipitation. The highest increase is projected in DJF of around 21.6% followed by SON i.e. 12.5%. In monsoon season, the precipitation shows an increase of 7.9% with 3.6% increase in MAM.

Under RCP8.5, the precipitation in southern region is expected to increase more as compared to RCP4.5 by 9.2% with highest increase in SON i.e. 18%. In Bahawalnagar, the increase in

precipitation is projected to be 12% annually. Similar to RCP4.5, the highest increase is projected in SON of 23% while during DJF the change is projected to be negligible. The monsoon precipitation shows an increase of 11.6% in the city while MAM show high increase of 14%. Bahawalpur shows an overall increase of 11.4% in annual daily precipitation. The highest increase is projected in SON of around 25.4% while DJF, MAM and JJA shows increase of 17.9%, 14.9% and 5.6% respectively. In Multan, the precipitation increase is projected to be minimal compared to 1976-2005 level and shows an increase of 7.8% on annual daily precipitation. The increase in monsoon precipitation is projected to be 3.4% in future while the increase in DJF, MAM and SON is projected as 13.7%, 6.8% and 19.88% respectively. The city of D.G Khan show an increase of 9.7% in annual daily precipitation. The highest increase is projected in SON of around 20.3% followed by SON i.e. 18.5%. In monsoon season, the precipitation shows an increase of 8% with 2.4% increase in MAM.

Table 3.13: Precipitation changes in South Punjab under RCP4.5 and 8.5

| | DJF | MAM | JJA | SON | AVERAGE |
|---|---|---|---|---|---|
| | | | RCP4.5 | | |
| **B-NAGAR** | | | | | |
| **1976-2005** | 0.30 | 0.40 | 1.40 | 0.25 | 0.59 |
| **2006-2050** | 0.30 | 0.44 | 1.54 | 0.28 | 0.64 |
| **CHANGE(%)** | -0.03 | 8.26 | 9.52 | 15.47 | 8.69 |
| **B-PUR** | | | | | |
| **1976-2005** | 0.22 | 0.24 | 0.98 | 0.25 | 0.42 |
| **2006-2050** | 0.27 | 0.26 | 1.02 | 0.29 | 0.46 |
| **CHANGE(%)** | 22.62 | 6.05 | 4.80 | 16.64 | 9.00 |
| **MULTAN** | | | | | |
| **1976-2005** | 0.26 | 0.42 | 1.12 | 0.32 | 0.53 |
| **2006-2050** | 0.31 | 0.43 | 1.15 | 0.36 | 0.56 |
| **CHANGE(%)** | 16.42 | 2.50 | 2.36 | 12.88 | 5.71 |
| **D.G KHAN** | | | | | |
| **1976-2005** | 0.39 | 0.71 | 1.39 | 0.39 | 0.72 |
| **2006-2050** | 0.48 | 0.73 | 1.49 | 0.44 | 0.79 |
| **CHANGE(%)** | 21.69 | 3.62 | 7.92 | 12.51 | 9.37 |
| **SOUTH** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **1976-2005** | **0.29** | **0.44** | **1.22** | **0.30** | **0.57** |
| **2006-2050** | **0.34** | **0.47** | **1.30** | **0.34** | **0.61** |
| **CHANGE(%)** | **13.09** | **4.53** | **6.09** | **12.32** | **7.63** |
| | | **RCP8.5** | | | |
| **B-NAGAR** | | | | | |
| **1976-2005** | 0.30 | 0.40 | 1.40 | 0.25 | 0.59 |
| **2006-2050** | 0.31 | 0.46 | 1.57 | 0.30 | 0.66 |
| **CHANGE(%)** | 1.58 | 14.13 | 11.63 | 23.60 | 12.01 |
| **B-PUR** | | | | | |
| **1976-2005** | 0.22 | 0.24 | 0.98 | 0.25 | 0.42 |
| **2006-2050** | 0.25 | 0.28 | 1.03 | 0.31 | 0.47 |
| **CHANGE(%)** | 17.92 | 14.99 | 5.63 | 25.48 | 11.46 |
| **MULTAN** | | | | | |
| **1976-2005** | 0.26 | 0.42 | 1.12 | 0.32 | 0.53 |
| **2006-2050** | 0.30 | 0.45 | 1.16 | 0.38 | 0.57 |
| **CHANGE(%)** | 13.79 | 6.84 | 3.47 | 19.87 | 7.87 |
| **D.G KHAN** | | | | | |
| **1976-2005** | 0.39 | 0.71 | 1.39 | 0.39 | 0.72 |
| **2006-2050** | 0.47 | 0.73 | 1.50 | 0.47 | 0.79 |
| **CHANGE(%)** | 18.62 | 2.42 | 8.06 | 20.35 | 9.79 |
| **SOUTH** | | | | | |
| **1976-2005** | **0.29** | **0.44** | **1.22** | **0.30** | **0.57** |
| **2006-2050** | **0.33** | **0.48** | **1.31** | **0.37** | **0.62** |
| **CHANGE(%)** | **11.50** | **7.28** | **7.01** | **17.99** | **9.28** |
| | | | | | |

## 3.7. Future Extreme Events:

**North Punjab:** The changing trends of both the temperature and precipitation indices are shown in Table (3.14) for North Punjab. Dry days show increasing trend in all the cities of north Punjab for both the RCPs except Rawalpindi, where they have slightly decreased than baseline in RCP8.5. Inversely, wet days have projected a decreasing trend in both scenarios with exception of Jhelum in RCP4.5. The dry days across north Punjab is projected with an increase of 2.52 days having total of 71.37 days during 2006 to 2050 in RCP4.5 and an increase

of 1.75 days with total 70.6 dry days in RCP8.5. The wet days from baseline decreases by 0.04 days in RCP4.5 and 0.47 in RCP8.5 projecting a total of 7.74 wet days and 7.31 wet days respectively. DTR during RCP4.5 projects an increase of 0.02 C across north Punjab except Rawalpindi and no projected change is observed across north Punjab and Mianwali under RCP8.5. All the precipitation indices (PRCPTOT, R20, R95 and R99, and Rx 5day) have shown increasing trend in both the representative scenarios. The only negative trend is projected by R10 in RCP4.5 in Rawalpindi and by all cities in RCP8.5. Likely, R95 in both the representative scenarios projects higher increase than R99. R95 for Rawalpindi experiences highest projection of 116.04 mm having total of 427.71 mm precipitation in RCP4.5 and 84.65 mm increase with total 396.32 mm precipitation during RCP8.5. The overall 5-day precipitation from 2006 to 2050 is highest for Rawalpindi but the change (increase) is more in Mianwali for both the RCPs.

Among temperature indices, Cool nights and days have projected decreasing trends over all the cities for both RCP4.5 and RCP8.5. Whereas, warm nights and days have increasing trends. The increase in warm days is higher than warm nights in all the cities of north Punjab. Over north Punjab, warm nights project an increase of 27.18 days by RCP4.5 and 30.6 days in RCP8.5. Warm days over north Punjab are predicted to increase by 29.9 days for RCP4.5 and 31.64 days for RCP8.5 during 2006 to 2050. Cold spells have decreasing trend in all the cities while warm spells have increasing trend under both scenarios. Warm spells across north Punjab for RCP4.5 predicts a total of 63.46 days and for RCP8.5 they are 73.13 days.

Table 3.14: Extreme Temperature and Precipitation Indices and their change in north Punjab under RCP4.5 and RCP8.5. The Italicized digits show the change from baseline (1976-2005) and (2006-2050

| | RCP4.5 | | | | RCP8.5 | | | |
|---|---|---|---|---|---|---|---|---|
| **Indices** | **North** | **Rawalpindi** | **Jhelum** | **Mianwali** | **North** | **Rawalpindi** | **Jhelum** | **Mianwali** |
| **CDD** | | | | | | | | |
| **Baseline** | 68.85 | 60.19 | 66.73 | 79.63 | 68.85 | 60.19 | 66.73 | 79.63 |
| **2006-2050** | 71.37 | 60.47 | 68.01 | 85.63 | 70.6 | 59.9 | 68.01 | 83.88 |
| ***Change*** | *2.52* | *0.28* | *1.28* | *6* | *1.75* | *-0.29* | *1.28* | *4.25* |
| **CWD** | | | | | | | | |
| **Baseline** | 7.78 | 8.95 | 8.54 | 5.85 | 7.78 | 8.95 | 8.54 | 5.85 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **2006-2050** | 7.74 | 8.92 | 8.4 | 5.91 | 7.31 | 8.7 | 8.01 | 5.23 |
| ***Change*** | *-0.04* | *-0.03* | *-0.14* | *0.06* | *-0.47* | *-0.25* | *-0.53* | *-0.62* |
| **DTR** | | | | | | | | |
| **Baseline** | 14.37 | 14.39 | 13.74 | 14.97 | 14.37 | 14.39 | 13.74 | 14.97 |
| **2006-2050** | 14.39 | 14.37 | 13.81 | 14.99 | 14.37 | 14.37 | 13.77 | 14.97 |
| ***Change*** | *0.02* | *-0.02* | *0.07* | *0.02* | *0* | *-0.02* | *0.03* | *0* |
| **PRCPTOP** | | | | | | | | |
| **Baseline** | 867.62 | 1196.65 | 875.79 | 530.41 | 867.62 | 1196.65 | 875.79 | 530.41 |
| **2006-2050** | 967.52 | 1308.19 | 954.12 | 640.25 | 923.15 | 1269.97 | 919.57 | 579.91 |
| ***Change*** | *99.9* | *111.54* | *78.33* | *109.84* | *55.53* | *73.32* | *43.78* | *49.5* |
| **R10mm** | | | | | | | | |
| **Baseline** | 24.72 | 33.69 | 24.53 | 15.95 | 24.72 | 33.69 | 24.53 | 15.95 |
| **2006-2050** | 24.73 | 33.43 | 24.78 | 15.98 | 24.13 | 33.14 | 24.05 | 15.21 |
| ***Change*** | *0.01* | *-0.26* | *0.25* | *0.03* | *-0.59* | *-0.55* | *-0.48* | *-0.74* |
| **R20mm** | | | | | | | | |
| **Baseline** | 13.42 | 19.01 | 13.29 | 7.95 | 13.42 | 19.01 | 13.29 | 7.95 |
| **2006-2050** | 14.08 | 19.68 | 14.01 | 8.54 | 13.69 | 19.46 | 13.53 | 8.08 |
| ***Change*** | *0.66* | *0.67* | *0.72* | *0.59* | *0.27* | *0.45* | *0.24* | *0.13* |
| **R95p** | | | | | | | | |
| **Baseline** | 234.76 | 311.67 | 244.89 | 147.72 | 234.76 | 311.67 | 244.89 | 147.72 |
| **2006-2050** | 340.63 | 427.71 | 333.27 | 260.92 | 302.43 | 396.32 | 301.87 | 209.1 |
| ***Change*** | *105.87* | *116.04* | *88.38* | *113.2* | *67.67* | *84.65* | *56.98* | *61.38* |
| **R99p** | | | | | | | | |
| **Baseline** | 74.51 | 98.78 | 78.98 | 45.77 | 74.51 | 98.78 | 78.98 | 45.77 |
| **2006-2050** | 136.18 | 146.56 | 121.03 | 140.96 | 115.87 | 134.12 | 113.95 | 99.53 |
| ***Change*** | *61.67* | *47.78* | *42.05* | *95.19* | *41.36* | *35.34* | *34.97* | *53.76* |
| **Rx5day** | | | | | | | | |
| **Baseline** | 204.94 | 255.93 | 211.12 | 147.78 | 204.94 | 255.93 | 211.12 | 147.78 |
| **2006-2050** | 245.09 | 289.92 | 233.38 | 211.96 | 232.12 | 282.56 | 230.05 | 183.76 |
| ***Change*** | *40.15* | *33.99* | *22.26* | *64.18* | *27.18* | *26.63* | *18.93* | *35.98* |
| **SU** | | | | | | | | |
| **Baseline** | 258.03 | 242.44 | 266.94 | 264.71 | 258.03 | 242.44 | 266.94 | 264.71 |
| **2006-2050** | 280.11 | 263.65 | 287.98 | 288.7 | 282.49 | 266.04 | 289.94 | 291.48 |
| ***Change*** | *22.08* | *21.21* | *21.04* | *23.99* | *24.46* | *23.6* | *23* | *26.77* |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **TN10p** | | | | | | | | |
| **Baseline** | 9.93 | 9.94 | 10.21 | 9.63 | 9.93 | 9.94 | 10.21 | 9.63 |
| **2006-2050** | 2.89 | 2.51 | 2.5 | 3.65 | 2.31 | 2.07 | 2.01 | 2.86 |
| ***Change*** | *-7.04* | *-7.43* | *-7.71* | *-5.98* | *-7.62* | *-7.87* | *-8.2* | *-6.77* |
| **TN90p** | | | | | | | | |
| **Baseline** | 10 | 10.25 | 10.36 | 9.39 | 10 | 10.25 | 10.36 | 9.39 |
| **2006-2050** | 27.18 | 26.48 | 28.58 | 26.48 | 30.6 | 29.71 | 31.61 | 30.49 |
| ***Change*** | *17.18* | *16.23* | *18.22* | *17.09* | *20.6* | *19.46* | *21.25* | *21.1* |
| **TR20** | | | | | | | | |
| **Baseline** | 144.16 | 123.37 | 155.49 | 153.61 | 144.16 | 123.37 | 155.49 | 153.61 |
| **2006-2050** | 163.25 | 146.37 | 174.13 | 169.24 | 165.77 | 148.79 | 176.61 | 171.91 |
| ***Change*** | *19.09* | *23* | *18.64* | *15.63* | *21.61* | *25.42* | *21.12* | *18.3* |
| **TX10** | | | | | | | | |
| **Baseline** | 10.52 | 10.55 | 10.63 | 10.37 | 10.52 | 10.55 | 10.63 | 10.37 |
| **2006-2050** | 5.66 | 5.65 | 5.45 | 5.89 | 4.94 | 4.95 | 4.72 | 5.14 |
| ***Change*** | *-4.86* | *-4.9* | *-5.18* | *-4.48* | *-5.58* | *-5.6* | *-5.91* | *-5.23* |
| **TX90p** | | | | | | | | |
| **Baseline** | 10.05 | 10.11 | 10.34 | 9.71 | 10.05 | 10.11 | 10.34 | 9.71 |
| **2006-2050** | 29.09 | 29.05 | 29.92 | 28.29 | 31.64 | 31.62 | 31.85 | 31.46 |
| ***Change*** | *19.04* | *18.94* | *19.58* | *18.58* | *21.59* | *21.51* | *21.51* | *21.75* |
| **CSDI** | | | | | | | | |
| **Baseline** | 9.09 | 8.79 | 9.83 | 8.65 | 9.09 | 8.79 | 9.83 | 8.65 |
| **2006-2050** | 2.4 | 2.82 | 1.9 | 2.48 | 1.76 | 1.64 | 1.48 | 2.15 |
| ***Change*** | *-6.69* | *-5.97* | *-7.93* | *-6.17* | *-7.33* | *-7.15* | *-8.35* | *-6.5* |
| **WSDI** | | | | | | | | |
| **Baseline** | 9.92 | 10.21 | 10.7 | 8.85 | 9.92 | 10.21 | 10.7 | 8.85 |
| **2006-2050** | 63.46 | 63.24 | 67.92 | 59.22 | 73.13 | 73.44 | 75.28 | 70.67 |
| ***Change*** | *53.54* | *53.03* | *57.22* | *50.37* | *63.21* | *63.23* | *64.58* | *61.82* |

**Central Punjab:** Warm temperature extreme indices have shown a positive increasing trend over central Punjab (Table 3.15). The rate of positive change in the temperature indices have higher rate in RCP8.5 over central Punjab and the cities located in it. In comparison to baseline, Cool days (TX10p) and nights (TN10p) are decreasing while warm days (TN90p) and nights (TN90p) have increased from 2006 to 2050. Warm nights have shown a higher increase

in RCP4.5 while warm days possess a higher increase in RCP8.5. Cold spells (CSDI) have been projected with a decreasing trend while warm spells (WSDI) have an increasing trend. The increase in warm spells among the rest of the temperature indices is the highest in all the cities. This indicates more extreme heat events in the region. Across Central Punjab, warm spells increase by 62.68 days in RCP4.5 and 69.62 days in RCP8.5 that counts up to 76.68 days and 80.22 days from 2006 to 2050 respectively. The highest increase in warm spells is shown by Faisalabad (65.93 days) in RCP4.5 and by Sialkot (74.02 days) in RCP8.5.

Consecutive dry days (CDD) have a decreasing trend from 2006 to 2050 in RCP 4.5 except Sargodha which has shown an increase of 2.14 days. In RCP8.5, dry days are showing a positive trend except for Sialkot. Consecutive wet days (CWD) have decreased during 2006-2050 in both the RCPs except Sialkot. All the other precipitation indices over central Punjab have shown positive increasing trend. The only index that is shown negatively is R10 in RCP8.5 for all the cities of central Punjab and Sargodha in RCP4.5. Unlike temperature indices, the precipitation indices have a greater increase in RCP4.5. Relatively in precipitation indices, the total precipitation (PRCPTOT), R95 and R99 have a higher increase which is an indication of more extreme rainfall over central Punjab. In the cities of central Punjab, Sialkot is projected to receive probably more extreme precipitation. The daily difference between the maximum and minimum temperature (DTR) has a decreasing trend in Lahore which might be due to more increase in minimum temperature than maximum.

Table 3.15: Extreme Temperature and Precipitation Indices and their change in central Punjab under RCP4.5 and RCP8.5. The Italicized digits show the change from baseline (1976-2005) and (2006-2050).

| | RCP4.5 | | | | | RCP8.5 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Indices** | **Center** | **Lahore** | **Faisalabad** | **Sialkot** | **Sargodha** | **Center** | **Lahore** | **Faisalabad** | **Sialkot** | **Sargodha** |
| **CDD** | | | | | | | | | | |
| **Baseline** | 88.2 | 87.43 | 104.45 | 70.64 | 90.27 | 88.2 | 87.43 | 104.45 | 70.64 | 90.27 |
| **2006-2050** | 87.7 | 86.02 | 104.27 | 68.11 | 92.41 | 89.71 | 87.6 | 107.38 | 70.53 | 93.32 |
| ***Change*** | *-0.5* | *-1.41* | *-0.18* | *-2.53* | *2.14* | *1.51* | *0.17* | *2.93* | *-0.11* | *3.05* |
| **CWD** | | | | | | | | | | |
| **Baseline** | 6.46 | 6.59 | 5.13 | 8.87 | 5.25 | 6.46 | 6.59 | 5.13 | 8.87 | 5.25 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **2006-2050** | 6.44 | 6.34 | 5.07 | 9.15 | 5.18 | 6.13 | 6.23 | 4.77 | 8.69 | 4.83 |
| ***Change*** | *-0.02* | *-0.25* | *-0.06* | *0.28* | *-0.07* | *-0.33* | *-0.36* | *-0.36* | *-0.18* | *-0.42* |
| **DTR** | | | | | | | | | | |
| **Baseline** | 13.41 | 12.29 | 14.06 | 13.14 | 14.16 | 13.41 | 12.29 | 14.06 | 13.14 | 14.16 |
| **2006-2050** | 13.53 | 12.3 | 14.21 | 13.17 | 14.45 | 13.45 | 12.28 | 14.1 | 13.16 | 14.26 |
| ***Change*** | *0.12* | *0.01* | *0.15* | *0.03* | *0.29* | *0.04* | *-0.01* | *0.04* | *0.02* | *0.1* |
| **PRCPTOP** | | | | | | | | | | |
| **Baseline** | 591.99 | 651.23 | 349.19 | 956.74 | 410.78 | 591.99 | 651.23 | 349.19 | 956.74 | 410.78 |
| **2006-2050** | 671.26 | 725.29 | 403.04 | 1088.32 | 468.39 | 636.41 | 700.83 | 376.08 | 1035.04 | 433.67 |
| ***Change*** | *79.27* | *74.06* | *53.85* | *131.58* | *57.61* | *44.42* | *49.6* | *26.89* | *78.3* | *22.89* |
| **R10mm** | | | | | | | | | | |
| **Baseline** | 17.09 | 18.25 | 10.76 | 26.45 | 12.88 | 17.09 | 18.25 | 10.76 | 26.45 | 12.88 |
| **2006-2050** | 17.24 | 18.73 | 10.84 | 26.55 | 12.85 | 16.7 | 18.21 | 10.34 | 25.92 | 12.31 |
| ***Change*** | *0.15* | *0.48* | *0.08* | *0.1* | *-0.03* | *-0.39* | *-0.04* | *-0.42* | *-0.53* | *-0.57* |
| **R20mm** | | | | | | | | | | |
| **Baseline** | 9.15 | 10.27 | 5.35 | 14.6 | 6.38 | 9.15 | 10.27 | 5.35 | 14.6 | 6.38 |
| **2006-2050** | 9.72 | 10.85 | 5.85 | 15.33 | 6.84 | 9.36 | 10.45 | 5.61 | 14.84 | 6.52 |
| ***Change*** | *0.57* | *0.58* | *0.5* | *0.73* | *0.46* | *0.21* | *0.18* | *0.26* | *0.24* | *0.14* |
| **R95p** | | | | | | | | | | |
| **Baseline** | 160.64 | 175.1 | 92.4 | 269.77 | 105.28 | 160.64 | 175.1 | 92.4 | 269.77 | 105.28 |
| **2006-2050** | 242.43 | 246.05 | 143.4 | 414.08 | 166.18 | 216.73 | 231.57 | 122.56 | 370.14 | 142.63 |
| ***Change*** | *81.79* | *70.95* | *51* | *144.31* | *60.9* | *56.09* | *56.47* | *30.16* | *100.37* | *37.35* |
| **R99p** | | | | | | | | | | |
| **Baseline** | 52.56 | 55.46 | 29.25 | 94.06 | 31.45 | 52.56 | 55.46 | 29.25 | 94.06 | 31.45 |
| **2006-2050** | 123.36 | 125.99 | 78.96 | 207.79 | 80.7 | 96.76 | 110.03 | 54.49 | 162.92 | 59.59 |
| ***Change*** | *70.8* | *70.53* | *49.71* | *113.73* | *49.25* | *44.2* | *54.57* | *25.24* | *68.86* | *28.14* |
| **Rx5day** | | | | | | | | | | |
| **Baseline** | 163.2 | 184.02 | 114.29 | 235.18 | 119.32 | 163.2 | 184.02 | 114.29 | 235.18 | 119.32 |
| **2006-2050** | 197.07 | 211.34 | 146.46 | 274.93 | 155.54 | 183.44 | 207.15 | 129.97 | 264.76 | 131.88 |
| ***Change*** | *33.87* | *27.32* | *32.17* | *39.75* | *36.22* | *20.24* | *23.13* | *15.68* | *29.58* | *12.56* |
| **SU** | | | | | | | | | | |
| **Baseline** | 264.05 | 268.61 | 265.85 | 251.55 | 270.19 | 264.05 | 268.61 | 265.85 | 251.55 | 270.19 |
| **2006-2050** | 286.41 | 292.08 | 287.89 | 270.86 | 294.79 | 288.69 | 294.72 | 290.13 | 273.36 | 296.56 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Change*** | *22.36* | *23.47* | *22.04* | *19.31* | *24.6* | *24.64* | *26.11* | *24.28* | *21.81* | *26.37* |
| **TN10p** | | | | | | | | | | |
| **Baseline** | 9.98 | 10.08 | 9.88 | 10.2 | 9.75 | 9.98 | 10.08 | 9.88 | 10.2 | 9.75 |
| **2006-2050** | 3.21 | 3.12 | 3.46 | 2.63 | 3.64 | 2.55 | 2.48 | 2.73 | 2.11 | 2.89 |
| ***Change*** | *-6.77* | *-6.96* | *-6.42* | *-7.57* | *-6.11* | *-7.43* | *-7.6* | *-7.15* | *-8.09* | *-6.86* |
| **TN90p** | | | | | | | | | | |
| **Baseline** | 9.95 | 10.22 | 9.82 | 10.28 | 9.47 | 9.95 | 10.22 | 9.82 | 10.28 | 9.47 |
| **2006-2050** | 30.07 | 29.78 | 30.52 | 29.71 | 30.27 | 33.48 | 33.46 | 33.83 | 33.49 | 33.15 |
| ***Change*** | *20.12* | *19.56* | *20.7* | *19.43* | *20.8* | *23.53* | *23.24* | *24.01* | *23.21* | *23.68* |
| **TR20** | | | | | | | | | | |
| **Baseline** | 162.74 | 176.25 | 159.33 | 149.58 | 165.8 | 162.74 | 176.25 | 159.33 | 149.58 | 165.8 |
| **2006-2050** | 180.38 | 193.85 | 176.7 | 167.99 | 182.99 | 183.21 | 197.68 | 179.19 | 170.58 | 185.37 |
| ***Change*** | *17.64* | *17.6* | *17.37* | *18.41* | *17.19* | *20.47* | *21.43* | *19.86* | *21* | *19.57* |
| **TX10** | | | | | | | | | | |
| **Baseline** | 10.47 | 10.52 | 10.52 | 10.49 | 10.34 | 10.47 | 10.52 | 10.52 | 10.49 | 10.34 |
| **2006-2050** | 5.51 | 5.47 | 5.48 | 5.29 | 5.78 | 4.85 | 4.88 | 4.79 | 4.6 | 5.14 |
| **Change** | -4.96 | -5.05 | -5.04 | -5.2 | -4.56 | -5.62 | -5.64 | -5.73 | -5.89 | -5.2 |
| **TX90p** | | | | | | | | | | |
| **Baseline** | 10.01 | 10.16 | 10.04 | 10.13 | 9.69 | 10.01 | 10.16 | 10.04 | 10.13 | 9.69 |
| **2006-2050** | 31.12 | 29.85 | 32.17 | 31.5 | 30.95 | 33.11 | 32.63 | 33.61 | 34.31 | 31.89 |
| ***Change*** | *21.11* | *19.69* | *22.13* | *21.37* | *21.26* | *23.1* | *22.47* | *23.57* | *24.18* | *22.2* |
| **CSDI** | | | | | | | | | | |
| **Baseline** | 9.44 | 9.8 | 9.74 | 9.33 | 8.9 | 9.44 | 9.8 | 9.74 | 9.33 | 8.9 |
| **2006-2050** | 2.52 | 2.58 | 2.58 | 1.91 | 2.99 | 1.89 | 2.02 | 1.98 | 1.59 | 1.95 |
| ***Change*** | *-6.92* | *-7.22* | *-7.16* | *-7.42* | *-5.91* | *-7.55* | *-7.78* | *-7.76* | *-7.74* | *-6.95* |
| **WSDI** | | | | | | | | | | |
| **Baseline** | 10.6 | 11.36 | 10.55 | 10.95 | 9.52 | 10.6 | 11.36 | 10.55 | 10.95 | 9.52 |
| **2006-2050** | 72.68 | 69.01 | 76.48 | 72.86 | 72.37 | 80.22 | 79.78 | 81.05 | 84.97 | 75.08 |
| ***Change*** | *62.08* | *57.65* | *65.93* | *61.91* | *62.85* | *69.62* | *68.42* | *70.5* | *74.02* | *65.56* |

**South Punjab:** Temperature and precipitation extreme indices have shown a prominent change over southern Punjab (Table 3.16). The increasing rate in trends in temperature indices have higher tendency in RCP8.5 over southern Punjab and its cities. The warm temperature indices are increasing while cold temperature indices are projected with

decrease in all the cities. Consecutive dry days (CDD) have an increasing trend in both the RCP scenarios for all the cities and over southern Punjab. The overall dry days are more in Bahawalpur but the rate of change (increase) is highest in Bahawalnagar. Across southern Punjab, dry days are likely 135 days and 137 days in RCP4.5 and RCP8.5. Consecutive dry days (CDD) have an increasing trend from 2006 to 2050 in RCP 4.5 except Bahawalpur which has shown a decrease 0.02 days. But in the high emission scenario RCP8.5, wet days have decreased over all the south Punjab. DTR in all the cities and over southern Punjab is decreasing from 2006 to 2050 in both RCP scenarios except Multan that shows positive trend for DTR in RCP8.5. All the precipitation indices are projected with an increasing trend except R10. Similar to central Punjab, most of the precipitation indices have a greater increase in RCP4.5. R10 shows negative trend for Bahawalnagar and southern Punjab in RCP8.5. Noticeably, the increase in R95 in all the cities is higher than R99 for both the RCP scenarios. Where Bahawalpur experiences higher change of 34.31 mm increase in R95 in RCP4.5 and Bahawalnagar of 32.71 mm increase comprising overall 74.48 mm and 82.28 mm precipitation during the period 2006 to 2050. Overall the precipitation indices i.e. PRCPTOT, R95, R99 and 5-day precipitation show greater rate of change (increase) for Bahawalpur during RCP4.5 and for Bahawalnagar during RCP8.5 in during 2006 to 2050. Under RCP4.5, warm spells have highest increase of 49.35 days across Multan in RCP4.5 and 61.86 days increase in Bahawalpur during RCP8.5. In comparison to baseline, Cool days (TX10p) and nights (TN10p) are decreasing while warm days (TN90p) and nights (TN90p) have increased from 2006 to 2050. Cold spells (CSDI) have been projected with a decreasing trend while warm spells (WSDI) have an increasing trend. Likewise, to Central Punjab, warm spells across southern Punjab also show highest increase in both the RCPs. The total warm spells over southern Punjab are 56.70 days for RCP4.5 and 69.93 days in RCP8.5. Warm nights have shown a higher increase as compared to warm days over all the cities of southern Punjab for both the scenarios.

Higher increase in tropical nights is projected for Bahawalpur in both the scenarios. Tropical nights over southern Punjab show an increase of 14.35 days in RCP4.5 that ensures the projected increase of tropical nights of 189.03 days. In RCP8.5, the increase in tropical nights is 18.15 days contributing to overall 192.83 days in the period 2006 to 2050.

Table 3.16: Extreme Temperature and Precipitation Indices and their change in south Punjab under RCP4.5 and RCP8.5. The Italicized digits show the change from baseline (1976-2005) and (2006-2050).

| | RCP4.5 | | | | RCP8.5 | | | |
|---|---|---|---|---|---|---|---|---|
| **Indices** | **South** | **Bahawalnagar** | **Bahawalpur** | **Multan** | **South** | **Bahawalnagar** | **Bahawalpur** | **Multan** |
| **CDD** | | | | | | | | |
| **Baseline** | 133.26 | 128.73 | 142.71 | 128.35 | 133.26 | 128.73 | 142.71 | 128.35 |
| **2006-2050** | 135.06 | 131.53 | 143.42 | 130.22 | 137.76 | 133.58 | 146.99 | 132.70 |
| ***Change*** | *1.80* | *2.80* | *0.71* | *1.87* | *4.50* | *4.85* | *4.28* | *4.35* |
| **CWD** | | | | | | | | |
| **Baseline** | 3.99 | 4.14 | 3.85 | 3.99 | 3.99 | 4.14 | 3.85 | 3.99 |
| **2006-2050** | 4.03 | 4.19 | 3.83 | 4.07 | 3.88 | 4.12 | 3.72 | 3.80 |
| ***Change*** | *0.04* | *0.05* | *-0.02* | *0.08* | *-0.11* | *-0.02* | *-0.13* | *-0.19* |
| **DTR** | | | | | | | | |
| **Baseline** | 14.29 | 13.74 | 14.77 | 14.37 | 14.29 | 13.74 | 14.77 | 14.37 |
| **2006-2050** | 14.21 | 13.64 | 14.68 | 14.30 | 14.28 | 13.63 | 14.68 | 14.52 |
| ***Change*** | *-0.08* | *-0.10* | *-0.09* | *-0.07* | *-0.01* | *-0.11* | *-0.09* | *0.15* |
| **PRCPTOP** | | | | | | | | |
| **Baseline** | 187.29 | 214.70 | 153.58 | 193.60 | 187.29 | 214.70 | 153.58 | 193.60 |
| **2006-2050** | 217.05 | 244.26 | 188.06 | 218.82 | 205.92 | 237.39 | 170.23 | 210.14 |
| ***Change*** | *29.76* | *29.56* | *34.48* | *25.22* | *18.63* | *22.69* | *16.65* | *16.54* |
| **R10mm** | | | | | | | | |
| **Baseline** | 5.64 | 7.08 | 4.66 | 5.19 | 5.64 | 7.08 | 4.66 | 5.19 |
| **2006-2050** | 5.86 | 7.15 | 4.84 | 5.59 | 5.57 | 6.70 | 4.67 | 5.33 |
| ***Change*** | *0.22* | *0.07* | *0.18* | *0.40* | *-0.07* | *-0.38* | *0.01* | *0.14* |
| **R20mm** | | | | | | | | |
| **Baseline** | 2.57 | 2.89 | 2.18 | 2.63 | 2.57 | 2.89 | 2.18 | 2.63 |
| **2006-2050** | 2.83 | 3.23 | 2.36 | 2.90 | 2.77 | 3.06 | 2.43 | 2.81 |
| ***Change*** | *0.26* | *0.34* | *0.18* | *0.27* | *0.20* | *0.17* | *0.25* | *0.18* |
| **R95p** | | | | | | | | |
| **Baseline** | 50.12 | 49.57 | 40.17 | 60.62 | 50.12 | 49.57 | 40.17 | 60.62 |
| **2006-2050** | 76.58 | 72.05 | 74.48 | 83.20 | 75.89 | 82.28 | 63.43 | 81.97 |
| ***Change*** | *26.46* | *22.48* | *34.31* | *22.58* | *25.77* | *32.71* | *23.26* | *21.35* |
| **R99p** | | | | | | | | |
| **Baseline** | 16.90 | 18.15 | 12.13 | 20.41 | 16.90 | 18.15 | 12.13 | 20.41 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **2006-2050** | 40.04 | 38.32 | 44.95 | 36.86 | 34.87 | 39.50 | 29.80 | 35.31 |
| ***Change*** | *23.14* | *20.17* | *32.82* | *16.45* | *17.97* | *21.35* | *17.67* | *14.90* |
| **Rx5day** | | | | | | | | |
| **Baseline** | 78.66 | 83.49 | 67.78 | 84.72 | 78.66 | 83.49 | 67.78 | 84.72 |
| **2006-2050** | 95.18 | 100.60 | 89.53 | 95.42 | 92.71 | 101.91 | 79.39 | 96.84 |
| ***Change*** | *16.52* | *17.11* | *21.75* | *10.70* | *14.05* | *18.42* | *11.61* | *12.12* |
| **SU** | | | | | | | | |
| **Baseline** | 285.40 | 280.69 | 291.89 | 283.61 | 285.40 | 280.69 | 291.89 | 283.61 |
| **2006-2050** | 307.38 | 302.19 | 312.85 | 307.10 | 310.12 | 304.67 | 315.68 | 310.02 |
| ***Change*** | *21.98* | *21.50* | *20.96* | *23.49* | *24.72* | *23.98* | *23.79* | *26.41* |
| **TN10p** | | | | | | | | |
| **Baseline** | 10.29 | 10.37 | 10.30 | 10.19 | 10.29 | 10.37 | 10.30 | 10.19 |
| **2006-2050** | 3.56 | 3.52 | 3.64 | 3.53 | 2.96 | 3.00 | 2.99 | 2.89 |
| ***Change*** | *-6.73* | *-6.85* | *-6.66* | *-6.66* | *-7.33* | *-7.37* | *-7.31* | *-7.30* |
| **TN90p** | | | | | | | | |
| **Baseline** | 10.08 | 10.26 | 9.97 | 10.02 | 10.08 | 10.26 | 9.97 | 10.02 |
| **2006-2050** | 29.94 | 30.29 | 29.30 | 30.23 | 34.80 | 34.91 | 34.35 | 35.13 |
| ***Change*** | *19.86* | *20.03* | *19.33* | *20.21* | *24.72* | *24.65* | *24.38* | *25.11* |
| **TR20** | | | | | | | | |
| **Baseline** | 174.68 | 179.63 | 170.87 | 173.55 | 174.68 | 179.63 | 170.87 | 173.55 |
| **2006-2050** | 189.03 | 194.04 | 185.57 | 187.49 | 192.83 | 197.87 | 189.38 | 191.25 |
| ***Change*** | *14.35* | *14.41* | *14.70* | *13.94* | *18.15* | *18.24* | *18.51* | *17.70* |
| **TX10** | | | | | | | | |
| **Baseline** | 10.56 | 10.59 | 10.58 | 10.50 | 10.56 | 10.59 | 10.58 | 10.50 |
| **2006-2050** | 5.68 | 5.69 | 5.76 | 5.59 | 5.01 | 5.04 | 5.09 | 4.89 |
| ***Change*** | *-4.88* | *-4.90* | *-4.82* | *-4.91* | *-5.55* | *-5.55* | *-5.49* | *-5.61* |
| **TX90p** | | | | | | | | |
| **Baseline** | 10.14 | 10.36 | 10.05 | 10.01 | 10.14 | 10.36 | 10.05 | 10.01 |
| **2006-2050** | 26.80 | 25.57 | 27.23 | 27.60 | 30.54 | 28.81 | 31.37 | 31.45 |
| ***Change*** | *16.66* | *15.21* | *17.18* | *17.59* | *20.40* | *18.45* | *21.32* | *21.44* |
| **CSDI** | | | | | | | | |
| **Baseline** | 10.23 | 10.66 | 10.02 | 10.00 | 10.23 | 10.66 | 10.02 | 10.00 |
| **2006-2050** | 2.86 | 2.90 | 2.89 | 2.79 | 2.40 | 2.38 | 2.53 | 2.30 |
| ***Change*** | *-7.37* | *-7.76* | *-7.13* | *-7.21* | *-7.83* | *-8.28* | *-7.49* | *-7.70* |
| **WSDI** | | | | | | | | |
| **Baseline** | 11.08 | 11.11 | 11.21 | 10.93 | 11.08 | 11.11 | 11.21 | 10.93 |
| **2006-2050** | 56.70 | 51.55 | 58.28 | 60.28 | 69.93 | 63.98 | 73.07 | 72.75 |
| ***Change*** | *45.62* | *40.44* | *47.07* | *49.35* | *58.85* | *52.87* | *61.86* | *61.82* |

## 3.8. Heat waves

**North Punjab:** Heat waves indices for both maximum and minimum temperature show increasing trend in both RCP4.5 and RCP8.5 over northern Punjab (Table 3.17). Over north Punjab, all the heat wave indices show higher increase in RCP8.5. The magnitude of maximum temperature heat waves shows higher projected increase in RCP4.5 for Rawalpindi and for Mianwali and Jhelum in RCP8.5. While the other heat indices i.e. amplitude, number, duration, and frequency show higher increase under RCP8.5. Among the cities Mianwali is projected to experience highest magnitude up to 43.8 ˚C and amplitude of 48.84 ˚C from 2006 to 2050 under RCP8.5. Across north Punjab, the magnitude projects a total of 41.86 ˚C mean temperature in RCP4.5 and 41.92 ˚C in RCP8.5 for the period (2006-2050), respectively with an average increase of 7.59 ˚C and 7.93 ˚C from base line. The amplitude of heat events over north Punjab increases up to 10.44 ˚C and 11.16 ˚C for RCP4.5 and RCP8.5 possessing a total of 46.63 ˚C and 47.01 ˚C amplitude during the period 2006 to 2050 respectively. Heat wave numbers over north Punjab are projected to occur 5.55 events and 6.46 events for RCP4.5 and RCP8.5. Among the cities, Rawalpindi projected the highest number of heat events i-e 5.81 in RCP4.5 and 6.57 in RCP8.5 events during the period 2006 to 2050. The longest heat wave event (HWD) show projected higher increase for Jhelum (8.39 days) during RCP4.5 and for Rawalpindi (10.19 days) in RCP8.5 contributing to overall 13.43 days in Jhelum and 14.97 days in Rawalpindi respectively. HWF have shown highest projected increase over Rawalpindi under both the RCPs. For north Punjab, the probability of the lengthiest event is projected to 12.43 days and 14.30 days, and frequency of 35.76 days and 43.62 days under RCP4.5 and RCP8.5 respectively from 2006 to 2050.

Minimum temperature based heat waves indices in all the cities and north Punjab increases under both the RCPs. The magnitude and amplitude shows highest increase in RCP4.5 over all the cities whereas, duration and frequency shows greater increase during RCP8.5. Heat wave number show more increase in RCP4.5 for Mianwali and in RCP8.5 for Rawalpindi and Jhelum. Mianwali projects highest magnitude (30.54 ˚C) and amplitude (33.47 ˚C) for RCP4.5 and magnitude of 28.53 ˚C and amplitude 31.94 ˚C for RCP8.5. Over north Punjab, magnitude increases up to 6.34 ˚C and 4.81˚ C projecting an overall magnitude of 28.61 ˚C and 26.93˚ C for RCP4.5 and RCP8.5 respectively. Amplitude across north Punjab shows an increase of 8.32

˚C and 6.79 ˚C projecting a total of 31.99˚ C and 30.38 ˚C from 2006 to 2050 respectively under RCP4.5 and RCP8.5. Mianwali projects over all highest number of duration 15.64 days and frequency 46.58 days in RCP4.5 while in RCP8.5 Jhelum projects the highest duration of 14.63 days and frequency of 45.1 days for the period 2006 to 2050. The duration across north Punjab is projected to 14.51 days for RCP4.5 and 13.73 days under RCP8.5. While the frequency is 41.59 days and 42.75 days in RCP4.5 and RCP8.5 respectively.

Table 3.17: Heat wave Indices derived from three different methods (EHF, TX90p, TN90p) and their change in north Punjab under RCP4.5 and RCP8.5. The Italicized digits show the change from baseline (1976-2005) and (2006-2050).

| | RCP4.5 | | | | | RCP8.5 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | HWM | HWA | HWN | HWD | HWF | HWM | HWA | HWN | HWD | HWF |
| | | | | | **TX90p** | | | | | |
| **RAWALPINDI** | | | | | | | | | | |
| **1976-2005** | 33.36 | 35.06 | 2.04 | 4.78 | 9.46 | 33.36 | 35.06 | 2.04 | 4.78 | 9.46 |
| **2006-2050** | 40.19 | 44.74 | 5.81 | 12.87 | 37.96 | 40.11 | 44.89 | 6.57 | 14.97 | 45.57 |
| ***CHANGE*** | *6.83* | *9.68* | *3.77* | *8.09* | *28.5* | *6.75* | *9.83* | *4.53* | *10.19* | *36.11* |
| **JHELUM** | | | | | | | | | | |
| **1976-2005** | 34.63 | 36.78 | 2.12 | 5.04 | 10.06 | 34.63 | 36.78 | 2.12 | 5.04 | 10.06 |
| **2006-2050** | 41.77 | 47.14 | 5.6 | 13.43 | 37.65 | 41.84 | 47.31 | 6.4 | 14.85 | 44.4 |
| ***CHANGE*** | *7.14* | *10.36* | *3.48* | *8.39* | *27.59* | *7.21* | *10.53* | *4.28* | *9.81* | *34.34* |
| **MIANWALI** | | | | | | | | | | |
| **1976-2005** | 34.82 | 36.72 | 1.99 | 4.68 | 9.24 | 33.98 | 35.71 | 1.86 | 4.26 | 8.44 |
| **2006-2050** | 43.61 | 48.02 | 5.25 | 10.98 | 31.67 | 43.8 | 48.84 | 6.4 | 13.07 | 40.9 |
| ***CHANGE*** | *8.79* | *11.3* | *3.26* | *6.3* | *22.43* | *9.82* | *13.13* | *4.54* | *8.81* | *32.46* |
| **NORTH** | | | | | | | | | | |
| **1976-2005** | 34.27 | 36.19 | 2.05 | 4.84 | 9.59 | 33.99 | 35.85 | 2.01 | 4.7 | 9.32 |
| **2006-2050** | 41.86 | 46.63 | 5.55 | 12.43 | 35.76 | 41.92 | 47.01 | 6.46 | 14.3 | 43.62 |
| ***CHANGE*** | *7.59* | *10.44* | *3.5* | *7.59* | *26.17* | *7.93* | *11.16* | *4.45* | *9.6* | *34.3* |
| | | | | | **TN90p** | | | | | |
| **RAWALPINDI** | | | | | | | | | | |
| **1976-2005** | 21.41 | 23.07 | 2.05 | 4.91 | 9.87 | 21.41 | 23.07 | 2.05 | 4.91 | 9.87 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **2006-2050** | 26.67 | 30.45 | 5.4 | 13.29 | 36.96 | 25.3 | 28.81 | 5.77 | 13.41 | 40.58 |
| ***CHANGE*** | *5.26* | *7.38* | *3.35* | *8.38* | *27.09* | *3.89* | *5.74* | *3.72* | *8.5* | *30.71* |
| **JHELUM** | | | | | | | | | | |
| **1976-2005** | 22.47 | 23.9 | 2.01 | 4.95 | 9.78 | 22.47 | 23.9 | 2.01 | 4.95 | 9.78 |
| **2006-2050** | 28.63 | 32.04 | 5.61 | 14.77 | 41.23 | 27.12 | 30.38 | 6 | 14.63 | 45.1 |
| ***CHANGE*** | *6.16* | *8.14* | *3.6* | *9.82* | *31.45* | *4.65* | *6.48* | *3.99* | *9.68* | *35.32* |
| **MIANWALI** | | | | | | | | | | |
| **1976-2005** | 22.92 | 24.03 | 1.92 | 4.55 | 9.25 | 22.63 | 23.8 | 1.68 | 4.37 | 7.85 |
| **2006-2050** | 30.54 | 33.47 | 6.19 | 15.64 | 46.58 | 28.53 | 31.94 | 6.15 | 13.13 | 42.58 |
| ***CHANGE*** | *7.62* | *9.44* | *4.27* | *11.09* | *37.33* | *5.9* | *8.14* | *4.47* | *8.76* | *34.73* |
| **NORTH** | | | | | | | | | | |
| **1976-2005** | 22.27 | 23.67 | 1.99 | 4.8 | 9.63 | 22.17 | 23.59 | 1.91 | 4.74 | 9.17 |
| **2006-2050** | 28.61 | 31.99 | 5.73 | 14.57 | 41.59 | 26.98 | 30.38 | 5.97 | 13.73 | 42.75 |
| ***CHANGE*** | *6.34* | *8.32* | *3.74* | *9.77* | *31.96* | *4.81* | *6.79* | *4.06* | *8.99* | *33.58* |

**Central Punjab:** Heat wave indices analyzed from maximum and minimum temperature have shown positive trend in both the base line and future in Central Punjab. However, the increase in more prominent in the period from 2006 to 2050 (Table 3.18). Heat wave magnitude derived from maximum temperature have shown more increase in RCP8.5 over central Punjab and in all the cities. The highest increase of 43.6 ˚C in magnitude of heat events is projected over Sargodha from 2006 to 2050 in RCP8.5. Overall, in central Punjab the heat wave magnitude is 41.75 ˚C with average increase of 7.77˚ C from baseline in RCP4.5 and 41.89 ˚C with an increase of 7.91 ˚C in RCP8.5 from 2006 to 2050. The amplitude of heat waves has greater increase in RCP8.5 in all the cities except Faisalabad which show greater increase in RCP4.5. The other heat indices such as number, duration, and frequency are projected with higher increase in RCP8.5 for all the central Punjab cities. Based on maximum temperature, central Punjab is projected to experience 5.51 number of heat events in RCP4.5 and 6.36 events in RCP8.5. In all the cities, frequency of heat waves is more than duration which ensures more frequent events. HWM and HWA from minimum temperature shows higher increase in RCP4.5 in all the cities of central Punjab. While, Heat wave number, duration, and frequency show greater increasing trend in RCP8.5. Minimum temperature based number of heat events are projected to be 6.03 events for RCP4.5 and 6.42 events for

RCP8.5 over central Punjab. In comparison, minimum temperature derived heat wave number, duration and frequency are higher than maximum temperature based in both RCPs. Also it is observed from the observed heat waves that there is less change in overall the indices.

Table 3.18: Heat wave Indices derived from three different methods (EHF, TX90p, TN90p) and their change in central Punjab under RCP4.5 and RCP8.5. The Italicized digits show the change from baseline (1976-2005) and (2006-2050).

| | RCP4.5 | | | | | RCP8.5 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | HWM | HWA | HWN | HWD | HWF | HWM | HWA | HWN | HWD | HWF |
| | | | | | **TX90p** | | | | | |
| **LAHORE** | | | | | | | | | | |
| **1976-2005** | 33.24 | 35.2 | 2.12 | 4.93 | 10.05 | 33.24 | 35.2 | 2.12 | 4.93 | 10.05 |
| **2006-2050** | 41.3 | 46.09 | 5.38 | 12.8 | 36.46 | 41.44 | 46.56 | 6.24 | 15.35 | 44.85 |
| ***CHANGE*** | *8.06* | *10.89* | *3.26* | *7.87* | *26.41* | *8.2* | *11.36* | *4.12* | *10.42* | *34.8* |
| **FAISALABAAD** | | | | | | | | | | |
| **1976-2005** | 33.7 | 35.45 | 1.93 | 4.66 | 8.95 | 33.7 | 35.45 | 1.93 | 4.66 | 8.95 |
| **2006-2050** | 42.27 | 47.48 | 5.63 | 12.98 | 38.77 | 42.32 | 47.41 | 6.53 | 15.08 | 45.63 |
| ***CHANGE*** | *8.57* | *12.03* | *3.7* | *8.32* | *29.82* | *8.62* | *11.96* | *4.6* | *10.42* | *36.68* |
| **SIALKOT** | | | | | | | | | | |
| **1976-2005** | 32.89 | 35.03 | 2.07 | 4.8 | 9.74 | 32.89 | 35.03 | 2.07 | 4.8 | 9.74 |
| **2006-2050** | 40.08 | 45.63 | 5.65 | 13.77 | 39.24 | 40.18 | 46.13 | 6.53 | 16.17 | 47.81 |
| ***CHANGE*** | *7.19* | *10.6* | *3.58* | *8.97* | *29.5* | *7.29* | *11.1* | *4.46* | *11.37* | *38.07* |
| **SARGODHA** | | | | | | | | | | |
| **1976-2005** | 36.08 | 37.9 | 1.96 | 4.63 | 8.95 | 36.08 | 37.9 | 1.96 | 4.63 | 8.95 |
| **2006-2050** | 43.34 | 48.86 | 5.39 | 11.76 | 35.28 | 43.6 | 48.88 | 6.15 | 13.18 | 40.47 |
| ***CHANGE*** | *7.26* | *10.96* | *3.43* | *7.13* | *26.33* | *7.52* | *10.98* | *4.19* | *8.55* | *31.52* |
| **CENTER** | | | | | | | | | | |
| **1976-2005** | 33.98 | 35.9 | 2.02 | 4.76 | 9.42 | 33.98 | 35.9 | 2.02 | 4.76 | 9.42 |
| **2006-2050** | 41.75 | 47.02 | 5.51 | 12.83 | 37.44 | 41.89 | 47.25 | 6.36 | 14.95 | 44.69 |
| ***CHANGE*** | *7.77* | *11.12* | *3.49* | *8.07* | *28.02* | *7.91* | *11.35* | *4.34* | *10.19* | *35.27* |
| | | | | | **TN90p** | | | | | |
| **LAHORE** | | | | | | | | | | |
| **1976-2005** | 22.85 | 23.97 | 1.95 | 4.71 | 9.49 | 22.85 | 23.97 | 1.95 | 4.71 | 9.49 |
| **2006-2050** | 29.8 | 32.68 | 5.98 | 15 | 43.83 | 28.44 | 31.32 | 6.36 | 16.54 | 50.24 |
| ***CHANGE*** | *6.95* | *8.71* | *4.03* | *10.29* | *34.34* | *5.59* | *7.35* | *4.41* | *11.83* | *40.75* |
| **FAISALABAAD** | | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **1976-2005** | 22.11 | 23.1 | 1.82 | 4.46 | 8.66 | 22.11 | 23.1 | 1.82 | 4.46 | 8.66 |
| **2006-2050** | 29.36 | 32.21 | 6.2 | 16.48 | 48 | 27.85 | 30.75 | 6.62 | 17.53 | 54.1 |
| ***CHANGE*** | *7.25* | *9.11* | *4.38* | *12.02* | *39.34* | *5.74* | *7.65* | *4.8* | *13.07* | *45.44* |
| **SIALKOT** | | | | | | | | | | |
| **1976-2005** | 21.52 | 22.74 | 2 | 4.93 | 9.75 | 21.52 | 22.74 | 2 | 4.93 | 9.75 |
| **2006-2050** | 27.56 | 30.64 | 5.98 | 15.93 | 45.5 | 26.34 | 29.39 | 6.32 | 16.56 | 50.96 |
| ***CHANGE*** | *6.04* | *7.9* | *3.98* | *11* | *35.75* | *4.82* | *6.65* | *4.32* | *11.63* | *41.21* |
| **SARGODHA** | | | | | | | | | | |
| **1976-2005** | 22.38 | 23.35 | 1.7 | 4.43 | 8.17 | 22.38 | 23.35 | 1.7 | 4.43 | 8.17 |
| **2006-2050** | 29.85 | 32.77 | 5.94 | 15.83 | 45.33 | 28.3 | 31.2 | 6.39 | 15.93 | 50.52 |
| ***CHANGE*** | *7.47* | *9.42* | *4.24* | *11.4* | *37.16* | *5.92* | *7.85* | *4.69* | *11.5* | *42.35* |
| **CENTER** | | | | | | | | | | |
| **1976-2005** | 22.22 | 23.29 | 1.87 | 4.63 | 9.02 | 22.22 | 23.29 | 1.87 | 4.63 | 9.02 |
| **2006-2050** | 29.14 | 32.08 | 6.03 | 15.81 | 45.67 | 27.73 | 30.67 | 6.42 | 16.64 | 51.46 |
| ***CHANGE*** | *6.92* | *8.79* | *4.16* | *11.18* | *36.65* | *5.51* | *7.38* | *4.55* | *12.01* | *42.44* |

**South Punjab:** Heat waves indices for both maximum and minimum temperature show increasing trend in both RCP4.5 and RCP8.5 over southern Punjab (Table 3.19). The magnitude of maximum temperature heat waves shows higher projected increase in RCP4.5 for all the cities of southern Punjab. Among which Bahawalnagar is projected to experience highest mean temperature (magnitude) up to 43.73 ˚C from 2006 to 2050. Across southern Punjab, the magnitude projects a total of 43.57 ˚C in RCP4.5 and 43.55 ˚C in RCP8.5 for the period (2006-2050) with an average increase of 8.69 ˚C and 8.67 ˚C from base line. Heat wave amplitude, number, duration and frequency have shown more increasing trend in RCP8.5 for all the cities and overall southern Punjab. The highest amplitude among the cities is observed for Multan i-e 48.52 ˚C in RCP8.5. The amplitude of heat events over southern Punjab increases up to 11.17 ˚C and 11. 61˚ C during the period 2006 to 2050 having a total amplitude of 47.84 ˚C and 48.28 ˚C for RCP4.5 and RCP8.5 respectively. Southern Punjab is projected over to experience 5.29 and 6.30 heat wave events under RCP4.5 and RCP8.5. Among the cities, the number of heat events is greater in Bahawalpur of 6.72 events from 2006 to 2050. Length of the longest heat wave event (HWD) and total contributing days (HWF) to heat events have shown higher projected increase under RCP8.5 over all the cities. For southern Punjab, the probability of the lengthiest event is projected to 11.47 days and 14.20 days, and frequency of 32.91 days and 42.67 days under RCP4.5 and RCP8.5 respectively from 2006 to

2050. In cities, Bahawalpur projects highest number of duration (12 to 15 days) and frequency (35 to 47 days) for the period 2006 to 2050.

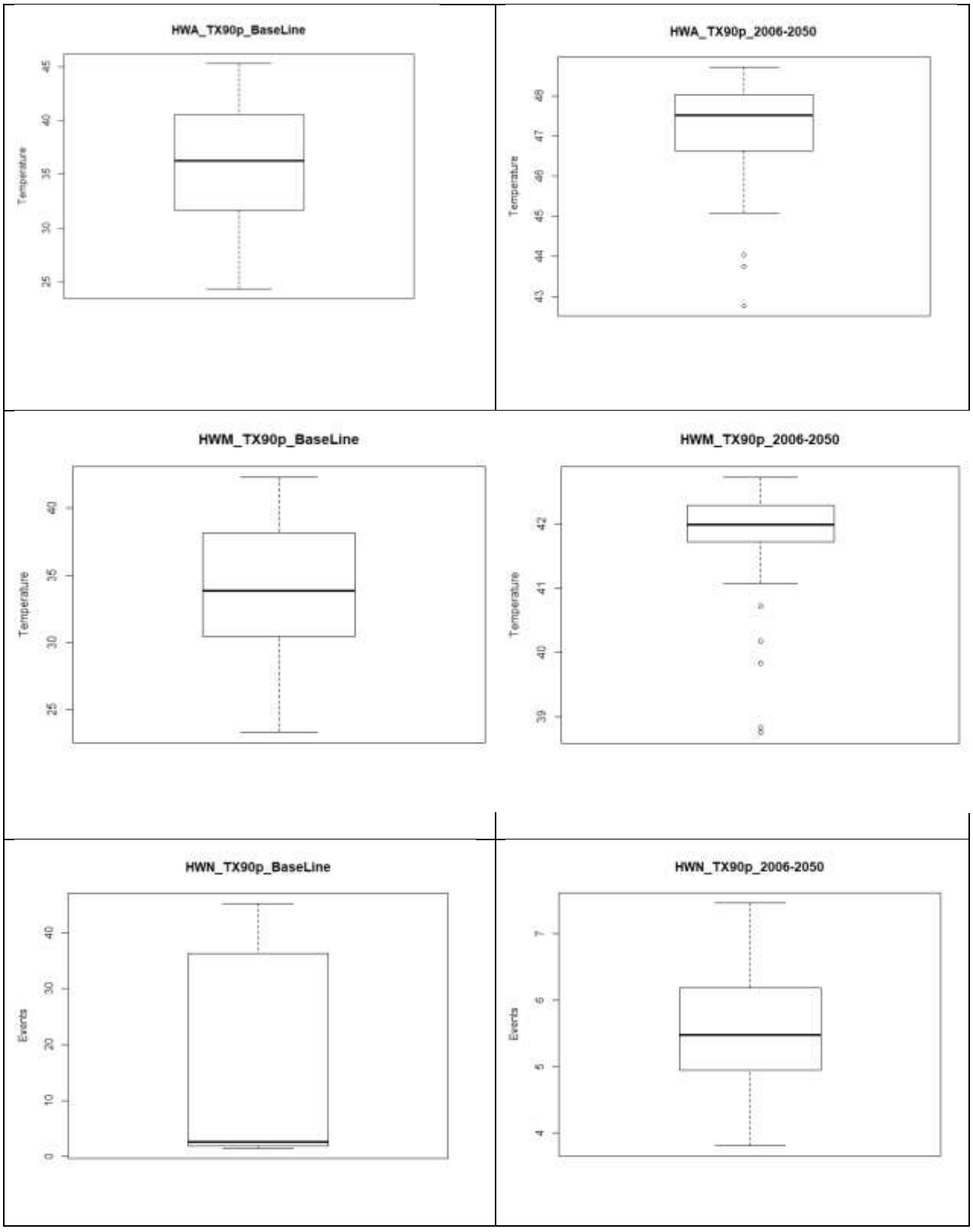
Heat waves indices from minimum temperature increases in all the cities and southern Punjab under both the RCPs. The magnitude and amplitude shows highest increase in RCP4.5 over all the cities whereas, like maximum temperature heat wave number, duration, and frequency is more increased under RCP8.5. Multan projects highest magnitude (30.54 ˚C) and amplitude (33.47 ˚C) for RCP4.5 and magnitude of 28.97 ˚C and amplitude 31.95 ˚C for RCP8.5. Over southern Punjab, magnitude is projected up to 30.31˚ C and 28.83 ˚C for RCP4.5 and RCP8.5. Amplitude across southern Punjab shows an increase of 9.39 C and 7.98 C projecting a total of 33.23 ˚C and 31.82 ˚C from 2006 to 2050 under RCP4.5 and RCP8.5 respectively. Multan projects over all highest number of duration (15 to 19 days) and frequency (46 to 57 days) for the period 2006 to 2050. The duration across southern Punjab is projected to be 15.25 days for RCP4.5 and 17.95 days under RCP8.5. While the frequency is 45.21 days and 54.99 days in RCP4.5 and RCP8.5 respectively.

Table 3.19: Heat wave Indices derived from three different methods (EHF, TX90p, TN90p) and their change in south Punjab under RCP4.5 and RCP8.5. The Italicized digits show the change from baseline (1976-2005) and (2006-2050).

| | RCP4.5 | | | | | RCP8.5 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | HWM | HWA | HWN | HWD | HWF | HWM | HWA | HWN | HWD | HWF |
| | | | | | **TX90p** | | | | | |
| **BAHAWALNAGAR** | | | | | | | | | | |
| **1976-2005** | 34.85 | 36.59 | 2.01 | 4.65 | 9.32 | 34.85 | 36.59 | 2.01 | 4.65 | 9.32 |
| **2006-2050** | 43.73 | 47.9 | 5.07 | 11.15 | 31.34 | 43.72 | 48.31 | 5.94 | 13.53 | 39.85 |
| ***CHANGE*** | *8.88* | *11.31* | *3.06* | *6.5* | *22.02* | *8.87* | *11.72* | *3.93* | *8.88* | *30.53* |
| **BAHAWALPUR** | | | | | | | | | | |
| **1976-2005** | 34.98 | 36.69 | 1.98 | 4.72 | 9.18 | 34.98 | 36.69 | 1.98 | 4.72 | 9.18 |
| **2006-2050** | 43.38 | 47.59 | 5.55 | 12.27 | 35.72 | 43.35 | 48 | 6.72 | 15.3 | 46.88 |
| ***CHANGE*** | *8.4* | *10.9* | *3.57* | *7.55* | *26.54* | *8.37* | *11.31* | *4.74* | *10.58* | *37.7* |
| **MULTAN** | | | | | | | | | | |
| **1976-2005** | 34.82 | 36.72 | 1.99 | 4.68 | 9.24 | 34.82 | 36.72 | 1.99 | 4.68 | 9.24 |
| **2006-2050** | 43.61 | 48.02 | 5.25 | 10.98 | 31.67 | 43.57 | 48.52 | 6.23 | 13.76 | 41.29 |
| ***CHANGE*** | *8.79* | *11.3* | *3.26* | *6.3* | *22.43* | *8.75* | *11.8* | *4.24* | *9.08* | *32.05* |
| **SOUTH** | | | | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **1976-2005** | 34.88 | 36.67 | 1.99 | 4.68 | 9.25 | 34.88 | 36.67 | 1.99 | 4.68 | 9.25 |
| **2006-2050** | 43.57 | 47.84 | 5.29 | 11.47 | 32.91 | 43.55 | 48.28 | 6.3 | 14.2 | 42.67 |
| ***CHANGE*** | *8.69* | *11.17* | *3.3* | *6.79* | *23.66* | *8.67* | *11.61* | *4.31* | *9.52* | *33.42* |
| | | | | | **TN90p** | | | | | |
| **BAHAWALNAGAR** | | | | | | | | | | |
| **1976-2005** | 23.06 | 24.21 | 1.95 | 4.79 | 9.61 | 23.06 | 24.21 | 1.95 | 4.79 | 9.61 |
| **2006-2050** | 30.4 | 33.37 | 6.14 | 15.21 | 45.05 | 28.9 | 31.94 | 6.82 | 17.59 | 55.19 |
| ***CHANGE*** | *7.34* | *9.16* | *4.19* | *10.42* | *35.44* | *5.84* | *7.73* | *4.87* | *12.8* | *45.58* |
| **BAHAWALPUR** | | | | | | | | | | |
| **1976-2005** | 22.25 | 23.27 | 1.87 | 4.46 | 8.99 | 22.25 | 23.27 | 1.87 | 4.46 | 8.99 |
| **2006-2050** | 29.98 | 32.86 | 6.07 | 14.9 | 44 | 28.62 | 31.57 | 6.57 | 17.53 | 53.37 |
| ***CHANGE*** | *7.73* | *9.59* | *4.2* | *10.44* | *35.01* | *6.37* | *8.3* | *4.7* | *13.07* | *44.38* |
| **MULTAN** | | | | | | | | | | |
| **1976-2005** | 22.92 | 24.03 | 1.92 | 4.55 | 9.25 | 22.92 | 24.03 | 1.92 | 4.55 | 9.25 |
| **2006-2050** | 30.54 | 33.47 | 6.19 | 15.64 | 46.58 | 28.97 | 31.95 | 6.61 | 18.72 | 56.42 |
| ***CHANGE*** | *7.62* | *9.44* | *4.27* | *11.09* | *37.33* | *6.05* | *7.92* | *4.69* | *14.17* | *47.17* |
| **SOUTH** | | | | | | | | | | |
| **1976-2005** | 22.74 | 23.84 | 1.92 | 4.6 | 9.28 | 22.74 | 23.84 | 1.92 | 4.6 | 9.28 |
| **2006-2050** | 30.31 | 33.23 | 6.13 | 15.25 | 45.21 | 28.83 | 31.82 | 6.66 | 17.95 | 54.99 |
| ***CHANGE*** | *7.57* | *9.39* | *4.21* | *10.65* | *35.93* | *6.09* | *7.98* | *4.74* | *13.35* | *45.71* |

Uncertainty in future data are analysed through Boxplots and Probability density function (PDF). In case of boxplots, the dotted line in between the boxplot represents the median of the data while the lines from outside the box represents the variability outside the upper and lower quartiles (Figure 3.11 a). Median of all the heat wave indices is greater during 2006 to 2050 than baseline over Punjab which show greater variability in data. All duration and frequency shows higher data variation for minimum temperature based heat waves while the dispersion in magnitude and amplitude is greater for maximum temperature derived heat waves. The maximum number of outliers are observed in magnitude and amplitude of maximum temperature derived heat waves. In case of PDFs (Figure 3.11 b), all the indices show positively skewed distribution whereas, greater variability is observed in kurtosis. In base line almost no differences in the distributional structure is found for all the indices over central, south and north Punjab. But from 2006 to 2050, higher distributional differences and large variabilities in average modes are represented. Duration, frequency and number of heat waves shows often wider and flattened distribution that indicates greater variability and more frequent heatwaves.


HWA_TX90p_BaseLine
Temperature
HWA_TX90p_2006-2050
Temperature
HWM_TX90p_BaseLine
Temperature
HWM_TX90p_2006-2050
Temperature
HWN_TX90p_BaseLine
Events
HWN_TX90p_2006-2050
Events

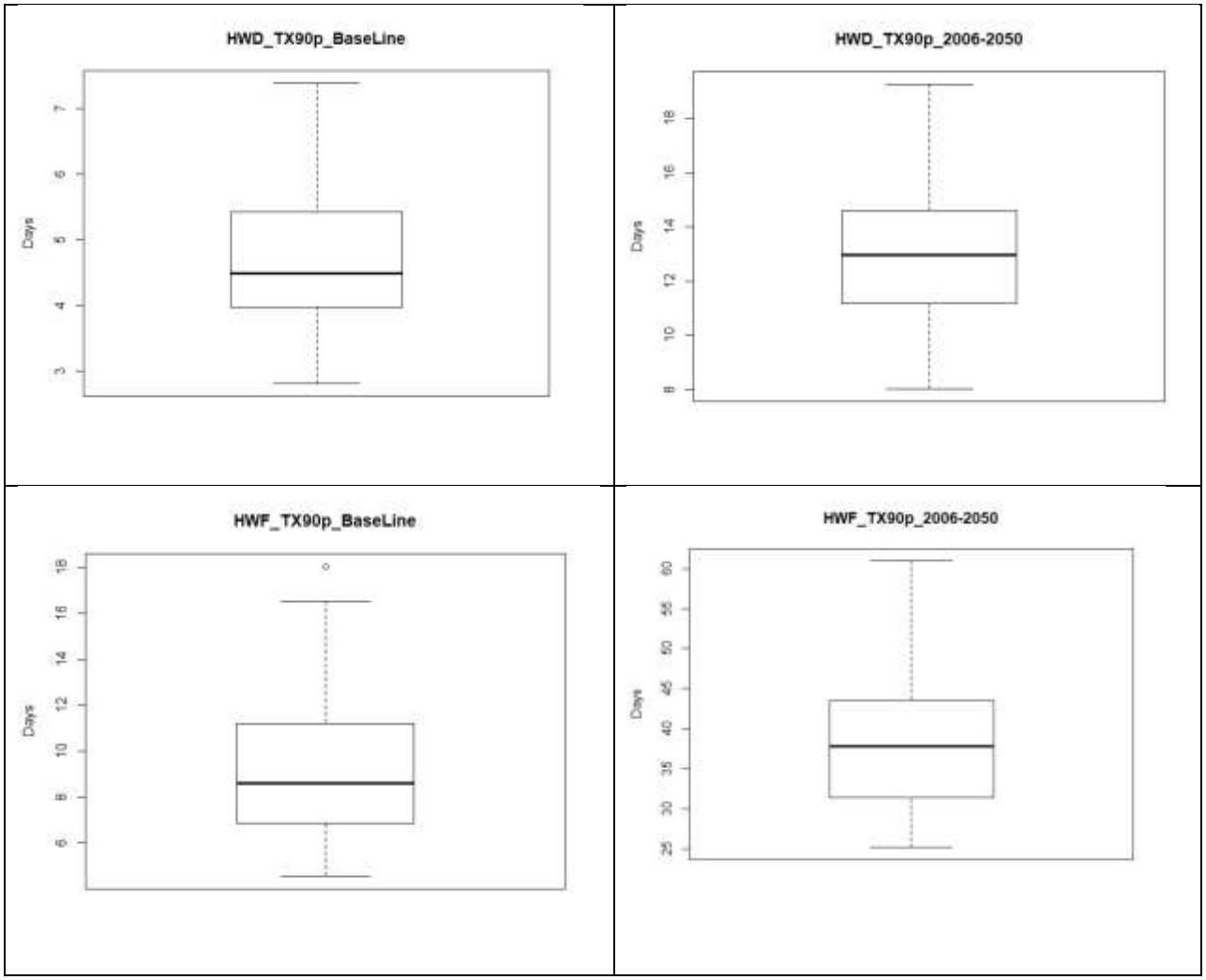
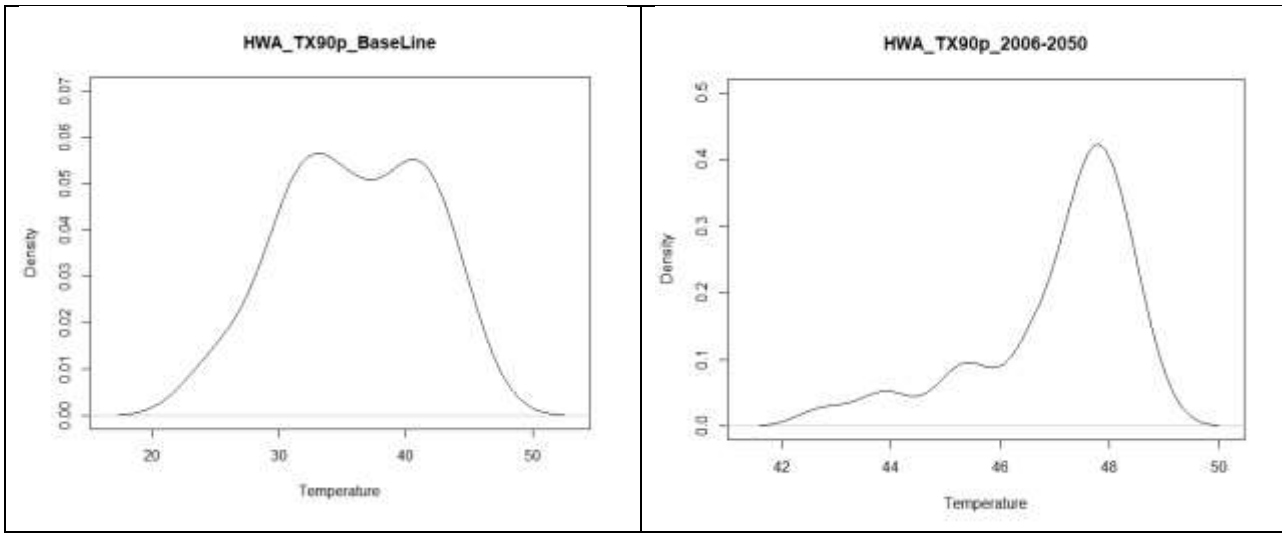
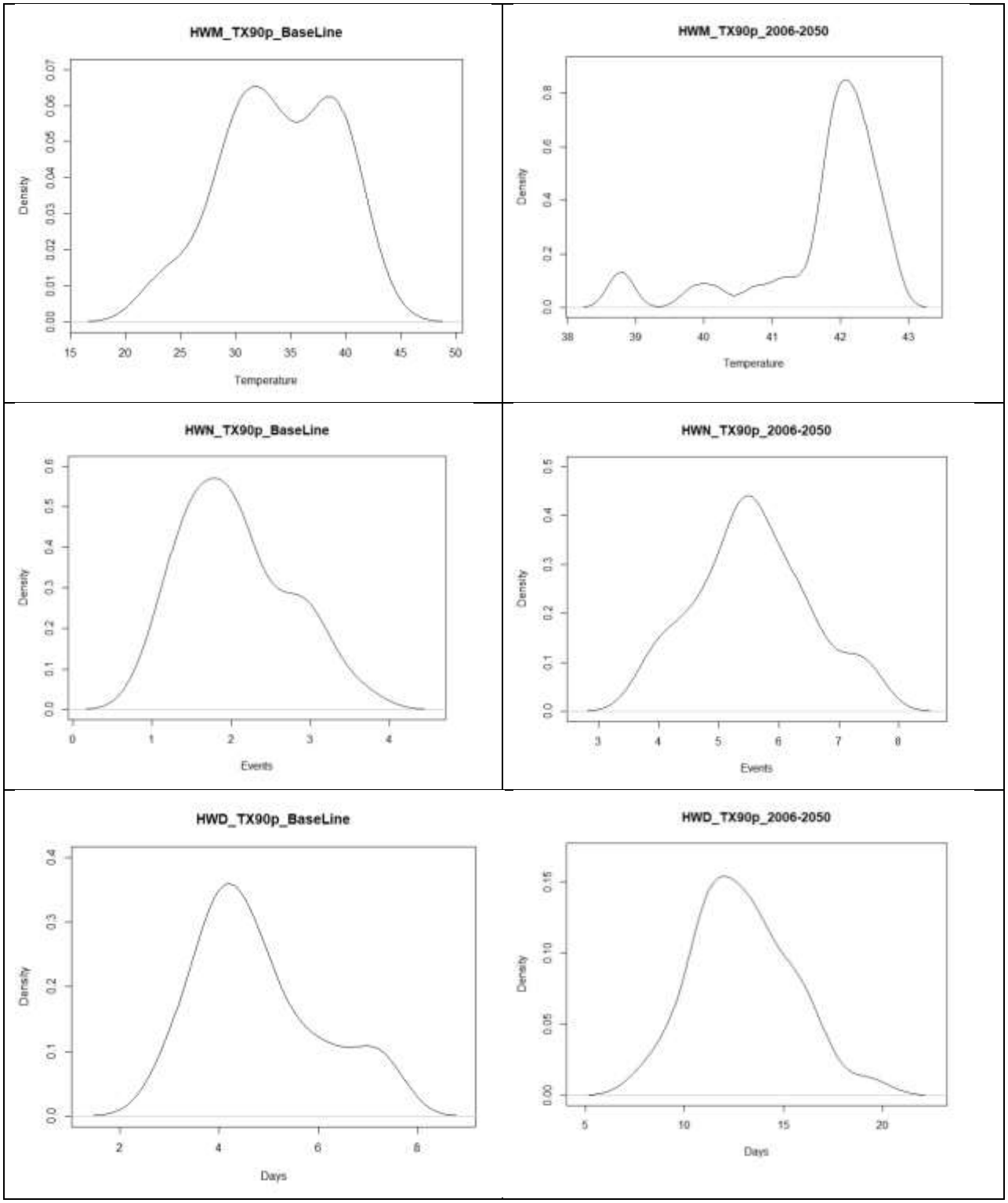



Figure 3.11 a: Box plots of heat wave indices over Punjab for baseline (1976-2005) and future (2006-205) period.




HWM_TX90p_BaseLine
Density
Temperature
HWM_TX90p_2006-2050
Density
Temperature
HWN_TX90p_BaseLine
Density
Events
HWN_TX90p_2006-2050
Density
Events
HWD_TX90p_BaseLine
Density
Days
HWD_TX90p_2006-2050
Density
Days

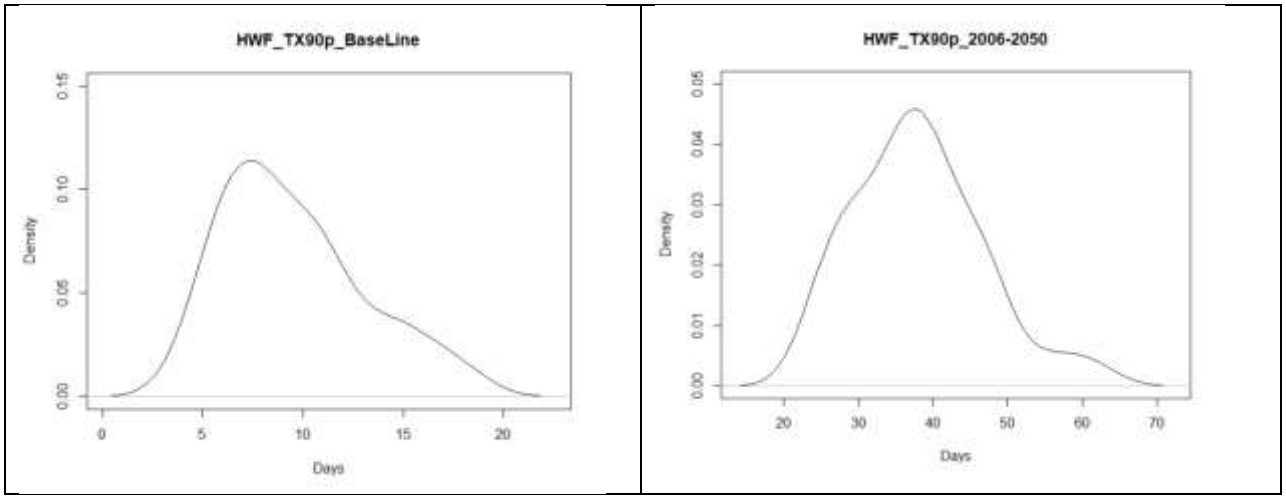
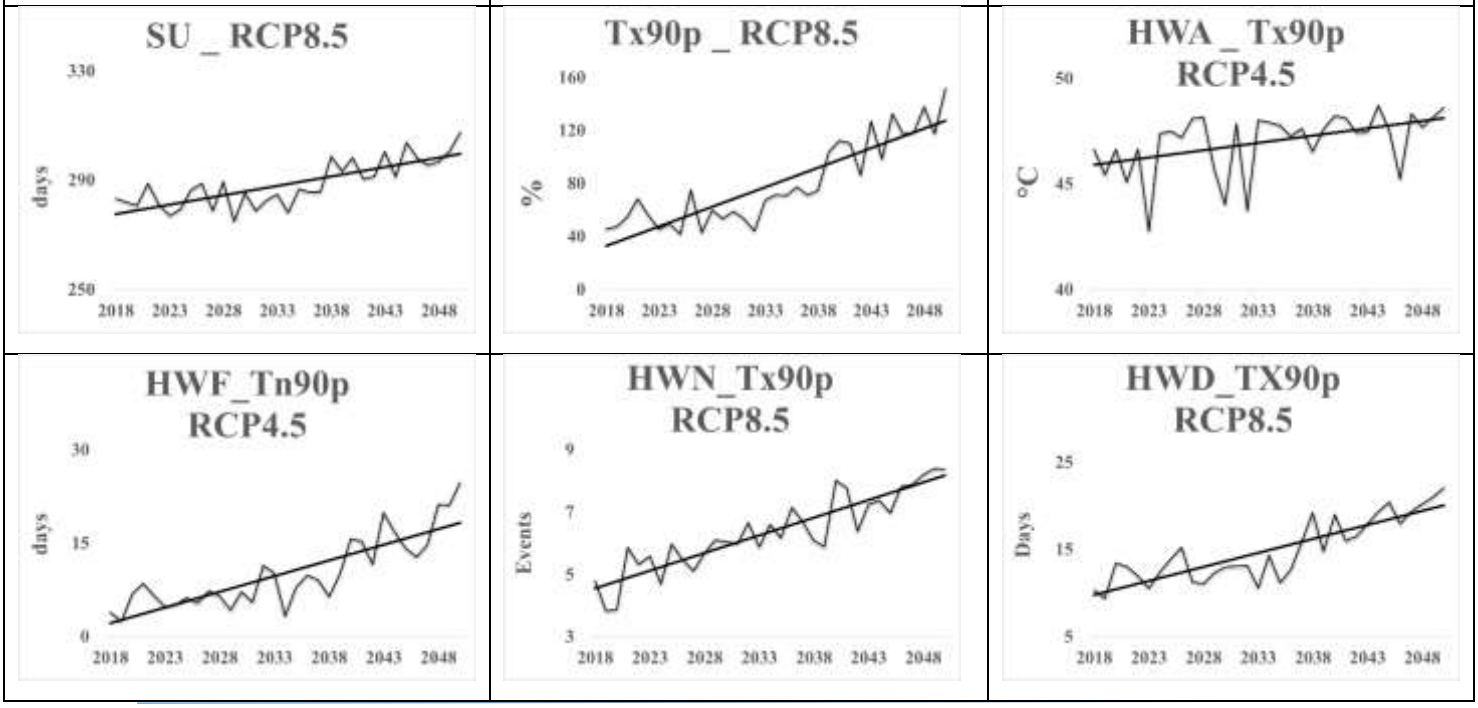



Figure 3.11 (b): Probability density function (PDF) analysis over Punjab for baseline (1976-2005) and future (2006-2050).

Hence, in conclusion, the trend of the time series plots of temperature extreme indices show a shift towards warming conditions over all regions of Punjab (Figure 3.12). All the warm temperature extremes are increasing while the cold temperature indices such as CSDI shows negative trend from 2006 to 2050. The heat wave indices also show an increasing trend in future with highest increase shown by frequency of heat waves. Warm spells have also shown higher increase among the other indices that predicts frequent heat waves in near future over Punjab.

**Center Punjab**



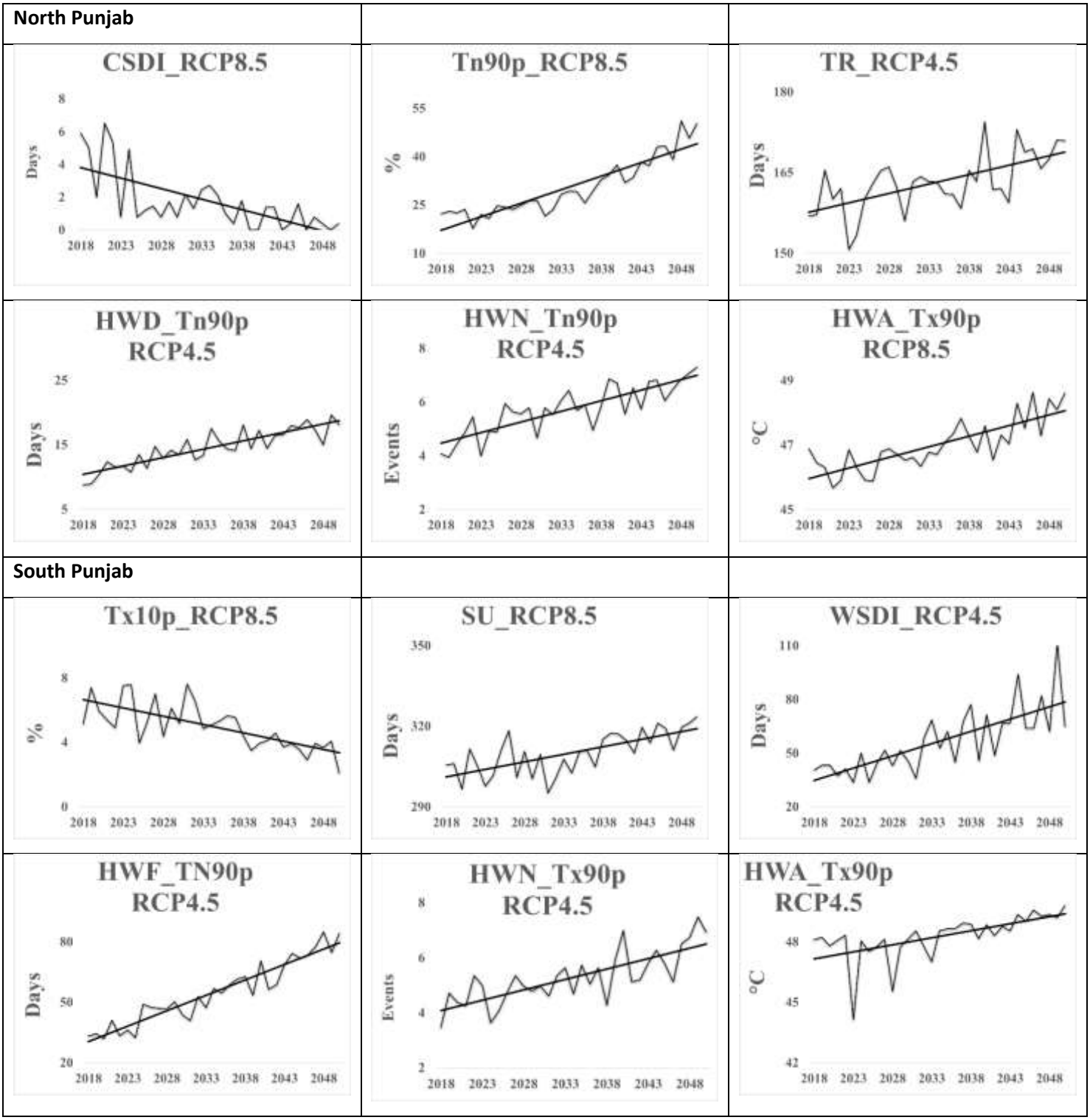



Figure 3.12: time series plots of extreme indices over center, north and south Punjab from 2018 to 2050.

## 3.9. Future GHGs emission scenario:

Many factors have to be taken into account when trying to predict how future global warming will contribute to climate change. The amount of future greenhouse gas emissions is a key variable. Developments in technology, changes in energy generation and land use, global and

regional economic circumstances and population growth must also be considered. There are many climate modelling teams around the world. If they all used different metrics, made different assumptions about baselines and starting points, then it would be very difficult to compare one study to another. In the same way, models could not be validated against other different, independent models, and communication between climate modelling groups would be made more complex and time-consuming.

The goal of working with scenarios is not to predict the future but to better understand uncertainties and alternative futures, in order to consider how robust different decisions or options may be under a wide range of possible futures". There are four pathways: RCP8.5, RCP6, RCP4.5 and RCP2.6 which are developed by modelling community and are used by IPCC Assessment report 2013 (Table 3.20). These scenario basically consists of numbers - a prodigious amount of them. For each category of emissions, an RCP contains a set of starting values and the estimated emissions up to 2100, based on assumptions about economic activity, energy sources, population growth and other socio-economic factors.

**RCP 8.5** International Institute for Applied Systems Analysis (IIASA), Austria increasing greenhouse gas emissions over time.

**RCP6**. Stabilized shortly after 2100, without overshoot, technologies and strategies for reducing greenhouse gas emissions.

**RCP 4.5**. It is a stabilization scenario in which total radiative forcing is stabilized shortly after 2050.

**RCP2.6**. very low greenhouse gas concentration levels. It is a "peak-and-decline" scenario; its radiative forcing level first reaches a value of around 3.1 $W/m^2$ by mid-century, and returns to 2.6 $W/m^2$ by 2100.

Table 3.20: Explanation of four RCPs with expected emissions and temperature anomaly by 21st Century. Source; IPCC AR-5

| Name | Radiative forcing | $CO_2$ equiv (p.p.m.) | Temp anomaly (°C) | Pathway | SRES temp anomaly equiv |
|---|---|---|---|---|---|
| RCP8.5 | 8.5 $Wm^2$ in 2100 | 1370 | 4.9 | Rising | SRES A1F1 |
| RCP6.0 | 6 $Wm^2$ post 2100 | 850 | 3.0 | Stabilization without overshoot | SRES B2 |
| RCP4.5 | 4.5 $Wm^2$ post 2100 | 650 | 2.4 | Stabilization without overshoot | SRES B1 |
| RCP2.6 (RCP3PD) | 3$Wm^2$ before 2100, declining to 2.6 $Wm^2$ by 2100 | 490 | 1.5 | Peak and decline | None |

Figure (3.13) shows trends in radiative forcing under different RCPs. RCP2.6 radiative forcing peaks around ~2055 (CO2 level ~ 445 ppm), goes down after that with CO2 level returning back to ~420ppm by the end of the century. On the other hand, RCP8.5 continuously increases throughout this period with CO2 levels reach >900 ppm by 2100. Therefore, at the end of the century (2100), the two radiative forcing scenarios are at different levels in their trajectories, one on the downward slope after reaching its peak and other at its maximum level of the 21st century

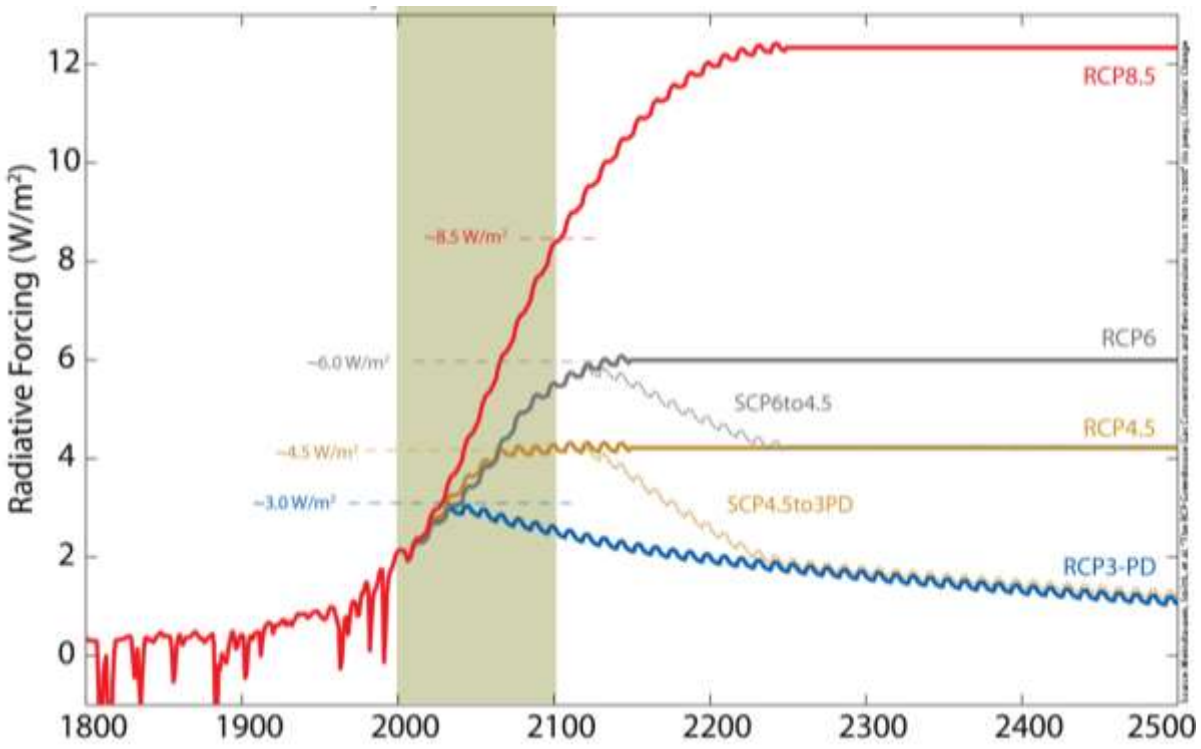



Figure 3.13: Total radiative forcing (anthropogenic plus natural) for RCPs,—supporting the original names of the four pathways as there is a close match between peaking, stabilization and 2100 levels for RCP2.6 , RCP4.5 & RCP6, as well as RCP8.5, respectively. Source (Meinshausen, et al. 2013)

The combination of trends in greenhouse gases and those in atmospheric pollutants translate to changes in concentrations affecting the overall development of radiative forcing. The RCPs, as specified in the original selection criteria, cover the trends and level of radiative forcing values of scenarios in the literature very well. Total radiative forcing is determined by both positive forcing from greenhouse gases and negative forcing from aerosols. The most dominant factor, by far, is the forcing from $CO_2$. As a result, both for the RCPs and in the overall literature, 2100 radiative forcing levels are correlated with cumulative 21st century $CO_2$ emissions.

The information is available in RCP repository related to emissions, concentrations, radiative forcing and land use—both at the level of aggregated regions and in gridded form (Table 3.21). By using the all the data available for the intervening years, a trajectory can be given for any specific emissions. Each RCP plots a different emissions trajectory (pathway) and cumulative emission concentration in 2100. The deliverable is a download from a central repository. Scientists can preview and download data on emissions, concentrations, radiative forcing and land use, in regional and gridded form, following different trajectories over similar timescales. These data sets can then be incorporated into any modelling exercise, providing consistent parameters for each emissions trajectory, and a consistent foundation for all climate modelling teams anywhere in the world.

Table 3.21: The available information on the data types available for the RCPs, the sectors by which emissions are broken down, and the geographical resolution of the information. (Source Vuuren et al., 2011)

| Available information from RCPs and resolution | | |
|---|---|---|
| | **Resolution (sectors)** | **Resolution (geographical)** |
| **Emissions of greenhouse gases** | | |
| $CO_2$ | Energy/industry, land | Global and for 5 regions |
| $CH_4$ | 12 sectors | 0.5°×0.5° grid |
| $N_2O$, HFCs, PFCs, CFCs, $SF_6$ | Sum | Global and for 5 regions |
| **Emissions aerosols and chemically active gases** | | |
| $SO_2$, Black Carbon, Organic Carbon, CO, $NO_x$, VOCs, $NH_3$ | 12 sectors | 0.5°×0.5° grid |
| Speciation of VOC emissions | | 0.5°×0.5° grid |
| **Concentration of greenhouse gases** | | |
| ($CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, CFCs, $SF_6$) | | Global |
| **Concentrations of aerosols & chemically active gases** | | |
| ($O_3$, Aerosols, N deposition, S deposition) | | 0.5°×0.5° grid |
| Land-use/land-cover data | Cropland, pasture, primary vegetation, secondary vegetation, forests | 0.5°×0.5° grid with subgrid fractions, (annual maps and transition matrices including wood harvesting) |

In this report, future changes in climate are assessed these two scenario as these are most anticipated scenarios in future. As RCP2.6 is a stabilization scenario which keeping in view the current development is not possible to attain Pakistan and Punjab. Therefore, it is very likely that incorporating the proposed development in PSS it is likely that the future emission scenarios will follow and lie in RCP4.5 following the adaptation strategies in place or in extreme case scenario without any adaptation RCP8.5 is expected, against which the future changes in climate are analysed and impacts are assessed in the report. Hence these the projections of future climate change by 2050 are provided against these two scenarios. As indicated from the future climate projections, the province of Punjab is highly vulnerable in terms of increased temperature, extreme events and changing precipitation pattern under a changing climate scenario. Even under a moderate emission scenario of RCP4.5, all the parts of the province are likely to cross 1.5 ˚C increase in average temperature while it is expected to move beyond 2 ˚C under intense emission scenario. This shows that by 2050, Punjab is likely to cross the targets of Paris Agreement in which can have adverse impacts on climate of the region.

## 3.10. Impact Assessment:

The assessment of future climate shows increased temperature, variable rainfall pattern and increasing frequency and magnitude of extreme weather events in all the three regions of Punjab. As there is no single part which can be exempted from the threat, the whole region would require almost similar efforts in mitigating the expected impacts.

As central Punjab, particularly Lahore and Faisalabad has been proposed to be a hub of industrial and development activities, the impacts caused by changing climate are likely to exacerbate in the central region as the region has already shown vulnerability to high increase in temperature and extreme events (Section 3.5, 3.7). Moreover, the region lie in core monsoon region of Pakistan (CMRP) with projected increase in monsoon precipitation as well. Therefore, increasing temperature and changing rainfall pattern have growing propensity for floods which would be detrimental to surface and groundwater recharge, posing threats to the region's water security.

Also, the housing demand is proposed to be highest in Lahore and Faisalabad which will be done at the cost of land use changes. As these cities have already been proposed as high priority areas for industrial development and road networks which could cause to make these cities as major source of GHGs in Punjab with less or no carbon sinks located. This intensive development in these cities will make them vulnerable to even higher adversity of changing climate due to increased and frequent extreme weather events and recurring floods and heat waves. Moreover, these projected changes in climate can have detrimental impacts on development proposed under PSS which needs to be incorporated in the plan. The central region of Punjab where high rate of development is proposed is vulnerable in terms of variable rainfall pattern, particularly, increased monsoon rainfall in future which makes the region prone to flooding, particularly the urban centres like Lahore, Faisalabad and Rawalpindi in North. This along with other extreme weather events can pose a danger to the proposed infrastructure and other associated activities, thus needs to be considered in PSS.

The changing patterns of temperature and precipitation can pose serious threats to agricultural productivity in the province as the areas of central and south Punjab comprise the food basket of the country. Likewise, as major agricultural zones are identified in

Southern part of Punjab, food security in that region may be placed under progressively greater pressure due to rising temperatures, heat extremes, floods, and increasing year-to-year rainfall variability that can disrupt agricultural food production and adversely impact crop yield in the region. It is important to introduce climate resilient crop varieties and a shift toward climate friendly agricultural practices to ensure food security and to minimize the harmful impacts on the proposed agricultural zones.

It is also expected that climate change may seriously compromise human health in the absence of risk mitigation, adaptation, or acclimatization, particularly among children and the elderly. Higher temperatures, extreme weather events, and higher climate variability have been associated with an elevated risk of heat strokes, cardiovascular and neurological diseases, and stress-related disorders. Heat stress in urban areas is often compounded by the heat island effect which is expected to be higher in the areas of Mianwali, Lahore and Faisalabad which is also demonstrated in PSS. Such considerations should be incorporated in proposed health system in PSS.

Warmer, higher moisture conditions, on average, are also more favourable for the spread of vector-borne diseases such as malaria and dengue fever. This problem is like to be more prevalent in congested cities like Lahore, Rawalpindi and Faisalabad where high traffic flow, industrial emission and congested living conditions will likely to exacerbate the impact.

All these changes can be exacerbated if the adequate adaptation and mitigation measures and environmental safeguards are not incorporated in PSS. However, with sufficient climate and environmental safeguard measures taken in consideration along with sustainable development efforts, PSS became as source of well-being of the people of Punjab not only in term s of economy but also for environment protection and conservation.

**Keeping the above mention impacts in view, following mitigation and adaptation strategies are recommended to incorporate in PSS.**

To hold this increase in temperature to limits, it is vital to reduce the GHG emissions in the province which need large scale changes industries. In this regard, it is suggested to develop all the new industries based on cleaner and renewable energy source, particularly

those proposed in the Central Punjab and along the north western CPEC motorway as these areas are already a great source of GHGs in Punjab.

Also, the shift toward efficient machinery is also pertinent to emit less pollution to the air. A massive shift to mass transit system and enforcing the use of efficient fuels in vehicle, particularly in congested cities like Rawalpindi, Faisalabad and Lahore can have a significant impact on curbing the impacts of climate change.

As land use changes can exacerbate the impacts of changing climate. Thereby, in the areas of North and Central Punjab where high housing demand is projected in future, vertical building structures should be encouraged to minimize the land use changes in the urban areas which will ultimately lead to less variability in climate over time.

Ambitious afforestation efforts likewise offer myriad benefits. Aside from mitigating climate change through carbon sequestration, trees also enhance resilience to flash floods and landslides by improving soil retention, improve resilience to droughts by increasing percolation of surface water into the soil, reduce vulnerability to extreme heat by reducing ambient temperatures, and support native wildlife and biodiversity. In short, forests and urban green spaces will deliver substantial economic benefits to whole region of Punjab by mitigating a wide range of the expected impacts of climate change and is the safest, most reliable means of realizing several of sustainable development goals. However, research on species that sequester more carbon should be taken in account along with promotion of indigenous species.

In the congested area, particularly Lahore, where sufficient green places cannot be developed, a concept of green walls should be introduced in vertical building patterns in the urban area to mitigate the GHGs and to gain multiple environmental benefits at the same time.

Moreover, as the region of Southern Punjab receive sufficient amount of solar insolation, the proposed infrastructure should be constructed with integrated solar photovoltaic system to ensure energy efficiency. Low impact development and green building infrastructure can reduce both urban heating and air pollution. A reduction in air pollution would greatly benefit human and environmental health, improve the efficiency of solar

energy generation, and even potentially aid in increasing the quantum of monsoon rainfall.

As indicated, precipitation is likely to increase in future which can pose a threat of flood in the region, especially in urban cities of North and Southern Punjab. Thereby, it is essential to incorporate disaster management strategies in future planning which include the assessment of flood risk areas and the type of development proposed in specific area under PSS should be conducted to incorporate changes in design accordingly. An increase in rainfall together with measures for water harvesting would aid the restoration of groundwater levels. Restoration of groundwater levels would not only improve water security and resilience to droughts but also help check land subsidence.

Moreover, climate change is likely to later the surface water availability in future in the southern region which can impact the agricultural productivity. To cope with adverse impacts on agriculture, it is important to introduce climate resilient varieties in agriculture. Moreover, as the seasonal patterns are also projected to change, it is necessary to plan the cultivation of crops in accordance with it.

An early warning system in this regard is essential to forecast the extreme weather events in all the parts of Punjab. Additionally, awareness at public level has a key role in coping with any unforeseen situation in the region. In conclusion, all the sectors likely to be impacted by climate change need to be consider while devising future development plans to ensure sustainability in the region.

Equity and social justice are critical to building climate resilience since the most vulnerable people such as the poor, the disabled, outdoor labourers and farmers will bear the brunt of climate change impacts. Incentives for introducing greener solution should be included to ensure sustainable development.

## Conclusion:

The assessment of future changes in climate displays enhanced vulnerability of all the regions of Punjab in terms of increasing temperature, variable rainfall pattern, increased extreme events and heat waves. While the proposed development is likely to be intensive in central region of Punjab, the region will likely to contribute more in future GHGs

emissions from transport sector, industries and land use changes. Consequently, the region will be under pressure of recurring heat waves and urban flooding in future which can also pose detrimental impact on proposed development of PSS. While major agricultural zones are identified in the southern part of Punjab, the projected changes in climate can have adverse impacts on the crops and agricultural productivity putting pressure on future food security. In the northern Punjab, highest increase in temperature is projected compared to baseline with highly variable rainfall pattern while the proposed developmental activities are likely to exacerbate the adverse impacts due to increased emissions. The increasing trend in extreme weather events and heat waves particularly in central and southern Punjab will raise serious concerns in terms of human and ecological health. All these impacts assessed in the report highlight the dire need of incorporating adaptation and mitigation strategies in all the sectors which involves emission of GHGs, land use changes and degradation of environment. All the development proposed under PSS should take in to account the likely impacts of changing climate on the environment and also on PSS activities in future to meet the goal of sustainable development.

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# Annex - 5

# Punjab Spatial Strategic 2047: Strategic Environmental Assessment – Biodiversity Report

**Dr. Uzma Khan**

**Coot, Chashma wildlife sanctuary**

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## 1.1 Introduction

Pakistan is rich in biodiversity because of its diverse landscape created primarily because differences in elevation, from the Arabian Sea to the second highest peak in the world – K2. This variation creates a wide range of climatic conditions producing different types of vegetations and these habitats are home to a wide variety of flora and fauna. The varied and diverse numbers of species in Pakistan is largely due to location in a transitional zone between two of the six major zoogeographical regions globally; the Palearctic and Oriental, species have also come from as far as the Ethiopian region (Robert, 1997). Pakistan and also the Punjab Province is very important for birds diversity, eight (Ucchali Wetlands Complex, Taunsa Wildlife Sanctuary, Chashma Wildlife Sanctuary, Bajwat/Marala Game Reserve, Rasool Barrage Wildlife Sanctuary, Head Qadirabad, Rangla Weltands Complex, Lal Suhanra National Park) out the 33 **Important Bird Areas, IBA, (Annex 1)** of Pakistan lie. These IBA are recognised by the BirdLife International based on an internationally agreed criteria to list areas as important for the conservation of birds' populations and other biodiversity. For example Rangla Wetlands Complex is the only breeding site of the Marbled teal (*Marmaronetta angustirotris*) in the Punjab province (Khan A *et al* 1999). Pakistan is also globally recognised because of its diversity of reptiles and Punjab province is home to many endemic reptilian species (Khan, 2006)

## 1.2 Biodiversity Baseline

Punjab Province has endangered population of the white-headed duck (Ali and Akhtar, 2005) and critically endangered Great Indian bustard, which are the only populations found in Pakistan (IUCN Red List). Additionally, irrigated forest plantations provide habitat to a range of wildlife species and some have also been declared as protected areas under the Punjab Wildlife Act (1974). Both sub mountainous habitat and irrigated forest plantations already face various threats from collection of firewood, grazing by livestock and destruction of the breeding and nesting grounds of birds' species and competition with and disease transmission by livestock to wild ungulates. The ecologically important wetlands are also threatened by pollution both industrial and agricultural, land conversion for agriculture practices. Annex 2 compiles all the species data from Punjab along with the taxonomic information and IUCN Red List status.

The endangered Indus River dolphin *Platanista gangentica minor* is now only restricted to the Indus River system between Jinnah and Kotri barrages and occupies approximately one fifth of its former range (Reeves, et al., 1991). Reeves et al. (1991) mentioned the dramatic decline in the range of the species, from the historical distribution of approximately 3,500km of river length to now 1,375 km, occurred presumably after the mainstream and major tributaries were segmented by barrages built between the 1930s and early 1970s. This resulted in a rapid decline of the Indus Dolphin especially considering that carrying capacity within the current range has decreased because of commercial fishing and water diversion for irrigation. The decreasing water supply and the consequent reduction in available habitat in the form of deep pools with sufficient food resources lead to population decline. Taunsa-Guddu river section in Punjab has 571 dolphins (WWF, 2017), which needs management as the dry season flows are insufficient to maintain the habitat thus making dolphins more vulnerable to entrapments in small pools and gill net entanglements.

Khan (2006) recommended an Indus Dolphin Reserve in Punjab towards downstream at Taunsa Barrage. The downstream Taunsa Barrage is particularly important area in this respect and is outside the sanctuary area. The baseline survey showed that dolphins move very close to the barrage in fall season and species needs to be effectively protected and area should be notified as a reserve. This site has not been notified as the Indus Dolphin Reserve till to date.

With this rate of growth, the population of Pakistan is expected to reach 214 million in 2020 (Trading Economics, 2014). With such statistics come perils to wildlife species, in particular those that a wide ranging such as the common leopard. The geographical territories of Pakistan used to have two other big felids; Asiatic lion *Panthera leo persica* and Bengal tiger *Panthera tigris*, however the last ones were shot in 1810 and 1886, respectively (Roberts, 1997). Widespread hunting has also impacted prey species, the recent extinction of the Blackbuck *Antelope cervicapra* in 1970s (Roberts, 1997) is an example of an ungulate extinction, although several failed attempts have been made to reintroduce the population into the arid habitat, along with supplementation of the Chinkara *Gazella bennetti* in the Cholistan desert (Toosy, 2005). The situation is not different for the mountain ungulates, the population of the grey goral, is very scanty in Pakistan (Abbas *et al.,* 2012). A part of growing human population and habitat loss, illegal wildlife trade is also rampant in Punjab, some species have suffered greatly because of this and the Indian pangolin is one example which is now endangered. Survey in the Potohar Plateau showed that communities are actively involved in the trafficking and approximately 275 pangolins were poached during 2013-2018 from the area (Waseem *et al* 2020).

Punjab is a biodiversity rich province however species cannot be divided into regions because the is extensive overall between of ranges. Details species table have been included in the relevant report as **Annex 2**. Below is a table 1 that indicates those species that are restricted to particular region:

**Table 1:** Unique wildlife species of regions

| # | North | Central | South |
|---|---|---|---|
| 1 | Grey Goral | There no species that is exclusive found in the central region | Great Indian bustard |
| 2 | Greater Flamingo (Khabekki and Uchalli lake) | | Houbara bustard (stronghold but population also exists in Bhakar in the Central region) |
| 3 | White headed duck | | Marbled teal |
| 4 | Common leopard (occasional reports from other regions) | | Blackbuck (some reports of the wild individuals by the Punjab Wildlife Department) |
| 5 | Punjab Urial | | Desert fox |

| # | North | Central | South |
|---|---|---|---|
| 6 | Leopard cat | | |
| 7 | Khalij pheasant | | |
| 8 | Yellow throated marten | | |
| 9 | Indian pangolin (stronghold but reported from other regions) | | |

## 1.3 State of the forests

According to the latest FAO report (FAO, 2015), Pakistan has only 1.9% of land under forest with a high deforestation rate, 2009 report analysed the forest cover of Pakistan at 2.5% with deforestation at -2.1%, which is highest in Asia (F.A.O., 2009). Pakistan has one of highest rates of forest loss in Asia[1] (FAO, 2005). Table 2 has been adapted from the report to illustrate how Pakistan has been losing its forest cover.

**Table 2:** Forest data of Pakistan according to FAO

| | **Extent of forest 1990-2015** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Extent of forest (1000 ha) | | | | | Annual rate of change | | | |
| | 1990 | 2000 | 2005 | 2010 | 2015 | 1990-2000 | 2000-2010 | 2010-2015 | 1990-2015 |
| Pakistan | 2527 | 2116 | 1902 | 1687 | 1472 | -1.8 | -2.2 | -2.7 | -2.1 |

The forest cover figure of the Government of Pakistan is different with 5.4% according to the NBSAP 2017-2030. While the World Bank 2018 data from World Development Indicators also reflect a steady decline of Pakistan forest and one of lowest in the region (Table 3).

**Table 3** Forest area (% of land area)

| ***Country*** | **2013** | **2014** | **2015** | **2016** |
|---|---|---|---|---|
| *Pakistan* | 2 | 2 | 1.9 | 1.9 |
| *India* | 23.7 | 23.7 | 23.8 | 23.8 |

1 FAO (2009) The state of the world's forest. Food and agriculture organisation of the United Nations, Rome, p 111

| | | | | |
|---|---|---|---|---|
| *Afghanistan* | 2.1 | 2.1 | 2.1 | 2.1 |
| *Sri Lanka* | 33.2 | 33.1 | 33 | 32.9 |
| *Maldives* | 3.3 | 3.3 | 3.3 | 3.3 |
| *Bangladesh* | 11 | 11 | 11 | 11 |
| *Bhutan* | 71.8 | 71.8 | 72.3 | 72.5 |
| *Nepal* | 25.4 | 25.4 | 25.4 | 25.4 |

Source: World Development Indicators 2018.

Loss of forest and increase in human settlements have brought wildlife species in conflict with local communities and this is serious in case of large predators for example the common leopard, one average in Pakistan six leopards are killed every year and many more may go unreported (Khan et al 2018). Erosion of soil and landslides, principally owing to this high deforestation is threatening the ecology of the area. Main factors contributing to this high deforestation include fuel wood and timber extraction, ongoing development programmes such as gas pipeline, expansion of the road network and forest land conversion to non forest uses (WWF – Pakistan, 2010). There is pressure on natural resources because of the growing human population. The total population in Pakistan appeared to be 2013 at 182,142,594 /182.12 million (World Bank, 2013) and 219 now (Trading Economics). It was 45.9 million in 1960, changing 302 per cent during the last 50 years (Pakistan Bureau of Statistics).

## 1.4 Forests in Punjab

There are only five of 36 districts in Punjab with more than 5% of forest cover. Rawalpindi has 18% and Mianwali has 6% forest cover of total area of the district (WWF – Pakistan). Punjab is the most populous province of Pakistan therefore there is already a great deal of anthropogenic pressure on biodiversity and natural resources.

**Table 4: Percentage forest covers for each province/territory of Pakistan[2]**

| Province/territory | Percentage geographic area covered by forest | Percentage of total forest area |
|---|---|---|
| **Federally Administered Areas** | 20.7 | 6.5 |
| **Balochistan** | 1.7 | 14.0 |
| **Northern Areas** | 9.5 | 15.7 |
| **N.W.F.P.** | 16.6 | 40.0 |
| **Punjab** | 2.9 | 14.4 |
| **Sindh** | 2.8 | 9.4 |

[2] Forestry Sector Master Plan (FSMP) Estimates of Land Use Based on Satellite Imagery Interpretation database

Punjab has variety of vegetation types, while the predominant natural forest in Punjab comprises of the tropical thorn forest and this type of forest has a more patchy distribution now in military controlled areas or forest plantations (Ahmed et al 2007). Seasonal flooding associated with rivers (Indus, Chenab, Jehlum) have riverine vegetation or belas. There are arid vegetation in Cholistan and Thar areas (Ahmed et al 2007). In the Punjab Province, the Murree Forest Division (MFD), is part of the Himalayan Subtropical Pine forest eco-region and Tropical and Subtropical Coniferous forest Biome (Wikramanayake et al., 2002). The altitudinal range is 355-2380 meters and the total area of the forests in Murree is approximately 467 $km^2$, which is formally divided into four forest divisions known as: Ghora Gali, Sambli, Lower Topa and Sehr Bagla (WWF-Pakistan, 2010). Murree is known to comprise three main forest types: subtropical Pine forests, moist temperate forest (limited areas) and broadleaved deciduous forest at lower altitudes (Hameed *et al.,* 2010). The terrain is marked with moderately steep hills-sloped at angles ranging between 30° and 50° (Hameed *et al.,* 2010). The area has a record of 192 plant species, 15 mammal species, 146 bird species and 22 reptile and 6 amphibian species (WWF-Pakistan, 2010). In Murree area the subtropical Pine forest zone mainly comprised chir pine *Pinus roxburghii* (Wikramanayake *et al.,* 2002) and at lower altitude warmer areas broad leaved species, Acacia/phulai *Acacia modesta*, Kau *Olea ferruginea* and sanatha *Dodoriaea viscosa* form the main vegetation (WWF, 2010). Scrub species found in the area may include: oleander *Nerium oleander*, Garanada *Caressa opaca* and Koranda *Caressa carandas* (Hameed *et al.,* 2010). Climber species found in the area include: Yam *Dioscorea deltoidea*, Himalayan Ivy *Hedera nepalensis* and Himalayan musk rose *Rosa brunonii* (EPD, 2010).

Irrigated forest plantations in Punjab are also important wildlife habitats, besides functioning as carbon sinks, providing NTFP. These plantations typical have natural vegetation in the form of tropical thorn forest and plantations of Sheesham *Dalbergia sissoo*, *Acacia nilotica*, Eucalyptus and poplar *Poplus spp*. Mesquite Prosopis glandulosa in some plantations, while Sheesham is mixed with mulberry *Morus alba*. Plantations are either wildlife sanctuaries or game reserves under the Punjab Wildlife Act, 1974 (Maan and Chaudhry 2001) for example Changa Manga Wildlife Sanctuary, Chichawatni Wildlife Sanctuary

## 1.5 Riverine Forests

These forests commonly known as the 'Belas' and are found in all three regions of Punjab. These largely occur on the flood plains and banks of the major rivers of the Indus Basin. Flooding for about 6 weeks / year appears to be necessary to sustain the growth of these forests. The main species are: Kikar (Acacia nilotica), Gazlai or Pilchui (Tamarisk dioica), Prosopis cineraria, Sheesham (Dalbergia sisso) and to some extent Bahan (Populus euphratica) (Sheikh 1993). The rich Indus delta and the highlands are great attractions for migratory birds. The Indus flyway is one of the world's top migration routes. The Indus valley wetlands constitute a secondary area of endemism, with one restricted range species. (Biodiversity Action plan 1998)

The riverine forests owe their existence to flooding by rivers. After the construction of embankments (bunds) some of these forests were left out of embankments but sluices were made in the embankments to allow flood water to reach these forests. With the construction of barrages (Guddu, Sukkur and Kotri) on the River Indus, canals displaced sluices for irrigation of most of these inland

(outside of protection *bunds)* forests. There is yet another category of riverine forests, mostly in the Province of Punjab, that has been raised as irrigated plantations (http://edu.iucnp.org/themeRforest/index1.htm**)**

The main tree species growing in the riverine forests of Punjab are *Dalbergia sissoo (*Shisham*) and Morus alba (*Mulberry*)*. The undergrowth usually consists of *Tamarisk dioca (Lai), Zizphus mauritiana (Beri), Acacia farnesiana, (*Kikri*), Saccharum munja, (*Kana*) and Saccharum spontaneum (*Kahi*).* The high-lying areas in riverine forests, especially in the Province of Punjab that were planted, were initially irrigated by a trench system. However, this was not found feasible, especially in sandy areas as it was difficult to maintain trenches. They silted up, seepage of water took place, and mesquite invaded these areas. Mesquite is difficult and expensive to eradicate. The trench irrigation system was replaced with flood irrigation. There are diverse habitats in riverine forests, their important parameters being soils, topography, water regime, crop composition and age of the crop. Most of these parameters are dependent on topography and so are the habitats. The low-lying and intermediate areas have the maximum species of wild plants and animals. Fish, otters, reptiles (turtles and tortoises), amphibians (frogs) and water birds (e.g. night heron) are associated with these water bodies. The low-lying areas mostly contain Saccharum and Tamarisk spp. of different age classes. This is the preferred habitat of hog-deer and wild boar. The intermediate and high-lying areas are inhabited by jungle cat, Indian hare, black and grey partridges, rose-ring parakeet, yellow eyed babbler, sand-lark, red munia, and coucal etc (http://edu.iucnp.org/themeRforest/index1.htm**)**.

The riverine forests are important both for economic and environmental reasons. The forest produce obtained from them are fuel-wood and charcoal for energy purposes, fodder for animals, and timber for furniture. The other minor produce consists of gum arabic, honey, and bark for tanning, lac for lacquer works and red dye. They also reduce the intensity of floods and damage to agricultural lands, settlements and infrastructure. They even provide early grazing on their banks to animals and wildlife. In the past, the riverine forests supported large herds of livestock during autumn, winter and spring providing grazing, browsing on pods and leaves of babul. Harvesting of NTFP is not done on scientific basis (http://edu.iucnp.org/themeRforest/index1.htm**)**.

Relatively common species of mammals in the riverine forests Asiatic jackal, Jungle cat and wild boar. The Jungle cat is associated with water and dense vegetative cover, especially reed swamps, marsh, and littoral and riparian environments. It is able to satisfy these requirements in a variety of habitats, from desert to scrub woodland and dry deciduous forest, as well as cleared areas in moist forest. Jungle cats do well in cultivated landscapes (especially those that lead to increased numbers of rodents) and artificial wetlands. However, reclamation and destruction of natural wetlands, ongoing throughout its range but particularly in the arid areas, still pose a threat to the species, as density in natural wetlands is generally higher.

## Strategic Environmental Assessment Baseline – Biodiversity Methods

### Protected areas in Punjab

There are 71 protected areas in Punjab of various protection categories, table 5 for reference. With just a handful of them have their management plans e.g Taunsa Wildlife Sanctuary, Lal Suhanra

National Park (needs to be updated), Salt Range Wetlands Complex etc. There are meagre resources available to manage these 71 protected areas.

**Table 5 Database of the Protected Areas of Punjab**

| Serial No. | Name | Govt. Classification | District | Area Ha |
|---|---|---|---|---|
| 1 | Abbasia | Game Reserve | Rahim Yar Khan | 10067 |
| 2 | Bheni | Game Reserve | N/A | 2068 |
| 3 | Bhon Fazil | Game Reserve | Hafizabad | 1062 |
| 4 | Bhono | Game Reserve | Lahore | 2068 |
| 5 | Chaupalia | Game Reserve | Bahawalnagar | 9857 |
| 6 | Daulana | Game Reserve | Jhang | 2314 |
| 7 | Diljabba-Domeli | Game Reserve | Jhelum | 116736 |
| 8 | Gatwala | Game Reserve | Faisalabad | 5883 |
| 9 | Head Islam/Chak Kotora | Game Reserve | Vehari/Bahawalpur | 3132 |
| 10 | Indo-Pak Border-I | Game Reserve | Bahawalpur, Bahawalnagar, Kasur, Lahore, Narowal, Okara, Rahim Yar Khan, Shiekhupura | 0 |
| 11 | Indo-Pak Border-II | Game Reserve | Bahawalnagar | 0 |
| 12 | Indo-Pak Border-III | Game Reserve | Bahawalnagar | 0 |
| 13 | Indo-Pak Border-IV | Game Reserve | Bahawalnagar | 0 |
| 14 | Kheri Murat | Game Reserve | Attock | 5553 |
| 15 | Kot Sabzal | Game Reserve | Rajanpur | 10000 |
| 16 | Namal Lake | Game Reserve | Mianwali | 480 |
| 17 | Rahri Bungalow | Game Reserve | Rahimyar Khan | 5464 |
| 18 | Rasool Barrage | Game Reserve | Jhelum/Gujrat | 1137 |
| 19 | Thal-I | Game Reserve | Khushab | 70451 |

| Serial No. | Name | Govt. Classification | District | Area Ha |
|---|---|---|---|---|
| 20 | Thal-II | Game Reserve | Bhakkar | 0 |
| 21 | Thal-III | Game Reserve | Leiah | 0 |
| 22 | Ucchali Lake | Game Reserve | Khushab | 942.5 |
| 23 | Bajwat and Marala | Game Reserve | Sialkot | 5739 |
| 24 | Cholistan | Game Reserve | Bahawalpur | 4208.326 |
| 25 | Kallar Kahar | Game Reserve | Chakwal | 85 |
| 26 | Chinji | National Park | Chakwal | 6046.07 |
| 27 | Kala Chitta | National Park | Attock | 36964.7 |
| 28 | Lal Suhanra | National Park | Bahawalur | 51588 |
| 29 | Murree Kotli Satian | National Park | Rawalpindi | 93369.6 |
| 30 | Kalabagh Game Reserve | Private Game Reserve | Mianwali | 1550 |
| 31 | Cholistan-II | Unclassified | Bahawalpur | 0 |
| 32 | Cholistan-III | Unclassified | Rahimyar | 0 |
| 33 | Harnoli Reserve Forest | Unclassified | Mianwali | 0 |
| 34 | Machu / Inayat Reserve Forest | Unclassified | Leiah | 0 |
| 35 | Bahawalpur Plantation/Bahawalpur | Wildlife Sanctuary | Bahawalpur | 541 |
| 36 | Bhagat Reserve Forest | Wildlife Sanctuary | Toba Tek Singh | 248 |
| 37 | Bhakkar Forest Plantation | Wildlife Sanctuary | Bhakkar | 2100 |
| 38 | Chak Kotora Reserve Forest | Wildlife Sanctuary | Bahawalpur | 529 |
| 39 | Changa Manga Plantation | Wildlife Sanctuary | Kasur | 5005 |
| 40 | Chashma Barrage | Wildlife Sanctuary | Mianwali | 32700 |
| 41 | Chichawatni Forest Plant | Wildlife Sanctuary | Sahiwal | 4612 |

| Serial No. | Name | Govt. Classification | District | Area Ha |
|---|---|---|---|---|
| 42 | Cholistan-I | Wildlife Sanctuary | Bahawalpur | 2033 |
| 43 | Chumbi-Surla | Wildlife Sanctuary | Chakwal | 55296 |
| 44 | Daphar Reserve Forest | Wildlife Sanctuary | Mandi Bahauddin | 2897 |
| 45 | Depalpur Plantation | Wildlife Sanctuary | Okara | 2850 |
| 46 | Fatah Major Forest Plantation | Wildlife Sanctuary | Bhakkar | 1240 |
| 47 | Head Qadirabad | Wildlife Sanctuary | Gujranwala | 2816 |
| 48 | Jahlar Lake | Wildlife Sanctuary | Khushab | 17 |
| 49 | Jalalpur Sharif Forest | Wildlife Sanctuary | Boundary | 2236 |
| 50 | Jauharabad Reserve Forest | Wildlife Sanctuary | Khushab | 394 |
| 51 | Kamalia Plantation | Wildlife Sanctuary | Toba Tek Singh | 4346 |
| 52 | Khabbeki Lake | Wildlife Sanctuary | Khushab | 283 |
| 53 | Khanewal Plantation | Wildlife Sanctuary | Khanewal | 7129 |
| 54 | Kharar Lake | Wildlife Sanctuary | Okara | 232 |
| 55 | Kotla Issan Reserve Forest | Wildlife Sanctuary | Muzaffargarh | 2152 |
| 56 | Kundal Rakh | Wildlife Sanctuary | N/A | 2964 |
| 57 | Kundian Plantation | Wildlife Sanctuary | Mianwali | 7710 |
| 58 | Miranpur Reserve Forest | Wildlife Sanctuary | Lodhran | 760 |
| 59 | Mitha Tiwana Plantation | Wildlife Sanctuary | Khushab | 1103 |
| 60 | Rajan Shah Plantation | Wildlife Sanctuary | N/A | 2086 |
| 61 | Rakh Ghulaman | Wildlife Sanctuary | Bhakkar | 4336.6 |
| 62 | Shorkot Forest Plantation | Wildlife Sanctuary | Jhang | 4078.8 |
| 63 | Sodhi | Wildlife Sanctuary | Khushab | 5817 |
| 64 | Taunsa Barrage | Wildlife Sanctuary | Muzaffargarh | 6490 |

| Serial No. | Name | Govt. Classification | District | Area Ha |
|---|---|---|---|---|
| 65 | Tehra Plantation/Jallo Park | Wildlife Sanctuary | Lahore | 355 |
| 66 | Walhar Reserve Forest | Wildlife Sanctuary | Rahimyar Khan | 1853 |
| 67 | Cholistan | Wildlife Sanctuary | Bahawalnagar | 660921 |
| 68 | Daman Reserve Forest | Wildlife Sanctuary | DG Khan | 2270.2 |
| 69 | Hamoli Reserve Forest | Wildlife Sanctuary | Mianwali | 878 |
| 70 | Inayat Reserve Forest | Wildlife Sanctuary | Sahiwal | 4210 |
| 71 | Machu Plantation | Wildlife Sanctuary | Leiah | 4115 |

Date source: WWF - Pakistan

## 2.1 Field Validation/Survey sites

**Marala Headworks/Bajwat wetlands**

Located in the District Sailkot on the river Chenab. It is designated as a Game reserve and an important wetland area. Bajwat covers an area of 19,452 ha. The habitat is important for waterfowl and other birds. The headworks were built in 1965-68, is located in the south-west corner of the area and upper Chenab and Marala-Ravi link canals emanate from the headworks (Bhinder et al 2015). Marala area of 5400 ha is also designated as an IBA.

**Marala**

**Changa Manga Forest**

Changa Manga is a irrigated forest covering an area of 5065 ha, it is naturally a tropical thorn forest comprising of jand (*Prospis cineraria*), wan (*Salvadora oleoides*), kikar (*Capparis aphylia*), rehru (*Acacia leucophlaea*) etc. Currently sheesham and eucalyptus are main species, however recently there is also plantation of arjun which is a medicinal plant from this region (personal obv). The forest also offer recreational opportunities for example there is a wildlife park, train ride, artificial lake. The forest is rich is biodiversity ( Maan and Chaudhry 2001)

**Mainwali**

**Kundian Plantation**

It is a Reserved Forest: Kundian North is total 9009.27acres and planted area is 8256.34 with total blank area 752.93 acres. Kundian South is total 10264.39 acres, planted is 8946.39 and blank is 1318 acres (Punjab Forest Department). Kundian Plantation is a wildlife Sanctuary and (Maan and Chaudhry 2001) identified 65 species from the plantation.

**Chashma Wildlife Sanctuary**

The Chashma Wildlife Sanctuary is located 25km southwest on the Mainwali to Dera Ismail Khan in the Punjab Province. The total area is 34,099 hectares. It was declared a wildlife sanctuary in 1974. The Sanctuary was renotified in July 1984 (Ramsar Directory). It was renotified in May 1999 and according to the notification issued in December 2004 that specifies an area of 81,750 acres (33,083ha) acres protected (Government of the Punjab, Forest, Wildlife and Fisheries Department Notification). The land of the barrage and reservoir is owned by the provincial Irrigation Department. Surrounding areas of the wetland are partly state owned and partly privately owned. Administratively most of the wetland lies in the district Mianwali and a small area lies in district Dera Ismail Khan. The principal values of the Chashma Barrage are flood control, storage of water for irrigation, generation of electricity and fisheries production. Some 636 metric tonnes of fish were harvested in 1984. From faunal point of view it is a very important staging and wintering area for a wide variety of waterfowl. The wetlands regularly support over 50,000 Antidae and coots in mid winter and in some years many more. Over 114,000 birds were present in January 1975 and about 100,000 in January 1987 and 1988 (Ramsar Directory online).

**Chakwal**

Habitat of the endemic Punjab Urial, the area was surveyed because of its significance for the species. The habitat is scrub forest and largely close to the existing motorway.

**South:**

**Rangla Wetlands Complex:**

It is located about 16 km from Muzaffargarh town, the complex has a network of 18 saline and lakes that developed through the seepage of the Muzaffargarh canal. It was discovered as an important

wetland of international significance in 1993 and is the only breeding ground of the Marbled teal *Marmoronetta angustirotris* in the Punjab province (Khan et al 1999). Rangla Weltands Complex is recognised by the Birdlife International as an Important Bird Area IBA and has a total area of 24,140 ha.

**Taunsa Wildlife Sanctuary**

The Taunsa Barrage has been declared as a Wildlife Sanctuary by the Government of the Punjab in 1972. It was renotified as a Wildlife Sanctuary in April 2003 by the Forest, Wildlife and Fisheries department covering an area of 2,800 ha or 7,000 acres (Source: PWPD). This is an important breeding and wintering area for a wide variety of water fowl, including at least one threatened species Marbled Teal Marmaronetta angustirostris. The endangered Indus River dolphin Platanista gangentica minor occurs in the river both upstream and downstream of the barrage (Khan, 2006).

The sanctuary status of a Protected Area prohibits all kinds of anthropogenic activities. The Punjab Wildlife Act 1974 states that no person shall enter or reside, cultivate any land, damage or destroy any vegetation, hunt, kill or capture any wild animal or fire any gun or other firearm within one mile of the boundaries, introduce any exotic species of plant or animal, introduce any domestic animal or allow it to stray, cause any fire and pollute water. But during the monitoring survey, all these restrictions were seen being violated due to excessive anthropogenic activities such as hunting, destruction of vegetation, fire and water pollution (Khan 2006)

Taunsa Barrage Wildlife Sanctuary is rich is large mammal population and is the habitat of declining species, for example, the Hog Deer. The Hog Deer is listed by IUCN as low risk species in 1996, however, the status needs to be reassessed. Cultivation of grasslands outside protected areas in increasingly fragmenting the population of this species. The Hog Deer is particularly associated with the riverine habitat of Tamarisk and Saccharum that provide good hiding places to this species. Decline in water supply to riverine habitat has led to the loss of habitat of this species (Robert 1991), further, illegal hunting is another factor threatening the population. The reeds provide places for dams to drop their fawn, where they remained camouflaged (Roberts 1991). They do not browse on Tamarisk, are very fond of Ber tree Zizyphus jujube and prefer grazing.

**Lal Suhanra National Park**

It is largest national park of the Punjab province and is also a UNESCO Biosphere Reserve and is also one the IBA designated by Birdlife International. It is part of the Greater Thar Desert in Southern Punjab. The total area of the biosphere is 65, 791 ha while the national park itself is 37, 426 ha. It was declared a Game Reserve in 1968 and a National Park in 1972, while it got the UNESCO Biosphere Reserve status in 1977. Historically this habitat was home extinct species such as Bengal tiger, One - horned Rhinoceros, Asiatic lion and blackbuck.

**Table 6: Field validation/survey sites (North, Central and South)**

| Survey Site | Observation points/Transect | Date of survey | Number of species of birds recorded | Indirect signs of presence mammals | Direct sighting of mammals |
|---|---|---|---|---|---|
| North Region | | | | | |
| **Chakwal** | 32.50.116 072.39.387 to 32.48.593 072.39.595 | 20th Jan 19 | 25 | Asiatic jackal Wild boar | |
| **Chashma Wildlife Sanctuary, Indus** | N 32.26.296 E071.27.859 | 22nd Jan 20 | 24 | Asiatic jackal Wild boar | |
| **Kundian Plantation/Wildlife Sanctuary** | N32.26.645 E071.31.345 to N32.25.996 E071.31.670 | 23rd Jan 20 | 27 | Asiatic jackal Jungle cat Wolf | |
| Central Region | | | | | |
| **Changa Manga Plantation** | N31.04.836 N073.58.026 To N31.04.890 E074.00.024<br><br>N 31.04.770 E 073.59.830 to 073.58.608 | 23 Nov 19 | 43 | Asiatic jackal Wild boar | |
| **Bajwat/Marala headworks, Chenab river** | N32.41.552 E74.27.853 | 24th December 2019 | 31 | Asiatic jackal Wild boar | |
| South Region | | | | | |
| **Rangla Wetlands Complex** | N 30.11.560 E071.08.068 | 24th Jan 20 | 39 | Wild boar | |
| **Taunsa Wildlife Sanctuary, Indus** | N30.32.664 E071.52.249 | 25th Jan 20 | 29 | Hog deer Wild boar Jungle cat | Jackal |
| **Lal Suhanra National Park** | Patisar Lake N 29.20.381 E 071.56.467<br><br>N29.20.622 E071.54.927 to N29.20.730 E071.56.373 | 26th- 27th Jan 20 | 43 | Jackal | Wild boar Asiatic jackal Porcupine Indian grey mongoose Small Indian mongoose |
| | Forest transect | | | Blue bull Fox | |

## 2.2 Results:

A total of eight sites were surveyed for field validation across all these sites bird biodiversity remained the key feature. Shannon Diversity (H) index indicated that the richness of birds' diversity were highest in the Rangla Wetlands in Muzafargarh and Changa Manga, followed by Lal Suhanra National Park. Out of the regions survey south appeared to be the most diverse. There is no sighting of any endangered bird species but the survey found some rare species such as the Peregrine falcon (Rangla and Marala) , see table 7

**Table 7:** Diversity and richness of avifauna across eight field sites

| Survey areas | Number of bird species | Total abundance | Shannon Diversity Index (H) | Evenness (Equatibility) $H_E$ |
|---|---|---|---|---|
| North | | | | |
| **Chakwal** | 25 | 308 | 2.455 | 0.76 |
| **Chashma** | 24 | 7233 | 1.42 | 0.422 |
| **Kundian** | 27 | 185 | 2.84 | 0.86 |
| Central | | | | |
| **Marala** | 31 | 659 | 2.533 | 0.68 |
| **Changa Manga** | 43 | 449 | 3.255 | 0.86 |
| South | | | | |
| **Taunsa** | 29 | 783 | 2.41 | 0.715 |
| **Rangla** | 39 | 460 | 3.142 | 0.855 |
| **Lal Suhanra National Park** | 42 | 592 | 2.8 | 0.75 |

$E_H$ is always equal to one (complete evenness, or equitability), but H increases dramatically as the number of species increases. $E_H$ reflects evenness so if a few species dominate in a community then it decreases as we witnessed in Chashma where one species dominated. H and $E_H$ clearly give more information about these communities than would species number (richness) alone.

## 2.3 Bird species data

**Table 8:** Bird species recorded during field visit across eight sites in three regions

| | North | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Chakwal** | | | **Kundian** | | | **Chashma** | |
| **#** | **Common name** | **Number of individuals** | **#** | **Common name** | **Number of individuals** | **#** | **Common name** | **Number of individuals** |
| 1 | Long-tailed Shrike | 4 | 1 | Rufous treepie | 5 | 1 | Common Coot | 4400 |
| 2 | Pond heron | 7 | 2 | Black Drongo | 6 | 2 | Black-winged stilt | 16 |
| 3 | jungle babbler | 13 | 3 | Spotted owl | 3 | 3 | Common Sandpiper | 3 |
| 4 | Indian silverbill | 21 | 4 | Indian roller | 5 | 4 | Little Stint | 7 |
| 5 | Red-vented bulbul | 17 | 5 | Black-rumped flameback | 2 | 5 | Red-wattled lapwing | 9 |
| 6 | Rufous fronted prinia | 7 | 6 | Rose ring Parakeet | 6 | 6 | Osprey | 1 |
| 7 | Red-wattled lapwing | 6 | 7 | Collared dove | 4 | 7 | Eurasian marsh harrier | 13 |
| 8 | Common hoopoe | 2 | 8 | Red-wattled lapwing | 3 | 8 | Great cormorant | 890 |
| 9 | Indian roller | 2 | 9 | Eurasian sparrowhawk | 2 | 9 | Little Cormorant | 530 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10 | Spotted owlet | 1 | 10 | Long-tailed Shrike | 1 | 10 | Little egret | 6 |
| 11 | Black shoulder kite | 1 | 11 | Oriental honey buzzard | 2 | 11 | Grey heron | 2 |
| 12 | Rufous treepie | 2 | 12 | Blue throat | 2 | 12 | Pied kingfisher | 4 |
| 13 | Black drongo | 5 | 13 | Black redstart | 3 | 13 | Pond heron | 21 |
| 14 | Indian robin | 2 | 14 | Oriental Magpie robin | 2 | 14 | Citrine wagtail | 9 |
| 15 | Common stonechat | 1 | 15 | Black francolin | 2 | 15 | Black-headed gull | 642 |
| 16 | Bank myna | 17 | 16 | Laughing dove | 4 | 16 | Common teal | 86 |
| 17 | Erested lark | 7 | 17 | White wagtail | 6 | 17 | Mallard | 38 |
| 18 | Common Starling | 36 | 18 | Yellow-footed green pigeon | 2 | 18 | Eurasian wigeon | 22 |
| 19 | White eared bulbul | 11 | 19 | Black shoulder kite | 4 | 19 | River tern | 316 |
| 20 | White wagtail | 6 | 20 | White-eyed buzzard | 1 | 20 | Gull-billed tern | 64 |
| 21 | Eitring wagtail | 1 | 21 | Common myna | 12 | 21 | Caspian gull | 94 |
| 22 | Rock bunting | 82 | 22 | Rufous fronted prinia | 10 | 22 | Little tern | 54 |
| 23 | Long legged buzzard | 1 | 23 | Jungle babbler | 25 | 23 | White-breasted kingfisher | 2 |
| 24 | White-capped bunting | 54 | 24 | House sparrow | 32 | 24 | White wagtail | 4 |
| 25 | Common Kestrel | 2 | 25 | Yellow wagtail | 9 | | | 7233 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 308 | 26 | Indian silverbill | 21 | | | |
| | | | 27 | Red-vented bulbul | 11 | | | |
| | | | | | 185 | | | |
| | **CENTRAL** | | | | | | | |
| | **Marala headworks** | | | **Changa Manga** | | | | |
| # | **Common name** | **Number of infividuals** | | | | | | |
| 1 | Purple moorhen | 24 | # | **Common name** | **Number of individuals** | | | |
| 2 | Coot | 80 | 1 | Long tailed Shrike | 9 | | | |
| 3 | Grey heron | 10 | 2 | Indian silver bill | 23 | | | |
| 4 | purple heron | 2 | 3 | Straited babbler | 54 | | | |
| 5 | Black-winged slilt | 14 | 4 | Greenish warbler | 24 | | | |
| 6 | Mallard | 29 | 5 | Common Chiffchaff | 23 | | | |
| 7 | Little carmorants | 23 | 6 | Black drongo | 10 | | | |
| 8 | Great Cormorant | 2 | 7 | Black kite | 20 | | | |
| 9 | Common moorhen | 9 | 8 | Bay-backed shrike | 2 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10 | Straited babbler | 5 | 9 | Rufous treepie | 12 | | | |
| 11 | Little egret | 12 | 10 | Blue throat | 8 | | | |
| 12 | Pond heron | 8 | 11 | Oriental Magpie robin | 1 | | | |
| 13 | Black souldered kite | 2 | 12 | Black redstart | 3 | | | |
| 14 | Bank myna | 16 | 13 | Common myna | 17 | | | |
| 15 | Cattle Egret | 4 | 14 | Red vented bulbul | 24 | | | |
| 16 | White breasted kingfisher | 2 | 15 | Ashy prinia | 10 | | | |
| 17 | Common Sandpiper | 3 | 16 | Common tailor bird | 4 | | | |
| 18 | Pheasant crow | 2 | 17 | Plain prinia | 7 | | | |
| 19 | Sand martin | 150 | 18 | Spotted owlet | 2 | | | |
| 20 | White tailed lapwing | 1 | 19 | Laughing dove | 6 | | | |
| 21 | Common teal | 153 | 20 | Shrike | 2 | | | |
| 22 | Black drongo | 2 | 21 | Pond heron | 53 | | | |
| 23 | chiffchaff | 1 | 22 | White-breasted kingfisher | 6 | | | |
| 24 | Marsh harrier | 4 | 23 | Greater coucal | 6 | | | |
| 25 | Steppe eagle | 1 | 24 | Bank myna | 4 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 26 | Common pochard | 86 | 2 | Citerin wagtail | 14 | | | |
| 27 | Common myna | 10 | 26 | Grey hornbill | 2 | | | |
| 28 | Shoveller | 1 | 27 | Bay-backed Shrike | 3 | | | |
| 29 | River tern | 1 | 28 | Indian roller | 4 | | | |
| 30 | Sparrow hawk | 1 | 29 | Black Francolin | 2 | | | |
| 31 | Peregrin falcon | 1 | 30 | Eurasian Wryneck | 1 | | | |
| | | 659 | 31 | Jungle babbler | 32 | | | |
| | | | 32 | Black-rumped flameback | 2 | | | |
| | | | 33 | Hoopoe | 2 | | | |
| | | | 34 | Indian robin | 3 | | | |
| | | | 35 | Rose-ringed parakeet | 8 | | | |
| | | | 36 | Collard dove | 2 | | | |
| | | | 37 | Coppersmith barbet | 7 | | | |
| | | | 38 | Yellow-footed green pigeon | 10 | | | |
| | | | 39 | White-breasted water hen | 6 | | | |
| | | | 40 | Red wattled lapwing | 2 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 41 | Common sandpiper | 1 | | | |
| | | | 42 | Cattle egret | 6 | | | |
| | | | 43 | Oriental white eye | 12 | | | |
| | | | | | 449 | | | |
| | **SOUTH** | | | | | | | |
| | **Changa Manga** | | | **Rangla Wetlands** | | | **Patisar and forest** | |
| **#** | **Common name** | **Number of individuals** | **#** | **Common name** | **Number of individuals** | **#** | **Common name** | **Number of individuals** |
| 1 | Long tailed Shrike | 9 | 1 | Great egret | 28 | 1 | Great reed warbler | 4 |
| 2 | Indian silver bill | 23 | 2 | Little egret | 17 | 2 | Common moorhen | 12 |
| 3 | Straited babbler | 54 | 3 | Pond heron | 52 | 3 | Pond Heron | 188 |
| 4 | Greenish warbler | 24 | 4 | Common moorhen | 21 | 4 | Night heron | 62 |
| 5 | Common Chiffchaff | 23 | 5 | Mallard | 9 | 5 | Marsh harrier | 13 |
| 6 | Black drongo | 10 | 6 | Common teal | 12 | 6 | Great coucal | 4 |
| 7 | Black kite | 20 | 7 | Northern pintail | 8 | 7 | White throat | 6 |
| 8 | Bay-backed shrike | 2 | 8 | Red crested pochard | 18 | 8 | White-breasted kingfisher | 4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 9 | Rufous treepie | 12 | 9 | Common pochard | 14 | 9 | Desert Warbler | 3 |
| 10 | Blue throat | 8 | 10 | Common coot | 64 | 10 | Black Drongo | 7 |
| 11 | Oriental Magpie robin | 1 | 11 | Blue throat | 4 | 11 | Bank myna | 38 |
| 12 | Black redstart | 3 | 12 | Osprey | 1 | 12 | Common Starling | 24 |
| 13 | Common myna | 17 | 13 | Great cormorant | 22 | 13 | Red Wattled | 3 |
| 14 | Red vented bulbul | 24 | 14 | White-breasted Kingfisher | 3 | 14 | Citrine wagtail | 9 |
| 15 | Ashy prinia | 10 | 15 | Black drongo | 4 | 15 | White wagtail | 13 |
| 16 | Common tailor bird | 4 | 16 | Red-wattled lapwing | 11 | 16 | Little cormorant | 9 |
| 17 | Plain prinia | 7 | 18 | River tern | 14 | 17 | River tern | 4 |
| 18 | Spotted owlet | 2 | 19 | Common babbler | 15 | 18 | Little grebe | 3 |
| 19 | Laughing dove | 6 | 20 | Great reed warbler | 6 | 19 | Purple heron | 1 |
| 20 | Shrike | 2 | 21 | Plain prinia | 4 | 20 | Long-tailed Shrike | 2 |
| 21 | Pond heron | 53 | 22 | Black-winged stilt | 24 | 21 | White breasted Moorhen | 5 |
| 22 | White-breasted kingfisher | 6 | 23 | Citrin wagtail | 13 | 22 | Oriental honey buzzard | 1 |
| 23 | Greater coucal | 6 | 24 | White wagtail | 6 | 23 | Jungle babbler | 25 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 24 | Bank myna | 4 | 25 | Straited babbler | 19 | 24 | long-tailed Shrike | 2 |
| 2 | Citerin wagtail | 14 | 26 | Marsh harrier | 7 | 25 | Rose ring Parakeet | 3 |
| 26 | Grey hornbill | 2 | 27 | Common kestrel | 2 | 26 | Hoopoe | 2 |
| 27 | Bay-backed Shrike | 3 | 28 | **Peregrine falcon** | 2 | 27 | Desert Warbler | 6 |
| 28 | Indian roller | 4 | 29 | Black crowned night heron | 32 | 28 | Shikra | 2 |
| 29 | Black Francolin | 2 | 30 | Little bittern | 1 | 29 | Black shoulder kite | 2 |
| 30 | Eurasian Wryneck | 1 | 31 | Southern grey shrike | 2 | 30 | Southern Grey Shrike | 1 |
| 31 | Jungle babbler | 32 | 32 | Long tailed Shrike | 3 | 31 | Rufous treepie | 6 |
| 32 | Black-rumped flameback | 2 | 33 | Rufous treepie | 2 | 32 | Red throated flycatcher | 8 |
| 33 | Hoopoe | 2 | 34 | Desert warbler | 3 | 33 | Blue throat | 3 |
| 34 | Indian robin | 3 | 35 | Black redstart | 2 | 34 | Indian robin | 2 |
| 35 | Rose-ringed parakeet | 8 | 36 | Indian roller | 2 | 35 | Black redstart | 4 |
| 36 | Collard dove | 2 | 37 | Eurasian collard dove | 6 | 36 | Common myna | 10 |
| 37 | Coppersmith barbet | 7 | 39 | Common redstart | 7 | 37 | White eared bulbul | 14 |
| 38 | Yellow-footed green pigeon | 10 | | | 460 | 38 | Plain prinia | 6 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 39 | White-breasted water hen | 6 | | | | 39 | Oriental white eye | 14 |
| 40 | Red wattled lapwing | 2 | | | | 40 | Common babbler | 24 |
| 41 | Common sandpiper | 1 | | | | 41 | Indian silverbill | 32 |
| 42 | Cattle egret | 6 | | | | 42 | Red-vented bulbul | 11 |
| 43 | Oriental white eye | 12 | | | | | | 592 |
| | | 449 | | | | | | |
| | | | | | | | | |

| Table 9 : Threats observed during field visit | |
|---|---|
| **#** | **Threats** |
| **1** | **Changa Manga** |
| | Livestock grazing |
| | Lopping |
| 2 | **Bajwat/Marala** |
| | Sand mining |
| | Fishing nets |
| | Livestock grazing |
| 3 | **Kundian Forest** |
| | Degraded forest with dominant exotic/invasive species such as eucalyptus and mesquite |
| | Livestock nomadic herders stay in the forest and have been reported to close the den of wolves to prevent any losses of their livestock |
| 4 | **Chashma Wildlife Sanctuary** |
| | Reed extraction |
| | Livestock grazing |
| | Fishing |
| 5 | **Chakwal forest for central CPEC** |
| | Livestock grazing |
| 6 | **Rangla** |
| | Deliberate reed fire |
| | Reed extraction contracts |
| | Grazing |
| 7 | **Taunsa Wildlife Sanctuary** |
| | Land encroachment |
| | Livestock grazing |
| | Fishing |
| 8 | **Lal Suhanra National Park** |
| | Grazing of livestock |
| | Illegal tree felling/lopping |
| | Exotic species |

**Policy Context: Relevant Conventions and Treaties**

The Government of Pakistan is signatory to the following international conventions and treaties Table 10 that are relevant to biodiversity component of the SEA.

**Table 10: Pakistan international commitments and associate national/provincial laws**

| # | Relevant conventions and treaties | Date of joining | Key elements and legal framework in Pakistan/Punjab Province |
|---|---|---|---|
| *1* | Convention on the Biological Diversity | 1992<br><br>Nagoya Protocol<br><br>Aichi Targets | Convention on Biological Diversity defines Sustainable use as the use of components of biological diversity in a way and at a rate that does not lead to the long term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generation (Heywood and Watson 1995). Punjab<br><br>Deals with biodiversity conservation both habitats and wildlife and related policy and legislative framework.<br><br>In accordance with the Article 6 of the convention, GoP has developed a National Biodiversity Strategy and Action Plan 2017- 2030 under CBD and SDGs, this NBSAP was submitted on 13 April 2018<br><br>Biodiversity Action Plan, 1992 was also prepared under CBD and was approved by the Pakistan Environment Protection Council in 2000.<br><br>National Conservation Strategy (NCS) was the first policy framework in Pakistan for biodiversity conservation.<br><br>Protected Areas Management Act 2020, recently approved (at the time of finalising this report) would support establishment of different types of protected areas and also Ramsar wetlands. Also see point 7 |
| | UNCSD – | Agenda 21 | |

| | | | |
|---|---|---|---|
| | | Rio +20 | |
| *2* | United Nations Convention on Climate Change (UNFCCC) | Paris Agreement 22 April 2016<br><br>Kyoto Protocol 10 Jan 2005<br><br>Copenhagen Accord | Integrates forest conservation and is focused on climate change.<br><br>Intended Nationally Determined Contributions (INDC) were submitted by GoP focused on adaptation and mitigation.<br><br>Pakistan has enacted Pakistan Climate Change Act 2017<br><br>It includes REDD which is Reducing Emissions from Deforestation and forest Degradation and REDD+ which covers conservation of forest carbon stocks, sustainable management, and enhancement of forest carbon stocks. |
| *3* | United Nations Convention to Combat Desertification | Established in 1994, Pakistan signed 1994 and ratified in 1997 | Commits to achieve Land Degradation Neutrality (LDN), reducing impacts of droughts on communities and biodiversity through sustainable management. Pakistan also has a National Action Plan |
| *4* | Ramsar Convention on Wetlands | Pakistan signed on 23 Nov 1976 | Ramsar defines 'Wise use' as "sustainable utilization for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem". Sustainable utilization is understood as "human use of a wetland so that it may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations". "Wise use" therefore has conservation of wetlands, as well as their management and restoration, at its heart (Ramsar Website accessed December 2019)<br><br>Punjab Protected Areas Management Act 2020, recently approved (at the time of finalising this report) supports Ramsar wetlands. |

| | | | |
|---|---|---|---|
| | | | Protection of wetlands, lists those wetlands that are important because of unique biodiversity of presence of migratory waterfowl or<br><br>There are 19 Ramsar wetlands in Pakistan and some have management plans developed under Pakistan Wetlands Programme of the Government of Pakistan and WWF - Pakistan |
| *5* | Convention on the Migratory Species | December 1987 | Protection migratory species and their habitats, removing obstacles to their migration and controlling factors that are endangering them. The Convention includes global and regional agreements. |
| *6* | Convention on the International Trade of Wild Fauna and Flora (CITES) | 1976 | Pakistan has developed Pakistan Trade Control Act of Wild Fauna and Flora, 2012 to provide legal framework to CITES list species. This convention aims to strictly monitor listed species so that they are not threatened by illegal trade.<br><br>This act has been embedded into the Punjab Wildlife Act, amended 2007. |
| *7* | International Whaling Commission | Pakistan is not a member yet but is very likely to become in near future | Protection and conservation of whales and dolphins. In the Punjab Province would be relevant to the Indus Dolphin. Punjab Fisheries Ordinance 1961The ordinance defines the legal practices, net sizes and seasons for fishing in Punjab. Powers and penalties. It also inclu48des the provision to declare any water to be a sanctuary for fish. Pakistan is already active in IWC for example participation in the Small Cetacean Committee that covers all species of river dolphins. |

## 3.1 Key legal gaps:

- The conventions and treaties are led by the Federal Ministry of Climate Change, while provinces are the implementation entities. There are gaps in the implementation of some the key biodiversity related conventions for example CITES. There is a federal level act (refer table 10) and till now the Punjab Wildlife Act has not been amended to provide protection to the CITES listed species or take action if an exotic species listed under CITES is brought into the province illegally.

- Although the three departments; Forest, Wildlife and Fisheries are under the same administrative supervision but there the ground actions are conflicting. For example wildlife

department declares an area as a wildlife sanctuary while forest department awards reed exaction contracts of the same area and the Fisheries department auctions fishing contracts, both practices are have negative impacts on the wildlife species. Ramsar convention on wetlands is very much aligned with both Fisheries and wildlife department but fisheries department is not involved in Ramsar wetlands. There is no monitoring mechanism to apply Ramsar monitoring tools. The recently approved Punjab Protected Areas Management Act 2020 covers wetlands and there is a hope that this would improve the management of wetlands.

- All major conventions and international commitments for example CBD, SDGs, Ramsar lay a great deal of emphasis on community development and involvement as important stakeholders, however, in the Punjab Wildlife Act there is no category of community conserved protected areas.

- **Access to Genetic Resources and Benefit Sharing Law under Nagoya Protocol CBD** is still in the draft form and integration into provincial laws in lacking.

- The Irrigation department is the key custodian of the management of rivers, besides conducting ecological studies and impacts assessments in case of any engineering work or infrastructure development. The irrigation department is not involved in any conservation work and neither is there any legal requirement. Habitat connectivity is widely accepted as a natural solution to flood mitigation as wetlands acts as natural sponges of flood water (Dudley et al 2010).

- **'Punjab Environmental Protection Council'** must include Secretary/DG of the Punjab Forest, Wildlife, Fisheries Department. The mandate of the PEPA covers biodiversity and ecosystem conservation. Provincial Sustainable Development Fund rules (2003) only specify sanctioning financial assistance to prevention of pollution, conservation of environment and sustainable development and are specified under the Punjab Environment Protection Act.

**GENERIC ASSESSMENT OF INTERVENTIONS:**

This section provides a discussion of the potential generic effects associated with different interventions.

Punjab Urban and Peri Urban Forest Policy 2019 is a proactive initiative and important step towards dealing with fine particulate matter of industrial and traffic emissions. A study found that dust deposition negatively impacts leaf dry weight, photosynthesis in all tree species. *Ficus religiosa* was found to be superior air pollution tolerant plant species with moderate dust removal capacity while *Dalbergia sissoo* is moderately air pollution tolerating species with highest dust removal capacity (Chaudhary and Rathore, 2018). Urban forestry is important for improving the air quality however this should not be linked towards targeting an increase in the forest cover to 20-25% as a global benchmark

for a balance economy as has been referred in the policy. There is no scientific study reflecting that a certain percent is needed for a country's economy, it entirely depends on the ecology. Increasing forest cover is directly proportional to water use and data suggests that less than 20 inch less rainfall produces only scrub forest. Planting forest requires huge quantities of sustained water supply, merely 1% percent increase in forest cover requires 6,000 cusecs of water per annum (Punjab Forest data sources). There is 26% land under agriculture in Pakistan and currently there is lack of water to irrigate it. Even existing plantations such as Khangarh plantation (near Muzafargarh) has bare land and sand dunes and have not been planted because of insufficient water supply. Natural forest also has blank patch, deforestation has caused soil erosion revealing rocky surfaces which are difficult to restore. 50% of coniferous area is blank and some can be restored but requires resources (Pers. Comm Dr Abdul Aleem Chaudhry, Former DG Punjab Wildlife and Parks Department).

This SEA can be divided into the following three areas to consolidate impacts in a more strategic manner, while more details of impacts at regional levels are available in Table 11 and Table 13 covers mitigation measures. Table 12 provides are a general overview of all interventions at the provincial level.

**Protected sites and key biodiversity areas**

Protected areas are instrumental in maintaining ecological functions and resilience, ecological services and species habitat. Punjab already has one of the lowest forest cover in Pakistan and the interventions particularly 'Freight and connectivity' will have major impacts in loss of habitats, in particular forests and the Indus River. This impact would include fragmentation of habitat and degradation and would have serious implications of both local and migratory species. Fragmented habitat impact migratory species because it is difficult for them to find save places and feeding spots, while for territorial species that defend their areas, bring animals more in conflict with people while make it difficult to find mates for breeding because of the 'edge effect' (Sodhi and Ehrlich, 2010). Linear plantations and creating small patches have high edge effect and is not suitable for wide ranging species and also exposes species populations and habitats to threats. Road network severely impacts small animals such as reptiles as there is a great deal of digging involved, although such impacts are short lived but considering Pakistan is rich in reptiles and also have many endemic species, such impacts are significant.

Road ecology is an emerging field which explores the interaction of roads with natural environment and there are various facets to it, a part from habitat fragmentation, creating barriers to movement of plants, animals and water and with the run off contaminating the ecosystem (Tepper 2011).

Agrochemical pollution in the key biodiversity areas for example some of the high value crop zones are coincide with the range of the Indus river dolphin. Areas of Bahawalpur District which is protected as Cholistan Wildlife Sanctuary and has some important species such as Houbara bustard and Great Indian bustard has been identified as the area for oil seed production

**Biodiversity**

There are various level of impacts on biodiversity. Noise, acoustics pollution, vessel collision, mortalities and serious impacts on breeding of the Indus river dolphin and food chain in the Indus e.g

fish species. When fish species decline then there are more intensive fishing practices that cause further damage. Indus is one the world famous flyways for migratory birds and this will lead to the disturbance in the migratory routes including some high profile birds species. Damage to fish species and breeding grounds, freshwater turtles and birds habitat not only in the Indus but other tributaries. This would impact riverine forest, which is the habitat of endangered hog deer. Impact on fisheries would also impact livelihoods of local communities which culminates into more intensive fishing practices and sometimes illegal fishing practices.

Entire new corridor and cuts through the Punjab Urial habitat in Chakwal, Kundian forest which is a wildlife sanctuary in Mianwali and crosses over the Indus in Muzaffargarh and DG Khan where the Indus River Dolphin's second largest population resides. Khangarh plantation will also be impacted by this corridor.

Construction itself would have severe impact on small species for example reptiles or burrowing mammals.

Punjab needs both approved forest and wildlife policies to prioritise interventions and develop site specific management plans, while ensuring resources for the management. There is a Punjab Forest Policy 1998-1999 and it was updated 2018 but not approved yet.

## 5 Table 11. Region wise impacts on biodiversity

### North region

| VEC | Connectivity and Freight | High speed regional rail | Industrial corridor | High value crop | High Value conservation area | Tourism zone | Direct Impact | Indirect impact | Cumulative Impact |
|---|---|---|---|---|---|---|---|---|---|
| **Flora/Forests** | All CPEC corridors pass through the forests for example Rakh Narian Task Banni Rakh, Rakh Maira Nalhad, Bhajuk unclassified forest, Dandi, pilo forest Malot reserved forest, Bakhshewala reserved forest and it would have multifaceted impacts causing loss of forests and watershed, fragmentation, of | There exist a few scrub and coniferous vegetation along the site proposed for railway for example Lohi Bher forest, Kawah Gar Reserve Forest. The smoke, fumes and dust from construction vehicles will pose serious threat to the local valuable species. It can also cause species imbalance and disturb sensitive ecosystems. Green | The proposed location of an industrial hub also coincides with several local vegetation and reserve forests for example Adiala reserved forest and. a part of the high value conservation area in Rawalpindi. Industrial units generally are a nuisance to environment and its valuable ecosystem components. The amount of smoke, dust, plumes and emissions produced during construction and | NA | High conservation values areas will help in offering protection to species and their habitat (forests) | Adventure Tourism has been indicated without discussing restricting access to certain areas. while 'Nature tourism' has not even been mentioned, thus has not received its due importance. | The interventions will cause fragmentation and loss of forests and also damage guzara forests impacting communities leading to increased pressure on protected and reserved forests. | Increasing access through road network increases conflict between wildlife and communities and increases 'edge effect'. | Interventions of such large scale may trigger the process of deforestation as smaller patches of plantations and forests are more difficult to protect. |

| VEC | Connectivity and Freight | High speed regional rail | Industrial corridor | High value crop | High Value conservation area | Tourism zone | Direct Impact | Indirect impact | Cumulative Impact |
|---|---|---|---|---|---|---|---|---|---|
| | habitats and community use.<br><br>Proposed highways also fragment forest | spaces will also be compromised | operations of industrial estates have very damaging impacts on the local flora | | | | | | |
| **Fauna** | Eastern CPEC corridor would destruction of habitat and protected forest in Rawalpindi, Chakwal. Impacts on reptiles and Urial and pangolin habitat. Habitat of endemic Punjab Urial and endangered Indian pangolin<br><br>Inland water way: Indus in Phase II<br><br>Noise, acoustics pollution, vessel collision, mortalities and serious impacts | The proposed rail tracks lay over two districts. The construction phase will induce displacement of local fauna, habitat destruction and specie imbalance. | Industrial corridor will challenge the habitats of local fauna as it extends to three major districts. During construction period, the noise, smoke, dust and chemical emissions may cause many species to displace. The operational phase may also result in habitat fragmentation and specie balance. | NA | The wide spread sites for high conservation value will challenge the local fauna species. There are sensitive habitats of Urial near Attock and Chakwal, which will be at risk in case of any extensive construction activities. | | Serious threats to protected areas and some of the high profile species.<br><br>With so many interventions in the pipeline, the fauna would be at risk because of smoke, dust, fumes and other emissions. Fauna | Railway track and industrial hub sites are almost in the same area and they will put all local fauna in competition for the resources such as water, food and habitat<br><br>Damage to freshwater turtles and | Serious impacts on habitat of endangered species and learning from the experiences of similar interventions in the Yangtze river led to the extinction of the Yangtze river dolphin and pushing the Yangtze finless porpoise to the critically endangered |

| VEC | Connectivity and Freight | High speed regional rail | Industrial corridor | High value crop | High Value conservation area | Tourism zone | Direct Impact | Indirect impact | Cumulative Impact |
|---|---|---|---|---|---|---|---|---|---|
| | on breeding of the Indus river dolphin and food chain in the Indus e.g fish species. When fish species decline then there are more intensive fishing practices that cause further damage. Indus flyway is one the world famous flyways for migratory birds and this will lead to the disturbance in the migratory routes including some high profile birds species. | | | | | | displacement might be an indirect impact of all sudden interventions. | birds habitat not only in the Indus but other tributaries. This would impact riverine forest, which is the habitat of endangered hog deer. | category. Increasing road network enhances conflict between communities and wildlife and also increases illegal wildlife trade. Further damage to fish breeding grounds. |

| VEC | Connectivity and Freight | High speed regional rail | Industrial corridor | High value crop | High Value conservation area | Tourism zone | Direct Impact | Indirect impact | Cumulative Impact |
|---|---|---|---|---|---|---|---|---|---|
| **Protected Area** | Chashma Wildlife Sanctuary, Indus also a Ramsar wetland with a population of the Indus river dolphin (170 dolphins in Chashma – Taunsa river section, WWF 2017 survey.<br><br>Chashma Wildlife Sanctuary There is a Ramsar wetland with a population of the Indus river dolphin (170 dolphins in Chashma – Taunsa river section, WWF 2017 survey) which will be severely compromised, CPEC route also coincides | here. | The industrial corridor is not anywhere near this protected area, however aerial and chemical emissions may travel to these sites and cause irreversible damage. | | | Regulated tourism can help in providing alternate livelihood to local communities and reduce their dependence on the natural resources. | Direct impacts on the Indus river dolphin population and some of important sites of the migratory birds.<br><br>Fragmentation of habitat of the Punjab Urial in the Salt range.<br><br>Increased transportation because of better travel and housing facilities will have detrimental impacts on | CPEC route very close to RAMSAR site and Important Bird Area combined with transport from tourism is going to increase the level of harmful emissions threatening the survival of these important species | Fragmentation of habitat which can cause irreversible damage to some of endangered species and fragmented populations can also have loss of genetic variability. Disturbance will cause reduction in the migratory birds. Loss of economic value of natural resources through trophy |

| VEC | Connectivity and Freight | High speed regional rail | Industrial corridor | High value crop | High Value conservation area | Tourism zone | Direct Impact | Indirect impact | Cumulative Impact |
|---|---|---|---|---|---|---|---|---|---|
| | Central Corridor also goes through Kundian plantation/wildlife sanctuary, Hamoli Reserve Forest, passes close to Namal Lake. Central CPEC corridor will impact Khangarh plantation and construction itself would have severe impact on small species for example reptiles or burrowing mammals.<br><br>Western corridor cuts through the protected area, damaging the habitat of a high profile species. Kalabagh Private Game Reserve, | | | | | | these very important biodiversity elements. | | hunting programmes lead to loss of incentive to the communities and increases illegal hunting. |

| VEC | Connectivity and Freight | High speed regional rail | Industrial corridor | High value crop | High Value conservation area | Tourism zone | Direct Impact | Indirect impact | Cumulative Impact |
|---|---|---|---|---|---|---|---|---|---|
| | habitat of one of the largest population of the endemic Punjab Urial with a variety of other important species such as black partridge, gray partridge, see partridge, Indian wolf and yellow throated marten. Construction activities have high impact on small animal biodiversity as well. Community based trophy hunting permits generate income for local communities and loss of resources will also occur as an impact. | | | | | | | | |

**Central region**

| VEC | Connectivity and Freight | High Speed Rail | Industrial Corridor | High Value Crop | High Value Conservation Area | Tourism zone | Direct Impact | Indirect Impact | Cumulative impact |
|---|---|---|---|---|---|---|---|---|---|
| **Flora/Forests** | Western corridor bisects the ***Shorkot Plantation/wildlife sanctuary*** plantation, fragmentation and loss of forest. Proposed highways also have the same impacts in Bhakkar | The rail network will require land clearing which will make this area even more barren. There will be species imbalance and disturbance to sensitive ecosystems, especially for small animals. | | NA | | ***Changa Manga*** Forest is part of the tourism zone which has a huge potential and inclusion in the PSS will have positive impact in improving the facilities for visitors and public education | | | Damage to the plantations in otherwise arid areas can have longer consequences. These patches of forest provide refuge to species and provide food resources. |
| **Fauna** | At ***Bhakkar***, the CPEC Central corridor passes through '***canal forest'*** and covers all the habitat of the ***houbara bustard.*** The | Industrial corridor and high speed railway increasing noise and pollution level. Impact of fish waterbirds species, particularly at Ravi river | Industrial corridors would impact the rivers in the central region | NA | | | Fragmentation of habitat, disturbances.<br><br>Most of the riverine forests are | Railway track and industrial hub sites are almost in the same area and they will put all local | Serious impacts on habitat of endangered species and learning from the experiences of similar |

| VEC | Connectivity and Freight | High Speed Rail | Industrial Corridor | High Value Crop | High Value Conservation Area | Tourism zone | Direct Impact | Indirect Impact | Cumulative impact |
|---|---|---|---|---|---|---|---|---|---|
| | houbara is a high profile species and population is already declining has been strictly monitored through a commission formed by the Lahore High Court, led by Dr Pervez Hassan. | ***Hog deer habitat, endangered species Lahore Narowal*** | especially in ***Chenab*** which is also important for migratory birds and Hog deer | | | | along the river banks, and any contamination in water reserve will harm this resource. | fauna in competition for the resources such as water, food and habitat. Labour colonies impact habitat and increase solid waste while also cause illegal hunting activities. | interventions in the Yangtze river led to the extinction of the Yangtze river dolphin and pushing the Yangtze finless porpoise to the critically endangered category. |
| **Protected Area** | Proposed highways passes through ***Thal 1*** | | | | | | | | |

**South region**

| VEC | Connectivity and Freight | High Speed Rail Network | Industrial Corridor | High Value Crop | High Value Conservation Area | Ecotourism | Direct Impact | Direct impact | Cumulative Impact |
|---|---|---|---|---|---|---|---|---|---|
| **Flora/Forests** | CPEC Central corridor passes through ***Fatah Major Forest Wildlife Sanctuary and Rajan Shah Plantation/Wildlife Sanctuary.*** In DG Khan and Rajanpur will cause loss of ***rangelands***.<br><br>Easter corridor close to ***Khanewal plantation***<br><br>Land clearing and addition of new species will harm the existing local flora. There will be habitat and fragmentation/loss.<br><br>These tracks lie over water bodies, putting | High speed train regional track is passing through the ***Khanpur plantation*** in Muzaffargarh, fragmentation and loss of forest | | NA | | Changa Manga Forest is part of the tourism zone which has a huge potential and inclusion in the PSS will have positive impact in improving the facilities for visitors and public education | DG Khan and Rajanpur have important rangelands and provide food to wild ungulates while also being critical for rural economy | Loss of rangeland would reflect in loss of grazing habitat for livestock and impact of rural people and would increase competition between wild ungulates and livestock which also cause disease transmission. | Loss of forests will create small forest patches which are extremely vulnerable with time and loss of rangeland will impact rural economy. |

| VEC | Connectivity and Freight | High Speed Rail Network | Industrial Corridor | High Value Crop | High Value Conservation Area | Ecotourism | Direct Impact | Direct impact | Cumulative Impact |
|---|---|---|---|---|---|---|---|---|---|
| | aquatic organisms at risk too. | | | | | | | | |
| **Fauna** | At Layyah, the CPEC Central corridor passes through 'canal forest' and covers all the habitat of the houbara bustard. It also passes through ***DG Khan and Rajanpur with impacts on the Houbara and Chinkara***<br><br>Some proposed highways cross over the ***Central Indus Wetlands Complex*** impacting Indus river dolphins and migratory birds | Industrial corridor and high speed railway increasing noise and pollution level. Impact of fish waterbirds species, particularly at Ravi river<br><br>Hog deer habitat, endangered species Lahore Narowal | . | Areas have been identified for cash crop production.<br>Areas of Bahawalpur District which is protected as Cholistan Wildlife Sanctuary and has some important species such as Houbara bustard and Great Indian bustard have been identified as the area for oil seed production | | | Disturbance in the habitat of the Houbara bustard, Chinkara, migratory birds species and reptiles' species.<br><br>Provision of access has a strong link with increased illegal hunting. | Railway track and industrial hub sites are almost in the same area and they will put all local fauna in competition for the resources such as water, food and habitat. | Serious impacts on habitat of endangered species and learning from the experiences of similar interventions in the Yangtze river led to the extinction of the Yangtze river dolphin and pushing the Yangtze finless porpoise to the critically endangered category. |

| VEC | Connectivity and Freight | High Speed Rail Network | Industrial Corridor | High Value Crop | High Value Conservation Area | Ecotourism | Direct Impact | Direct impact | Cumulative Impact |
|---|---|---|---|---|---|---|---|---|---|
| | routes along with freshwater turtles | | | Crops do not integrate climate change resilient varieties<br><br>Increase in livestock production will have impact on habitats and disease transmission from livestock to wild animals and competition | | | | | Increasing livestock production in areas with important ungulate species for example chinkara would increase competition and would put the indigenous wildlife to risk. |

| VEC | Connectivity and Freight | High Speed Rail Network | Industrial Corridor | High Value Crop | High Value Conservation Area | Ecotourism | Direct Impact | Direct impact | Cumulative Impact |
|---|---|---|---|---|---|---|---|---|---|
| **Protected Area** | CPEC Central Corridor would pass through the Indus river, Indus river dolphin population (Taunsa Guddu river section has 571 population, WWF 2017 survey), second largest population of the species in the Indus, riverine forest and population of the endangered Hog deer.<br><br>***Taunsa wildlife Sanctuary is a Ramsar site***<br><br>Some of the proposed highways go through the protected areas for example ***Lal Suhanra National Park and Cholistan Wildlife Sanctuary.*** | | | | | Lal Suhanra National Park and Cholistan fall under ecotourism zone which can help in promoting awareness and general resources if managed properly and would also help in generating resources for communities. | Damage to fish species and breeding grounds, freshwater turtles and birds habitat not only in the Indus but other tributaries. This would impact riverine forest, which is the habitat of endangered hog deer.<br><br>Impact on fisheries would also impact livelihoods of local communities which culminates into more intensive fishing practices | Noise, acoustics pollution, vessel collision, mortalities and serious impacts on breeding of the Indus river dolphin and food chain in the Indus e.g fish species. When fish species decline then there are more intensive fishing practices that cause further damage. Indus is one the world famous flyways for migratory birds and this will lead to the disturbance in | Serious impacts on the habitat of some of the high profile species habitat and their food chain and this would also impact livelihoods of local communities. |

| VEC | Connectivity and Freight | High Speed Rail Network | Industrial Corridor | High Value Crop | High Value Conservation Area | Ecotourism | Direct Impact | Direct impact | Cumulative Impact |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | and sometimes illegal fishing practices. | the migratory routes including some high profile birds species. Damage to fish species and breeding grounds, freshwater turtles and birds' habitat not only in the Indus but other tributaries. This would impact riverine forest, which is the habitat of endangered hog deer. | |

## 5.1 Table 12 Cumulative Effects of interventions on biodiversity

| Effects on Biodiversity | | | | | | |
|---|---|---|---|---|---|---|
| **Intervention** | **Area of Concern** | **Description of effect** | **Key sensitivities and impacts** | **Duration (Permanent/ Temporary/ long term)** | **Mitigation** | **Residual effect with mitigation** |
| Industries | Growth targets of textiles and leather industries | Increasing water/habitat pollution | There have been serious impacts of these two sectors on environment; extensive use of water and effluents discharge. SDGs Goal 9 on innovative infrastructure has not been addressed as to what would be done.<br><br>There are no sector specific standards. This is important if we want to build on exports and internationally brands are becoming more environmentally | Long term | Sector specific standards to promote best practices and reducing impacts, nature-based solutions for treatment of water | Negligible to low |

| Effects on Biodiversity | | | | | | |
|---|---|---|---|---|---|---|
| **Intervention** | **Area of Concern** | **Description of effect** | **Key sensitivities and impacts** | **Duration (Permanent/ Temporary/ long term)** | **Mitigation** | **Residual effect with mitigation** |
| | | | and socially conscious and want products/raw materials produced in a sustainable manner. | | | |
| Agriculture | High value crop and ensuring water, fertilizers and pesticides. Policy focus does not include reducing the use of agrochemicals. Policy mentions capturing global markets but does not include organic produce and addition of finished products for example rapeseed can be processed into a finished product of rapeseed oil which has a great international market. Awareness of farmers about high value crop and cropping | Direct disturbance of habitats<br><br>Conflict with wildlife<br><br>Toxic pollution | Agrochemical pollution in the key biodiversity areas for example some of the high value crop zones are coincide with the range of the Indus river dolphin. Areas of Bahawalpur District which is protected as Cholistan Wildlife Sanctuary and has some important species such as Houbara bustard and Great Indian bustard has been identified as the area for oil seed production | Long term | Incentivising farmers to produce organic produce.<br><br>Value added industry for export growth and economic growth.<br>Concessions to value chain | Low |

| Effects on Biodiversity | | | | | | |
|---|---|---|---|---|---|---|
| **Intervention** | **Area of Concern** | **Description of effect** | **Key sensitivities and impacts** | **Duration (Permanent/ Temporary/ long term)** | **Mitigation** | **Residual effect with mitigation** |
| | patterns has been stressed upon. | Agriculture already contributes 174.56 MT of CO2 (second major contributor of GHG in Pakistan) | Crops do not integrate climate change resilient varieties | | | |
| | Increase in livestock production | | Will have impact on habitats and disease transmission from livestock to wild animals and competition, impacts on vegetation. | | | |
| | | | | | Building capacity of livestock and diary departments and improving community access to veterinary medicines and vaccinations. | |

| Effects on Biodiversity | | | | | | |
|---|---|---|---|---|---|---|
| **Intervention** | **Area of Concern** | **Description of effect** | **Key sensitivities and impacts** | **Duration (Permanent/ Temporary/ long term)** | **Mitigation** | **Residual effect with mitigation** |
| Tourism | Adventure Tourism has been indicated without discussing restricting access to certain areas. while 'Nature tourism' has not even been mentioned, thus has not received its due importance. Districts like Khushab and Muzafargarh offer unique opportunities for nature tourism. | Direct disturbance to habitats and species without off setting impacts on biodiversity. | Tourism can cause serious disturbance to wildlife species and habitats | Temporary | It is important to establish a conservation fund where nature tourism is involved with a mechanism to set aside the fund for the conservation of the area. Establishment of Conservation Fund where tourism is linked to 'nature' | No effect |
| **Connectivity and Freight** | Inland water way: Indus in Phase II | Direct disturbance of the | Noise, acoustics pollution, vessel collision, mortalities and serious impacts on breeding of the Indus | Permanent | This should not be taken forward as the Indus river is | High |

| Effects on Biodiversity | | | | | | |
|---|---|---|---|---|---|---|
| **Intervention** | **Area of Concern** | **Description of effect** | **Key sensitivities and impacts** | **Duration (Permanent/ Temporary/ long term)** | **Mitigation** | **Residual effect with mitigation** |
| | | species and their habitat.<br><br>Pollution from vessels and barges | river dolphin and food chain in the Indus e.g fish species. When fish species decline then there are more intensive fishing practices that cause further damage. Indus is one the world famous flyways for migratory birds and this will lead to the disturbance in the migratory routes including some high profile birds species. Damage to fish species and breeding grounds, freshwater turtles and birds habitat not only in the Indus but other tributaries. This would impact riverine forest, which is the habitat of endangered hog deer.<br><br>Impact on fisheries would also impact livelihoods of local communities which culminates | | only habitat of the endangered Indus river dolphin, and the species is endemic to the indus river system with a population of less than 2000 individuals. There are only 571 dolphins in Punjab (Aisha et al 2017) and this would lead to its extinction. | |

| Effects on Biodiversity | | | | | | |
|---|---|---|---|---|---|---|
| **Intervention** | **Area of Concern** | **Description of effect** | **Key sensitivities and impacts** | **Duration (Permanent/ Temporary/ long term)** | **Mitigation** | **Residual effect with mitigation** |
| | | | into more intensive fishing practices and sometimes illegal fishing practices. | | | |
| | Central CPEC alignment | Direct disturbance/loss and degradation of habitat and species | Entire new corridor and cuts through the Punjab Urial habitat in Chakwal, Kundian forest which is a wildlife sanctuary in Mianwali and crosses over the Indus in Muzaffargarh and DG Khan where the Indus River Dolphin's second largest population resides. Khangarh plantation will also be impacted by this corridor.<br><br>Construction itself would have severe impact on small species for example reptiles or burrowing mammals. | Permanent | Re-routing<br><br>Species corridors, habitat connectivity | High |

| Effects on Biodiversity | | | | | | |
|---|---|---|---|---|---|---|
| **Intervention** | **Area of Concern** | **Description of effect** | **Key sensitivities and impacts** | **Duration (Permanent/ Temporary/ long term)** | **Mitigation** | **Residual effect with mitigation** |
| | Eastern CPEC alignment | Direct disturbance/loss and degradation of habitat and species | Destruction of habitat and protected forest in Rawalpindi, Chakwal. Impacts on reptiles | Permanent | Improving protected area management for Punjab urial, pangolin, establishing corridors, strictly monitoring vehicular speed in ecological areas to prevent road accidents. Reforestation to offset forest loss | High |
| | Western CPEC alignment | Direct disturbance/loss and degradation of habitat and species | Destruction of forest/species habitat | Permanent | As above | High |

| Effects on Biodiversity | | | | | | |
|---|---|---|---|---|---|---|
| **Intervention** | **Area of Concern** | **Description of effect** | **Key sensitivities and impacts** | **Duration (Permanent/ Temporary/ long term)** | **Mitigation** | **Residual effect with mitigation** |
| | Road corridors Network | Direct disturbance/loss of habitat and species | Fragmentation of habitat, collision, losses of wildlife | Long term | Public awareness, species corridors, habitat protection in the vicinity of networks. Road ecology | Medium |
| Water and Irrigation | Small dams and reservoirs | Direct impacts on habitats and species | Fragmentation of habitats, barriers in the upstream movement of fish species, reduced breeding of fish, impacts on the associated habitat | Long term | Promotion of sustainable energy, enhancing, water stewardship by business, policy on land use conversion e.g Agriculture into housing. | High |

| Effects on Biodiversity | | | | | | |
|---|---|---|---|---|---|---|
| **Intervention** | **Area of Concern** | **Description of effect** | **Key sensitivities and impacts** | **Duration (Permanent/ Temporary/ long term)** | **Mitigation** | **Residual effect with mitigation** |
| | | | | | Water infrastructure standards. Ensuring functional fish ladders | |
| | | | Has not taken into considering the upstream construction under Indus Cascade Project and strategy to deal with impacts downstream. | | Determining and implementing environmental flow requirements for ecological sustainability | |
| Energy | Biomass | Indirect impact by pollution | Smog | Temporary | Use of biodegradable | None |

| Effects on Biodiversity | | | | | | |
|---|---|---|---|---|---|---|
| **Intervention** | **Area of Concern** | **Description of effect** | **Key sensitivities and impacts** | **Duration (Permanent/ Temporary/ long term)** | **Mitigation** | **Residual effect with mitigation** |
| | | | | | waste from cities to power transport. | |
| | Wind energy | Direct impact on installation site | Disturbance during installation process | Temporary | Installation must avoid areas that are critical for biodiversity and migratory bird routes. | None |
| | Exploration of new coal, natural gas and coal | Direct impacts on habitats | Mining has serious impacts on species and habitat, blasting and noise. This is also directly related to unsustainable energy sources and not aligned with SDGs | | Rehabilitation of mined areas afterwards the exploration has completed. | Low |

| Effects on Biodiversity | | | | | | |
|---|---|---|---|---|---|---|
| **Intervention** | **Area of Concern** | **Description of effect** | **Key sensitivities and impacts** | **Duration (Permanent/ Temporary/ long term)** | **Mitigation** | **Residual effect with mitigation** |
| | Shale gas | Direct impacts of habitats | Shale gas extraction process requires large amounts of water, while can affect water availability in others areas (www.geology.com), particularly in a country like Pakistan which is semi arid | Long term | Focus on alternate and sustainable energy sources. | Low |

## 6 Table 13 Region wise Cumulative impact with mitigation measures

**Mitigation Matrix – North Punjab**

| VECs | Cumulative Impact | Mitigation Measures | Residual Impact |
|---|---|---|---|
| **Flora/Forests** | Local vegetation will be compromised during land clearing<br><br>Eastern CPEC corridor would destruction of habitat and protected forest in Rawalpindi, Chakwal. Impacts on reptiles and Urial and pangolin habitat<br><br>All CPEC corridors pass through the reserved, protected guzara forests and it would have multifaceted impacts causing loss of forests, fragmentation, watershed areas, species habitats and community use | • Green belt/ spaces must be an integral part of new propositions<br>• Afforestation and reforestation efforts must be practiced<br>• Rehabilitation of forest and offsetting impact with the help of the Punjab Forest Department. Establish corridor for urial movement<br>• During construction it should be monitored that illegal logging is strictly controlled. The project would need additional 'rangers' to protect sensitive areas and species.<br>• Development of site specific management plans with the relevant custodian departments with the involvement of the relevant civil society organisations.<br>• Developing plans for rehabilitation of forests to offset the loss of ecological services and functions | Low Effect |

| | | | |
|---|---|---|---|
| | | • Restoration of forest to connect forest patches and creating corridors for wide ranging species like the common leopard and reducing potential conflict with communities and tourist. Restrict tourist in areas at certain times when the leopard tends to active | |
| **Fauna** | • Biodiversity and sensitive ecosystems will be disturbed because of construction activities and anthropogenic intervention<br>• Habitat loss/ fragmentation<br>• Competition of access to basic resources and sustenance of life<br>• Deteriorating quality of immediate environment and its elements may create a new challenge for the survival of local species<br>• Construction of dams and water reservoir will reduce water flows in rivers and would change sediments flow, impact fisheries productive and change ecological dynamics.<br>• Inland waterways Phase II | • Creation of new habitats to cover up for compromised habitats of local fauna<br>• Construction activities and other interventions must be limited to day light hours in order to reduce the extent of impacts<br>• White considering sites for new projects, habitats and critical habitats of all species around must be taken into consideration in order to conserve biodiversity<br>• Environmental flows should be determined, monitored and maintained.<br>• Considering that Indus dolphin is only found in the Indus river and the species already became extinct from other tributaries owing to water infrastructure development, no mitigation measures can be proposed. This Inland waterway project will be fatal for this species and is not recommended. | Low Effect |

| | | | |
|---|---|---|---|
| **Protected areas** | • Western corridor cuts through the protected area, damaging the habitat of a high profile species. Construction activities have high impact on small animal biodiversity as well. Community based trophy hunting permits generate income for local communities and loss of resources will also occur as an impact<br>• Central Corridor also goes through Kundian plantation/wildlife sanctuary, Hamoli Reserve Forest, passes close to Namal Lake. Central CPEC corridor will impact Khangarh plantation<br><br>Serious impacts on Chahsma Wildlife Sanctuary/Ramsar site | Kalabagh is a private game reserve so a plan should be discussed with the owners. This area also has a sanctioned community based sustainable use hunting programme therefore has a economic benefit too. This makes it a bit complex and strategy needs to be devised with the private owners and the Punjab Wildlife and Parks Department.<br><br>• Strict monitoring during the construction work. Low impact activities during the migratory birds' season at Namal Lake<br>• Kundian is a wildlife sanctuary which is the highest level of legal protection under the Punjab Wildlife Act. Restoration of the plantation with indigenous trees.<br>• Restoration of coniferous forest in the tourism zones in the north specific to the common leopard habitat will help in connecting forest patches and creating corridors for wide ranging species like the common leopard and reducing potential conflict with communities and tourists. Restrict tourist in areas at certain times when the leopard tends to active.<br>• Slight realignment is recommended to mitigate any negative impacts on the Chashma wildlife Sanctuary/Ramsar wetland/IBA (Important Bird Area declared by the Birdlife International) | Low Effect |

**Mitigation Matrix – Central Punjab**

| VEC's | Cumulative Impact | Mitigation Measures | Residual Impact |
|---|---|---|---|
| **Flora/forests** | • Local species of vegetation will be compromised during land clearing<br>• There will b loss of green spaces<br>• Local species may face competition due to introduction of new species<br>• Low environment quality may result in stunted growth or even loss of sensitive fauna species<br><br>Shorkot Plantation/wildlife sanctuary<br><br>• Western corridor bisects the plantation, fragmentation and loss of forest | • Efficient afforestation and reforestation efforts must be an integral part of every new intervention<br>• Green spaces must be added using local available species<br><br>• Minor realignment can save this plantation<br><br>Rehabilitation and protection of riverine forest in adjoining areas, managing speed of rail in the habitat to ensure no losses of animals | Low |

| | | | |
|---|---|---|---|
| **Fauna** | • Biodiversity and sensitive ecosystems will be disturbed because of construction activities and anthropogenic intervention<br>• Habitat loss/ fragmentation for important species such as houbara<br>• Competition of access to basic resources and sustenance of life<br>• Deteriorating quality of immediate environment and its elements may create a new challenge for the survival of local species<br>• CPEC Central corridor passes through 'canal forest' and covers all the habitat of the houbara bustard. The houbara is a high profile species and population is already declining<br><br>Ravi river and Chenab, important for migratory birds<br><br>Industrial corridor and high speed railway increasing noise and pollution level. Impact of fish waterbirds species<br><br>Hog deer habitat, endangered species Lahore Narowal<br><br>• | • Development of new habitats to counteract for the compromised habitats of local fauna<br>• Construction activities and other interventions must be limited to day light hours in order to reduce the extent of impacts<br>• White considering sites for new projects, habitats and critical habitats of all species around must be taken into consideration in order to conserve biodiversity<br>• Allocation for resources to monitor houbara during construction so that no illegal hunting associated with construction is carried out, provide special rangers during the construction for this protection.<br><br>Ensuring water treatment and minimizing noise pollution, constructed wetlands to offer nature-based solutions<br><br>• Rehabilitation and protection of riverine forest in adjoining areas, managing speed of rail in the habitat to ensure no losses of animals because of collision, creating corridor for wildlife crossing and signage to create awareness | Low |

| | | | |
|---|---|---|---|
| **Protected areas** | Highways passing through Thal 1 with impacts on chinkara, reptiles, and avian (birds) biodiversity | Strict speed monitoring, signage. Vegetation is sparse and critical for local wildlife species and the highway needs to planned in a way it has minimum impact on trees offer roosting for important species including the endangered Egyptian vulture and browse to Chinkara, shrubs and grasses are critical for houbara and collection of seeds of indigenous grasses from the desert and using these for restoration of grasses will help in conservation of species that depend on these as food resources. | Low |

**Mitigation Matrix – South Punjab**

| VECs | Cumulative Impact | Mitigation Measures | Residual Impact |
|---|---|---|---|
| **Flora/forests** | • Local species of vegetation will be compromised during land clearing<br>• There will b loss of green spaces<br>• Local species may face competition due to introduction of new species<br>• Low environment quality may result in stunted growth or even loss of sensitive fauna species<br>• Khanpur Plantation, Muzaffargarh<br>High speed train regional track is passing through the plantation, fragmentation and loss of forest<br>• These interventions would impact riverine forest, which is the habitat of endangered hog deer. | • Efficient afforestation and reforestation efforts must be an integral part of every new intervention<br>• Green spaces must be added using local available species<br><br>Can be realigned or it should be offset by providing the area lost and rehabilitation of land into forest. This should be discussed with the leading implementation agency – Punjab Forest Department | Low |
| **Fauna** | Inland waterway Indus in Phase II would cause noise, acoustics pollution, vessel collision, mortalities and serious impacts on breeding of the Indus river dolphin and food chain in the Indus e.g fish species. When fish species decline then there are more intensive fishing practices that cause further damage. Indus is one the world famous flyways for migratory birds and this will lead to the disturbance in the migratory routes including some high profile birds species. Damage to fish species and breeding | • Inland waterway Indus Phase II is not recommended for execution.<br><br>To manage the impacts of the Central CPEC corridor on the Indus river dolphin this area should be strictly monitored no ensure the any entrapped dolphin could be rescued while pingers (acoustic deterrents) or bubble curtains should be used to keep the dolphins away from the construction site3 and the work should be scheduled in a manner that low | High |

[3] This mitigation measure is valid for all CPEC corridors construction where Indus river dolphin range is involved

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| | grounds, freshwater turtles and birds habitat not only in the Indus but other tributaries<br>Impact on fisheries would also impact livelihoods of local communities which culminates into more intensive fishing practices and sometimes illegal fishing practices<br><br>At Layyah, the CPEC Central corridor passes through 'canal forest' and covers all the habitat of the houbara bustard. It also passes through DG Khan and Rajanpur with impacts on the Houbara and Chinkara | impact activities are carried out during the migratory bird season from October to March. Construction activities, labour colonies and later increase of traffic because of road network and increased access increases the pressure on wildlife in the form of illegal hunting and wildlife trade. The custodian department would need to increase their rangers/wildlife watchers to protect species and habitats. | |
| **Protected areas** | • Indus river, Indus river dolphin population (Taunsa Guddu river section has 571 population, WWF 2017 survey), second largest population of the species in the Indus, riverine forest and population of the endangered Hog deer.<br>• Taunsa wildlife Sanctuary is a Ramsar site<br>• DG Khan and Rajanpur have important rangelands and provide food to wild ungulates while also being critical for rural economy. Loss of rangelands would reflect in loss of grazing habitat for livestock and impact of rural people<br>• Khanewal plantation - Eastern corridor close plantation<br>• Cholistan Wildlife Sanctuary/Bahalwalpur district habitat of endangered species - and has some important species such as Houbara bustard and critically endangered Great Indian bustard have been identified as the area for oil seed production<br>• Proposed highway goes inside the Lal Suhanra National Park (UNESCO Biosphere Reserve)<br>• Inland waterways are also part of the Southern region in the Indus with serious impact on fisheries and Indus river dolphins | • Rangelands are already degraded because of high grazing pressures. The project can offset impacts by rehabilitation of rangelands in these districts<br>• During construction it should be monitored that illegal logging is strictly controlled. The project would need additional 'rangers' to protect sensitive areas and species.<br><br>Increase in livestock production will have impact on habitats and disease transmission from livestock to wild animals and competition, building capacity of livestock and diary departments and improving community access to veterinary medicines and vaccinations.<br><br>Highway going inside the National Park should not be allowed. The Park should be divided into zones and absolutely no intervention should be allowed in the core zone to protect species and activities should be restricted to buffer zone. An updated management plan should be developed and approved for the National Park. Efforts should be made to restore the integrity of a UNESCO site. | Mild |

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| | | Inland waterway is not recommended because of serious impact on the endemic, endangered species – Indus river dolphin which is one of the only five species of freshwater dolphins in the world (also see details in the fauna section above) | |

# 7 Conclusion

Minor realignments of CPEC corridors can protect many reserved and protected forests/plantations and internationally recognised protected areas (Chashma Wildlife Sanctuary and Taunsa Wildlife Sanctuary).

The SEA does not recommend Inland waterway Indus Phase II because it overlaps with the habitat of the endemic, endangered species – Indus river dolphin, which is one of the only three obligate freshwater dolphins in the world. Intrusive methods are used to make any river navigable. Navigation would cause acoustics pollution, mortalities caused by vessel collision and serious impacts on breeding of the Indus river dolphin and food chain in the Indus e.g fish species with additional impacts on the ecological and hydrological functions of the river. This would also have serious implications on the livelihoods of people dependent on inland fisheries.

Site specific management plans will help in long term conservation and provide support towards institutionalizing the protection/rehabilitation/conservation of sites impacted because of PSS interventions.

# 8 Recommendations:

**Re-routing CPEC and inland water routes**

The intervention with the highest impact is Connectivity and Freight and it is highly recommended the CPEC routes must be redefined as they are cutting across legally protected areas.

Strategy views *'Inland Water Transport Development Company'* and potential of waterways in the province and embarking a pilot project on a 200 km stretch of the river as a failure and looks as this a huge potential. This intervention will be detrimental to the globally important endangered species for example the Indus river dolphin with serious impact of river ecology and livelihoods of local communities that depend on fishing. This is not aligned with the SDGs, where 'Life on Land' specifically focuses on inland fisheries and conservation of water resources for communities and biodiversity. There is a complete disconnect between the strategy and impacts on biodiversity and serious implication on the destruction of breeding areas of fish. The river depth is high variable and usually a deep channel is created in the river to use it for transport e.g Yangtze river in China. In the Yangtze river, the endemic river dolphin species, the Yangtze river dolphin is already extinct, while the Yangtze finless porpoise is critically endangered.

**Environment Protection and Conservation Areas:**

High value conservation areas have been proposed for Hog deer, common leopard, Punjab Urial, Indian pangolin and Great Indian Bustard which is a positive development. The report is very comprehensive. However, there is a need to establish a protected area for Indus river dolphin in

Punjab. Currently there is no protected area in Punjab where this high profile species, endemic to the Indus river system is protected in Punjab. Taunsa Wildlife Sanctuary is the only protected area where a few river dolphins are reported occasionally.

The strategy is silent on human-wildlife conflict and illegal wildlife trade of species, while these along with habitat loss are the three critical factors impacting wildlife species. The major component of the PSS is Freight and Connectivity which increases access to areas, causes fragmentation of a wide variety of species. This has potential and inevitable links with causes human-wildlife conflict and exasperating illegal wildlife trade which are already widespread in Pakistan. Further this intervention also need to take into consideration 'road ecology'. This needs to be addressed under PSS.

Site specific management plans should be developed

**Other Effective Area-based Conservation Measure (OECMs)**

Considering that not all areas can be legally notified as a 'Protected Area' which is legally defined in the Punjab Wildlife Protection Management Act 2007 or Protected or Reserved Forests as defined in the Punjab Forest Act. There are other measures that have been listed in Convention on Biological Conservation (CBD) and defined at the CBD COP 14 in 2018 that can recognise conservation happening outside protected areas and has the ability to engage a broader range of stakeholders in conservation for example communities, local and national level organisations and NGOs. This also helps in establishing connectivity across systems of protected and conserved areas. According to the IUCN World Commission on Protected Areas OECMs have three categories:

- Land under indigenous communities use
- Areas with secondary conservation objectives such as watersheds managed primarily for water resource management.
- Areas such as military areas which have restricted access consequently effective protection of habitat and species.

Punjab Wildlife Department has spearheaded a ***Protected Areas Act 2020*** (passed by the Punjab Assembly on the 2nd of Sept 2020) is an excellent initiative. The PSS can influence the Protected Areas Act 2020 to include establishment of ***Key Biodiversity Areas (KBAs)*** through the KBA Partnerships and ***Important Bird Areas*** which is more strategic and internationally recognised. This will help in managing business in the area and promoting better practices through innovation.

Role of community as a key stakeholder needs to be identify and considering Nagoya Protocol there needs to be benefit sharing with the local community and building their stewardship.

**Technology use in biodiversity monitoring and management and innovation**

There is a clear gap in integrating technology into implementation and monitoring the impacts of PSS. For example drones are used to monitor illegal activities (logging, poaching), SMART (Spatial Management and Reporting Tools) are used to manage field patrols and improvement PA management, maintenance of data from industries is another technological need that EPA currently lacks. There is also a clear capacity gap within the stakeholder departments to protect the species and their habitat and mitigate the impacts of any projects.

There needs to be innovation in the PSS for example Sector specific standards in industries should be developed to promote best practices and reducing impacts, nature-based solutions for disaster management and also treatment of water and these areas can be potential habitat of species particularly migratory birds. In the cites the solid waste can be used to fuel transport and this has been practiced in many countries.

**Tourism, ecotourism, adventure tourism or nature tourism**

Tourism should be divided into ecotourism, nature tourism and there are clear differences in them. Nature tourism which would cover aspects of forest and wildlife should include mechanism for fundraising for conservation (Gyuan 2006). "Nature tourism is travel for the purpose of enjoying undeveloped natural areas or wildlife", Ecotourism is defined as "responsible travel to natural areas which conserves the environment and improves the welfare of local people (The International Ecotourism Society 2007). Ecotourism must adhere to the following principles:

- Minimise impact
- Build environmental and cultural awareness and respect
- Provide positive experiences for both visitors and host
- Provide direct financial benefits for conservation
- Provide financial benefits and empowerment for local people
- Raise sensitivity to host countries, political environmental and social climate.

**Education and awareness raising**

There needs to be more awareness raising of masses about biodiversity conservation and the role the public can play. Citizen science is a growing field and can help in environmental monitoring and field data collection, this has been going on in many countries in the region for example India and China. District level environmental books should be developed and integrated into the curriculum so that students learn about the biodiversity, environmental issues and challenges about their area.

Provincial Sustainable Development Fund is only mentioned in the Punjab Environment Protection Act and is not part of the Punjab Wildlife, Fisheries or Forest laws. More integrated approach is required.

**Governance structure:**

**SDG Unit and P&D**

The planning and implementation of SDGs is largely under the purview of the provinces and the major source of funding can be through Annual Development Programmes (ADPs), alignment of provincial developing expenditure. Considering that SDGs integrate economic, social and environment, P&D would need to bring together a range expertise for the PSS and work closely with SDG Unit of Punjab. Although, the SDG Unit is under the Planning and Development Board, Government of Punjab though being managed by UNDP. This unit currently does not have an environment expert on board. In order to successfully deliver on SDGs more integration is needed as intervention in one area (sector) impacts

the other. There are capacity gaps within relevant departments to understand, monitor and deliver on the SDGs.

There is an evident gap in the implementation of proposed plans of the protected areas on the ground level. The custodian government department mandated to protect biodiversity Forest, Wildlife and Fisheries Department is under resourced to protect and manage even the current areas. There are capacity gaps and the departments are not equipped adequately to protect natural resources. The function of conservation would need to embedded in Planning and Development Department and current the position of the Board Member (Environment and Climate Change) is vacant and this function is managed through an additional charge. It is vital to get a Member environment on board and associated Chief. Currently, there is no position a Chief for Environment. Another gap that usually occurs is that when 'Environment is taken into consideration biodiversity (wildlife and forests) do not receive the due significance and importance and environmental issues tend to focus on brown issues (pollution, industries and climate change and its mitigation and adaptation).

The Punjab Planning and Development Department would need a focal person to manage biodiversity impact mitigation and coordinate with the relevant stakeholders including government and non-governmental organisations.

The Punjab Wildlife Management Board is the top-level body formulated as per the Punjab Wildlife Management, Protection and Conservation Act 2007, it has been recently notified and the Punjab Chief Minister is the Chair of the Board. It would be relevant to have member Environment P&D to be included in the Punjab Wildlife Management Board so that collaboration is established and updated.

Considering that each intervention of the PSS would have significant impact on the wildlife and forests, the custodian departments need to be engaged in the planning from the very beginning. PSS would need a steering group that includes forest and wildlife departments along with leading conservation organisations.

The **Urban and Peri Urban forest policy** is indicating 'wild meat' as a way of supporting SDG Goal 2 (Zero hunger), while largely illegal and it would be insignificant part to meet the SDG and it should be taken out. Urban and peri urban forestry is largely patchy and without corridor so it can only benefit common species of birds and small mammals and/or reptile species and would not provide habitat for medium to large mammals. The policy will not establish any corridors in the Rawalpindi District, particularly focusing on the Murree forest that will help the movement of wide ranging species e.g common leopard with in degraded forest patches within Punjab and connecting the habitat between Punjab and KP.

There is a need to reflect the inclusion of treaties and conventions in the strategy and how PSS would strengthen the conservation of internationally recognised areas (IBAs), Ramsar wetlands or species that are listed under international conventions.

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Annex 1 IBA of Pakistan referred as annex-6 of main report

**Annex 2: Species Database Punjab**

**Birds**

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **1** | Grebe, Little | *Tachybaptus ruficollis* | Least Concern |
| **2** | Grebe, Great Crested | *Podiceps cristatus* | Least Concern |
| **3** | Grebe, Black-necked or Eared | *Podiceps nigricollis* | Least Concern |
| **4** | Cormorant, Great | *Phalacrocorax carbo* | Least Concern |
| **5** | Cormorant, Indian (Shag) | *Phalacrocorax fuscicollis* | Least Concern |
| **6** | Cormorant, Little or Javanese | *Phalacrocorax niger* | Least Concern |
| **7** | Darter or Snakebird | *Anhinga melanogaster* | Least Concern |
| **8** | Pelican, Great White or Rosy | *Pelecanus onocrotalus* | Least Concern |
| **9** | Pelican, Dalmatian or Grey | *Pelecanus crispus* | Near Threatened |
| **10** | Bittern, Great or Eurasian | *Botaurus stellaris* | Least Concern |
| **11** | Bittern, Little | *Ixobrychus minutus* | Least Concern |
| **12** | Bittern, Yellow or Chinese Little | *Ixobrychus sinensis* | Least Concern |
| **13** | Bittern, Cinnamon or Chestnut | *Ixobrychus cinnamomeus* | Least Concern |
| **14** | Bittern, Black | *Ixobrychus flavicollis* | Least Concern |
| **15** | Heron, Black-crowned Night or Night - | *Nycticorax nycticorax* | Least Concern |
| **16** | Heron, Little or Striated or Green or Green-backed | *Butorides striatus* | Least Concern |
| **17** | Heron, Indian Pond | *Ardeola grayii* | Least Concern |
| **18** | Egret, Cattle or Buff-backed Heron | *Bubulcus ibis* | Least Concern |
| **19** | Egret, Little | *Egretta garzetta* | Least Concern |
| **20** | Egret, Intermediate | *Egretta intermedia* | Least Concern |
| **21** | Egret, Great or Large - | *Egretta alba* | Least Concern |
| **22** | Heron, Grey | *Ardea cinerea* | Least Concern |
| **23** | Heron, Purple | *Ardea purpurea* | Least Concern |
| **24** | Stork, Painted | *Mycteria leucocephala* | Near Threatened |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **25** | Stork, Asian Openbill | *Anastomus oscitans* | Least Concern |
| **26** | Stork, Black | *Ciconia nigra* | Least Concern |
| **27** | Stork, Woolly-necked or White-necked | *Ciconia episcopus* | Vulnerable |
| **28** | Stork, White | *Ciconia ciconia* | Least Concern |
| **29** | Ibis, Glossy | *Plegadis falcinellus* | Least Concern |
| **30** | Spoonbill, White | *Platalea leucorodia* | Least Concern |
| **31** | Flamingo, Greater | *Phoenicopterus ruber* | Least Concern |
| **32** | Duck, Lesser Whistling (Teal) or Tree - | *Dendrocygna javanica* | Least Concern |
| **33** | Goose, Greylag | *Anser anser* | Least Concern |
| **34** | Goose, Bar-headed | *Anser indicus* | Least Concern |
| **35** | Shelduck, Ruddy or Brahminy Duck | *Tadorna ferruginea* | Least Concern |
| **36** | Shelduck, Common | *Tadorna tadorna* | Least Concern |
| **37** | Goose, Cotton Pygmy or Cotton Teal | *Nettapus coromandelianus* | Least Concern |
| **38** | Wigeon, Eurasian | *Anas penelope* | Least Concern |
| **39** | Gadwall | *Anas strepera* | Least Concern |
| **40** | Teal, Common | *Anas crecca* | Least Concern |
| **41** | Mallard | *Anas platyrhynchos* | Least Concern |
| **42** | Duck, Spot-billed | *Anas poecilorhyncha* | Least Concern |
| **43** | Pintail, Northern | *Anas acuta* | Least Concern |
| **44** | Garganey | *Anas querquedula* | Least Concern |
| **45** | Shoveler, Northern or - | *Anas clypeata* | Least Concern |
| **46** | Teal, Marbled | *Marmaronetta angustirostris* | Vulnerable |
| **47** | Pochard, Red-crested | *Netta rufina* | Least Concern |
| **48** | Pochard, Common or - | *Aythya ferina* | Least Concern |
| **49** | Duck, Ferruginous or White-eyed Pochard | *Aythya nyroca* | Vulnerable |
| **50** | Duck, Tufted or Tufted Pochard | *Aythya fuligula* | Least Concern |
| **51** | Goldeneye, Common | *Bucephala clangula* | Least Concern |
| **52** | Smew | *Mergus albellus* | Least Concern |
| **53** | Merganser, Goosander or Common | *Mergus merganser* | Least Concern |
| **54** | Duck, White-headed | *Oxyura leucocephala* | Endangered |
| **55** | Buzzard, Crested Honey | *Pernis ptilorhyncus* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **56** | Kite, Black-shouldered or Black-winged - | *Elanus caeruleus* | Least Concern |
| **57** | Kite, Black | *Milvus migrans* | Least Concern |
| **58** | Kite, Brahminy | *Haliastur indus* | Least Concern |
| **59** | Eagle, Pallas's or Ring-tailed Fish | *Haliaeetus leucoryphus* | Endangered |
| **60** | Vulture, Lammergeier or Bearded | *Gypaetus barbatus* | Near Threatened |
| **61** | Vulture, Egyptian or Scavenger - | *Neophron percnopterus* | Endangered |
| **62** | Vulture, Oriental White-backed | *Gyps bengalensis* | Critically Endangered |
| **63** | Vulture, Eurasian Griffon | *Gyps fulvus* | Least Concern |
| **64** | Vulture, Cinereous or Eurasian Black | *Aegypius monachus* | Near Threatened |
| **65** | Eagle, Short-toed or Snake | *Circaetus gallicus* | Least Concern |
| **66** | Harrier, Marsh | *Circus aeruginosus* | Least Concern |
| **67** | Harrier, Hen | *Circus cyaneus* | Least Concern |
| **68** | Harrier, Pallid | *Circus macrourus* | Near Threatened |
| **69** | Harrier, Montagu's | *Circus pygargus* | Least Concern |
| **70** | Goshawk, Northern or - | *Accipiter gentilis* | Least Concern |
| **71** | Hawk, Eurasian Sparrow | *Accipiter nisus* | Least Concern |
| **72** | Hawk, Shikra or Indian Sparrow | *Accipiter badius* | Least Concern |
| **73** | Eagle, White-eyed Buzzard or Buzzard | *Butastur teesa* | Least Concern |
| **74** | Buzzard, Long-legged | *Buteo rufinus* | Least Concern |
| **75** | Eagle, Greater Spotted Eagle or Spotted | *Aquila clanga* | Least Concern |
| **76** | Eagle, Tawny | *Aquila rapax* | Least Concern |
| **77** | Eagle, Imperial | *Aquila heliaca* | Vulnerable |
| **78** | Eagle, Booted. | *Hieraaetus pennatus* | Least Concern |
| **79** | Eagle, Mountain Hawk-Eagle or Hodgson's Hawk- | *Nisaetus nipalensis* | Least Concern |
| **80** | Kestrel, Common or Eurasian | *Falco tinnunculus* | Least Concern |
| **81** | Falcon, Red-necked or Red-headed Merlin or Turumtee | *Falco chicquera* | Least Concern |
| **82** | Merlin | *Falco columbarius* | Least Concern |
| **83** | Hobby, Northern | *Falco subbuteo* | Least Concern |
| **84** | Falcon, Laggar | *Falco jugger* | Near Threatened |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **85** | Falcon, Saker | *Falco cherrug* | Endangered |
| **86** | Falcon, Shanghar | *Falco cherrug milvipes* | Endangered |
| **87** | Falcon, Peregrine | *Falco peregrinus* | Least Concern |
| **88** | Chukar | *Alectoris chukar* | Least Concern |
| **89** | Partridge, See-See | *Ammoperdix griseogularis* | Least Concern |
| **90** | Francolin, Black or Partridge | *Francolinus francolinus* | Vulnerable |
| **91** | Francolin, Grey or Indian Grey Partridge | *Francolinus pondicerianus* | Least Concern |
| **92** | Quail, Common | *Coturnix coturnix* | Least Concern |
| **93** | Quail, Rain or Black-breasted - | *Coturnix coromandelica* | Least Concern |
| **94** | Pheasant, Koklass | *Pucrasia macrolopha* | Least Concern |
| **95** | Pheasant, Kalij | *Lophura leucomelana* | Least Concern |
| **96** | Peafowl, Indian | *Pavo cristatus* | Least Concern |
| **97** | Buttonquail, Striped, Little Button or Bustard Quail and Hemipode, Andalus | *Turnix sylvatica* | Least Concern |
| **98** | Buttonquail, Yellow-legged | *Turnix tanki* | Least Concern |
| **99** | Rail, Water | *Rallus aquaticus* | Least Concern |
| **100** | Crake, Spotted | *Porzana porzana* | Least Concern |
| **101** | Crake, Little | *Porzana parva* | Least Concern |
| **102** | Crake, Baillon's | *Porzana pusilla* | Least Concern |
| **103** | Crake, Ruddy-breasted or Ruddy - | *Porzana fusca* | Least Concern |
| **104** | Waterhen, White-breasted | *Amauromis phoenicurus* | Least Concern |
| **105** | Moorhen, Common or Common Waterhen | *Gallinula chloropus* | Least Concern |
| **106** | Swamphen, Purple, Purple Gallinule or Purple Coot | *Porphyrio prophyrio* | Least Concern |
| **107** | Watercock or Kora | *Gallicrex cinerea* | Least Concern |
| **108** | Coot, Black or Eurasian | *Fulica atra* | Least Concern |
| **109** | Crane, Common | *Grus grus* | Least Concern |
| **110** | Crane, Demoiselle | *Anthropoides virgo* | Least Concern |
| **111** | Bustard, Little | *Tetrax tetrax* | Near Threatened |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **112** | Bustard, Houbara | *Chlamydotis undulata* | Vulnerable |
| **113** | Bustard, Great Indian | *Ardeotis nigriceps* | Critically Endangered |
| **114** | Florican, Lesser or Likh | *Sypheotides indica* | Endangered |
| **115** | Jacana, Pheasant-tailed | *Hydrophasianus chirurgus* | Least Concern |
| **116** | Snipe, Greater Painted- | *Rostratula benghalensis* | Least Concern |
| **117** | Stilt, Black-winged | *Himantopus himantopus* | Least Concern |
| **118** | Pied Avocet | *Recurvirostra avosetta* | Least Concern |
| **119** | Curlew, Stone | *Burhinus oedicnemus* | Least Concern |
| **120** | Thick-knee, Great or Stone Plover | *Esacus recurvirostris* | Least Concern |
| **121** | Courser, Cream-coloured | *Cursorius cursor* | Least Concern |
| **122** | Courser, Indian | *Cursorius coromandelicus* | Least Concern |
| **123** | Pratincole, Collared | *Glareola pratincola* | Least Concern |
| **124** | Pratincole, Small or Little | *Glareola lactea* | Least Concern |
| **125** | Plover, Little Ringed | *Charadrius dubius* | Least Concern |
| **126** | Plover, Kentish or Snowy | *Charadrius alexandrinus* | Least Concern |
| **127** | Plover, Lesser or American Golden - | *Pluvialis dominica* | Least Concern |
| **128** | Plover, Grey or Black-bellied | *Pluvialis squatarola* | Least Concern |
| **129** | Lapwing, Red-wattled | *Hoplopterus indicus* | Least Concern |
| **130** | Lapwing, Sociable or Sociable Plover | *Chettusia gregaria* | Critically Endangered |
| **131** | Lapwing, White-tailed | *Chettusia leucura* | Least Concern |
| **132** | Lapwing, Northern or Green Plover | *Vanellus vanellus* | Near Threatened |
| **133** | Stint, Little | *Calidris minuta* | Least Concern |
| **134** | Stint, Temminck's | *Calidris temminckii* | Least Concern |
| **135** | Sandpiper, Curlew | *Calidris ferruginea* | Near Threatened |
| **136** | Dunlin | *Calidris alpina* | Least Concern |
| **137** | Ruff (and Reeve) | *Philomachus pugnax* | Least Concern |
| **138** | Snipe, Jack | *Lymnocryptes minimus* | Least Concern |
| **139** | Snipe, Common or Fantail - | *Gallinago gallinago* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **140** | Woodcock, Eurasian | *Scolopax rusticola* | Least Concern |
| **141** | Godwit, Black-tailed | *Limosa limosa* | Near Threatened |
| **142** | Curlew, Eurasian | *Numenius arquata* | Least Concern |
| **143** | Redshank, Spotted or Dusky | *Tringa erythropus* | Least Concern |
| **144** | Redshank, Common | *Tringa totanus* | Least Concern |
| **145** | Sandpiper, Marsh | *Tringa stagnatilis* | Least Concern |
| **146** | Greenshank, Common | *Tringa nebularia* | Least Concern |
| **147** | Sandpiper, Green | *Tringd ochropus* | Least Concern |
| **148** | Sandpiper, Wood | *Tringa glareola* | Least Concern |
| **149** | Sandpiper, Common | *Actitis hypoleucos* | Least Concern |
| **150** | Phalarope, Red-necked or Northern | *Phalaropus lobatus* | Least Concern |
| **151** | Gull, Great Black-headed | *Larus ichthyaetus* | Least Concern |
| **152** | Gull, Common Black-headed | *Larus ridibundus* | Least Concern |
| **153** | Gull, Brown-headed or Tibetan | *Larus brunnicephalus* | Least Concern |
| **154** | Gull, Mew or Common | *Larus canus* | Least Concern |
| **155** | Gull, Herring | *Larus argentatus* | Least Concern |
| **156** | Tern, Gull-billed | *Gelochelidon nilotica* | Least Concern |
| **157** | Tern, Caspian | *Sterna caspia* | Least Concern |
| **158** | Tern, Swift or Great Crested | *Sterna bergii* | Least Concern |
| **159** | Tern, River | *Sterna aurantia* | Least Concern |
| **160** | Tern, Black-bellied | *Sterna acuticauda* | Endangered |
| **161** | Tern, Little | *Sterna albifrons* | Least Concern |
| **162** | Tern, Whiskered | *Chlidonias hybridus* | Least Concern |
| **163** | Skimmer, Indian or Scissorbill | *Rynchops albicollis* | Vulnerable |
| **164** | Sandgrouse, Painted | *Pterocles indicus* | Least Concern |
| **165** | Sandgrouse, Crowned or Coronetted | *Pterocles coronatus* | Least Concern |
| **166** | Sandgrouse, Spotted | *Pterocles senegallus* | Least Concern |
| **167** | Sandgrouse, Chestnut-bellied or Indian | *Pterocles exustus* | Least Concern |
| **168** | Sandgrouse, Black-bellied or Imperial | *Pterocles orientalis* | Least Concern |
| **169** | Sandgrouse, Pin-tailed | *Pterocles alchata* | Least Concern |
| **170** | Dove or Rock Pigeon | *Columba livia* | Least Concern |
| **171** | Dove, Pale-backed Eastern or Yellow-eyed Stock | *Columba eversmanni* | Least Concern |
| **172** | Wood-pigeon, Common | *Columba palumbus* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **173** | Dove, Eurasian Collared or Indian Ring | *Streptopelia decaocto* | Least Concern |
| **174** | Dove, Red Collared or Turtle | *Streptopelia tranquebarica* | Least Concern |
| **175** | Dove, Oriental Turtle or Eastern Rufous | *Streptopelia orientalis* | Least Concern |
| **176** | Dove, Laughing, Little Brown or Senegal | *Streptopelia senegalensis* | Least Concern |
| **177** | Dove, Spotted or Chinese | *Streptopelia chinensis* | Least Concern |
| **178** | Pigeon, Yellow-footed Green | *Treron phoenicoptera* | Least Concern |
| **179** | Pigeon, Wedge-tailed Green | *Treron sphenura* | Least Concern |
| **180** | Parakeet, Alexandrine or Large Indian | *Psittacula eupatria* | Near Threatened |
| **181** | Parakeet, Rose-ringed | *Psittacula krameri* | Least Concern |
| **182** | Parakeet, Plum-headed | *Psittacula cyanocephala* | Least Concern |
| **183** | Parakeet, Slaty-headed | *Psittacula himalayana* | Least Concern |
| **184** | Cuckoo, Pied or Jacobin | *Clamator jacobinus* | Least Concern |
| **185** | Cuckoo, Common Hawk or Brainfever Bird | *Hierococcyx varius* | Least Concern |
| **186** | Cuckoo, Grey-bellied Plaintive | *Cacomantis passerinus* | Least Concern |
| **187** | Cuckoo, Indian or Short-winged | *Cuculus micropterus* | Least Concern |
| **188** | Cuckoo, Common | *Cuculus canorus* | Least Concern |
| **189** | Cuckoo, Oriental or Himalayan | *Cuculus saturatus* | Least Concern |
| **190** | Cuckoo, Lesser, Little or Small | *Cuculus poliocephalus* | Least Concern |
| **191** | Koel, Common | *Eudynamys scolopacea* | Least Concern |
| **192** | Malkoha, Sirkeer or Cuckoo | *Taccocua leschenaultii* | Least Concern |
| **193** | Pheasant, Greater Coucal or Common Crow | *Centropus sinensis* | Least Concern |
| **194** | Owl, Barn | *Tyto alba* | Least Concern |
| **195** | Owl, Indian or Collared Scops | *Otus bakkamoena* | Least Concern |
| **196** | Owl, Oriental or Indian Scops | *Otus sunia* | Least Concern |
| **197** | Owl, Striated or Pallid Scops | *Otus brucei* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **198** | Owl, European Scops | *Otus scops* | Least Concern |
| **199** | Owl, Spotted or Mountain Scops | *Otus spilocephalus* | Least Concern |
| **200** | Owl, Northern Eagle | *Bubo bubo* | Least Concern |
| **201** | Owl, Dusky Eagle Owl or Dusky Horned | *Bubo coromandus* | Least Concern |
| **202** | Owl, Brown Fish | *Ketupa zeylonensis* | Least Concern |
| **203** | Owl, Collared Pygmy or Collared Owlet | *Glaucidium brodiei* | Least Concern |
| **204** | Owlet, Asian Barred | *Glaucidium cuculoides* | Least Concern |
| **205** | Owl, Spotted Little or Spotted Owlet | *Athene brama* | Least Concern |
| **206** | Owl, Tawny, Himalayan and Scully's Wood | *Strix aluco* | Least Concern |
| **207** | Owl, Long-eared | *Asio otus* | Least Concern |
| **208** | Owl, Short-eared | *Asio flammeus* | Least Concern |
| **209** | Nightjar, Savanna, Allied or Franklin's | *Caprimulgus affinis* | Least Concern |
| **210** | Nightjar, Sykes's or Sind | *Caprimulgus mahrattensis* | Least Concern |
| **211** | Nightjar, Jungle or Grey | *Caprimulgus indicus* | Least Concern |
| **212** | Nightjar, European or Unwin's | *Caprimulgus europaeus* | Least Concern |
| **213** | Swift, White-throated Needletail, or White-throated Spinetail | *Hirundapus caudacutus* | Least Concern |
| **214** | Swift, Pacific, Asian White-rumped or Fork-tailed | *Apus pacificus* | Least Concern |
| **215** | Swift, Alpine | *Apus melba* | Least Concern |
| **216** | Swift, Little, House or Indian House | *Apus affinis* | Least Concern |
| **217** | Kingfisher, White-throated or Smyrna | *Halcyon smyrnensis* | Least Concern |
| **218** | Kingfisher, Common, Eurasian or Small Blue | *Alcedo atthis* | Least Concern |
| **219** | Kingfisher, Pied, or Small Pied | *Ceryle rudis* | Least Concern |
| **220** | Kingfisher, Crested, Large Pied, or Himalayan Pied | *Ceryle lugubris* | Least Concern |
| **221** | Bee-eater, Green, Little Green or Small Green | *Merops orientalis* | Least Concern |
| **222** | Bee-eater, Blue-cheeked | *Merops superciliosus* | Least Concern |

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|---|---|---|---|
| **223** | Bee-eater, Blue-tailed | *Merops philippinus* | Least Concern |
| **224** | Roller, European or Kashmir | *Coracias garrulus* | Least Concern |
| **225** | Roller, Indian or Blue-jay | *Coracias benghalensis* | Least Concern |
| **226** | Hoopoe | *Upupa epops* | Least Concern |
| **227** | Hornbill, Indian Grey | *Tockus birostris* | Least Concern |
| **228** | Barbet, Great or Great Himalayan | *Megalaima virens* | Least Concern |
| **229** | Barbet, Blue-throated | *Megalaima asiatica* | Least Concern |
| **230** | Barbet, Coppersmith or Crimson Breasted | *Megalaima haemacephala* | Least Concern |
| **231** | Wryneck, Eurasian | *Jynx torquilla* | Least Concern |
| **232** | Piculet, Speckled | *Picumnus innominatus* | Least Concern |
| **233** | Woodpecker, Grey-headed or Black-naped Green | *Picus canus* | Least Concern |
| **234** | Woodpecker, Scaly-bellied | *Picus squamatus* | Least Concern |
| **235** | Woodpecker, Sind | *Dendrocopos assimilis* | Least Concern |
| **236** | Woodpecker, Himalayan | *Dendrocopos himalayensis* | Least Concern |
| **237** | Woodpecker, Rufous-bellied or Rufous-bellied Sapsucker | *Dendrocopos hyperythrus* | Least Concern |
| **238** | Woodpecker, Yellow-fronted, Mahratta Pied or Yellow-crowned Pied | *Dendrocopos mahrattensis* | Least Concern |
| **239** | Woodpecker, Brown-fronted | *Dendrocopos auriceps* | Least Concern |
| **240** | Woodpecker, Fulvous-breasted | *Dendrocopos macei* | Least Concern |
| **241** | Woodpecker, Grey-capped Pygmy or Grey-headed Pied | *Dendrocopos canicapillus* | Least Concern |
| **242** | Pitta, Indian | *Pitta brachyura* | Least Concern |
| **243** | Bushlark, Singing | *Mirafra cantillans* | Least Concern |
| **244** | Bushlark, Indian or Red-winged | *Mirafra erythroptera* | Least Concern |
| **245** | Finch-Lark, Black-crowned | *Eremopterix nigriceps* | Least Concern |
| **246** | Finch-Lark, Ashy-crowned | *Eremopterix grisea* | Least Concern |
| **247** | Finch, Lark, Rufous-tailed Lark | *Ammomanes phoenicurus* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **248** | Lark, Desert or Finch | *Ammomanes deserti* | Least Concern |
| **249** | Lark, Hoopoe or Bifasciated | *Alaemon alaudipes* | Least Concern |
| **250** | Lark, Bimaculated or Eastern Calandra | *Melanocorypha bimaculata* | Least Concern |
| **251** | Lark, Greater Short-toed or Yarkand Short-toed | *Calandrella brachydactyla* | Least Concern |
| **252** | Lark, Lesser Short-toed | *Calandrella rufescens* | Least Concern |
| **253** | Lark, Sand or Indus Sand | *Calandrella raytal* | Least Concern |
| **254** | Lark, Crested | *Galerida cristata* | Least Concern |
| **255** | Skylark, Oriental or Small or Lesser | *Alauda gulgula* | Least Concern |
| **256** | Skylark, Eurasian | *Alauda arvensis* | Least Concern |
| **257** | Lark, Horned or Shore | *Eremophila alpestris* | Least Concern |
| **258** | Martin, Brown-throated or Indian Sand Martin, Plain or African Sand | *Riparia paludicola* | Least Concern |
| **259** | Martin, Collared Sand or Bank Swallow | *Riparia riparia* | Least Concern |
| **260** | Martin, Pale Crag or African Rock | *Ptyonoprogne fuligula* | Least Concern |
| **261** | Martin, Northern Crag | *Ptyonoprogne rupestris* | Least Concern |
| **262** | Swallow, Barn | *Hirundo rustics* | Least Concern |
| **263** | Swallow, Wire-tailed | *Hirundo smithii* | Least Concern |
| **264** | Swallow, Red-rumped | *Hirundo daurica* | Least Concern |
| **265** | Swallow, Indian Cliff | *Hirundo fluvicola* | Least Concern |
| **266** | Martin, Asian House | *Delichon dasypus* | Least Concern |
| **267** | Pipit, Richard's Pipit or Paddyfield | *Anthus novaeseelandiae* | Least Concern |
| **268** | Pipit, Upland | *Anthus sylvanus* | Least Concern |
| **269** | Pipit, Tawny | *Anthus campestris* | Least Concern |
| **270** | Pipit, Long-billed or Indian or Persian Rock | *Anthus similis* | Least Concern |
| **271** | Pipit, Tree Pipit or Brown Tree | *Anthus trivialis* | Least Concern |
| **272** | Pipit, Meadow | *Anthus pratensis* | Least Concern |
| **273** | Pipit, Rosy or Vinous-breasted Pipit or Hodgson's | *Anthus roseatus* | Least Concern |
| **274** | Pipit, Water | *Anthus spinoletta* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **275** | Wagtail, Citrine Wagtail or Yellow-headed | *Motacilla citreola* | Least Concern |
| **276** | Wagtail, Grey | *Motacilla cinerea* | Least Concern |
| **277** | Wagtail, White-browed Wagtail or Large Pied | *Motacilla maderaspatensis* | Least Concern |
| **278** | shrike, CommonWoodshrike or Lesser Wood | *Tephrodornis pondicerianus* | Least Concern |
| **279** | Shrike, Large Cuckoo Shrike or Black-faced Cuckoo | *Coracina novaehollandiae* | Least Concern |
| **280** | Shrike, Black-winged Cuckoo Shrike or Lesser Grey, or Dark Grey Cuckoo | *Coracina melaschistos* | Least Concern |
| **281** | Minivet, Long-tailed | *Pericrocotus ethologus* | Least Concern |
| **282** | Minivet, Small or Wandering | *Pericrocotus cinnamomeus* | Least Concern |
| **283** | Minivet, Rosy | *Pericrocotus roseus* | Least Concern |
| **284** | Bulbul, White-Cheecked | *Pycnonotus leucogenys* | Least Concern |
| **285** | Bulbul, Red-vented | *Pycnonotus cafer* | Least Concern |
| **286** | Bulbul, Black Bulbul or Grey | *Hypsipetes madagascariensis* | Least Concern |
| **287** | Dipper, White-throated Dipper or Common | *Cinclus cinclus* | Least Concern |
| **288** | Dipper, Brown or Asiatic | *Cinclus pallasii* | Least Concern |
| **289** | America, Northern Wren or Winter Wren in North | *Troglodytes troglodytes* | Least Concern |
| **290** | Accentor, Rufous-breasted Accentor or Jerdon's | *Prunella strophiata* | Least Concern |
| **291** | Accentor, Black-throated | *Prunella atrogularis* | Least Concern |
| **292** | Accentor, Robin | *Prunella rubeculoides* | Least Concern |
| **293** | Accentor, Alpine | *Prunella collaris* | Least Concern |
| **294** | Rufous-tailed Scrub-robin or Bush Chat or Grey-backed Warbler or Robin | *Cercotrichas galactotes* | Least Concern |
| **295** | Blue-throat | *Luscinia svecica* | Least Concern |
| **296** | Rubythroat, White-tailed or Himalayan - or Black-breasted - | *Luscinia pectoralis* | Least Concern |
| **297** | Chat, Indian Blue Robin or Indian Blue | *Luscinia brunnea* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **298** | Blue-tail, Orange-flanked Bush-robin or Red-flanked | *Tarsiger cyanurus* | Least Concern |
| **299** | Golden Bush-robin | *Tarsiger chrysaeus* | Least Concern |
| **300** | Magpie-robin or Dhyal | *Copsychus saularis* | Least Concern |
| **301** | Redstart, Eversmann's or Rufous-backed | *Phoenicurus erythronotus* | Least Concern |
| **302** | Redstart, Blue-headed or Blue-capped | *Phoenicurus caeruleocephalus* | Least Concern |
| **303** | Redstart, Redstart, Black or Indian | *Phoenicurus ochruros* | Least Concern |
| **304** | Redstart, Blue-fronted | *Phoenicurus frontalis* | Least Concern |
| **305** | Redstart, Plumbeous or Slaty-blue | *Rhyacornis fuliginosus* | Least Concern |
| **306** | Chat, Brown Rock | *Cercomela fusca* | Least Concern |
| **307** | chat, Common Stone-chat or Collared Bush | *Saxicola torquata* | Least Concern |
| **308** | chat, White-tailed Stone-chat, White-tailed Bush- | *Saxicola leucura* | Least Concern |
| **309** | chat, Pied Stone-chat or Pied Bush- | *Saxicola caprata* | Least Concern |
| **310** | chat, Grey Bush-chat or Dark-grey Bush- | *Saxicola ferrea* | Least Concern |
| **311** | Wheatear, Isabelline | *Oenanthe isabellina* | Least Concern |
| **312** | Wheatear, PiedWheatearorPleschanka's | *Oenanthe pleschanka* | Least Concern |
| **313** | Wheatear, Desert | *Oenanthe deserti* | Least Concern |
| **314** | Chat, Red-tailed Wheatear or Golden-tailed Wheatear or Red-rumped | *Oenanthe xanthoprymna* | Least Concern |
| **315** | Chat, White-capped Redstart or Water Redstart or River | *Chaimarrornis leucocephalus* | Least Concern |
| **316** | Chat, Indian Robin or Indian | *Saxicoloides fulicata* | Least Concern |
| **317** | Rock, Thrush, Blue | *Monticola solitarius* | Least Concern |
| **318** | Whistling, Thrush, Blue | *Myiophoneus caeruleus* | Least Concern |
| **319** | Thrush, Orange-headed Ground | *Zoothera citrina* | Least Concern |
| **320** | Scaly Thrush, White's/ Golden/Small-billed Mountain Thrush, Tiger Thrush | *Zoothera dauma* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **321** | Thrush, Tickell's | *Turdus unicolor* | Least Concern |
| **322** | Blackbird, Grey-winged | *Turdus boulboul* | Least Concern |
| **323** | Blackbird, Eurasian | *Turdus merula* | Least Concern |
| **324** | Thrush, Chestnut Thrush or Grey-headed | *Turdus rubrocanus* | Least Concern |
| **325** | Thrush, Naumann's Thrush or Dusky Thrush or Rufous-tailed | *Turdus naumanni* | Least Concern |
| **326** | Dark-throated Thrush (Red and Black-throated Thrushes) | *Turdus ruficollis* | Least Concern |
| **327** | Thrush, Mistle | *Turdus viscivorus* | Least Concern |
| **328** | Forktail, Little | *Enicurus scouleri* | Least Concern |
| **329** | Forktail, Spotted | *Enicurus maculatus* | Least Concern |
| **330** | Warbler, Strong-footed Bush | *Cettia fortipes* | Least Concern |
| **331** | Warbler, Grey-sided or Rufous-capped Bush | *Cettia brunnifrons* | Least Concern |
| **332** | Warbler, Cetti's | *Cettia cetti* | Least Concern |
| **333** | Warbler, Large-billed Bush | *Bradypterus major* | Least Concern |
| **334** | Warbler, Zitting Cisticola, Fan-tailed Warbler or Streaked Fantail | *Cisticola juncidis* | Least Concern |
| **335** | Warbler, Graceful Stripe-backed Prinia or Streaked Wren | *Prinia gracilis* | Least Concern |
| **336** | Warbler, Grey-breasted Prinia, Franklin's or Ashy-grey Wren | *Prinia hodgsonii* | Least Concern |
| **337** | Warbler, Rufous-fronted Prinia, or Wren | *Prinia buchanani* | Least Concern |
| **338** | Warbler, Ashy Prinia, Ashy Wren-warbler or Ashy Longtail | *Prinia socialis* | Least Concern |
| **339** | Warbler, Yellow-bellied Prinia or Yellow-bellied Wren | *Prinia flaviventris* | Least Concern |
| **340** | Warbler, Striated Prinia or Brown Hill | *Prinia criniger* | Least Concern |
| **341** | Warbler, Scrub Warbler or Streaked Scrub | *Scotocerca inquieta* | Least Concern |
| **342** | Tailorbird, Common | *Orthotomus sutorius* | Least Concern |
| **343** | Warbler, Grasshopper | *Locustella naevia* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **344** | Warbler, triated Warbler or Striated Marsh | *Megaluru palustris* | Least Concern |
| **345** | Warbler, Moustached | *Acrocephalus melanopogon* | Least Concern |
| **346** | Warbler, Blunt-winged or Swinhoe's Reed | *Acrocephalus concinens* | Least Concern |
| **347** | Warbler, Paddyfield | *Acrocephalus agricola* | Least Concern |
| **348** | Warbler, Clamorous or Southern Great Reed Warbler or Indian Great Reed | *Acrocephalus stentoreus* | Least Concern |
| **349** | Warbler, Booted | *Hippolais caligata* | Least Concern |
| **350** | Warbler, Desert | *Sylvia nana* | Least Concern |
| **351** | Warbler, Orphean | *Sylvia hortensis* | Least Concern |
| **352** | Whitethroat, Lesser | *Sylvia curruca* | Least Concern |
| **353** | Whitethroat, Common | *Sylvia communes* | Least Concern |
| **354** | warbler, Grey-hooded Warbler or Gray-headed Flycatcher- | *Seicercus xanthoschistos* | Least Concern |
| **355** | Warbler, Golden-spectacled or Yellow-eyed - or Black-browed Flycatcher- | *Seicercus burkii* | Least Concern |
| **356** | Warbler Blyth's or Greater White-tailed Leaf, Small Crowned | *Phylloscopus reguloides* | Least Concern |
| **357** | Warbler, Western Crowned or Large Crowned Leaf | *Phylloscopus occipitalis* | Least Concern |
| **358** | Warbler, Tytler's or Slender-billed Leaf | *Phylloscopus tytleri* | Least Concern |
| **359** | Warbler, Green Warbler or Bright Green Leaf | *Phylloscopus nitidus* | Least Concern |
| **360** | Warbler, Sundevall Greenish Warbler or Dull Green Leaf | *Phylloscopus trochiloides* | Least Concern |
| **361** | Warbler, Large-billed Leaf | *Phylloscopus magnirostris* | Least Concern |
| **362** | Warbler, Pallas'sorYellow-rumpedLeaf | *Phylloscopus proregulus* | Least Concern |
| **363** | Warbler, Brooks's Leaf | *Phylloscopus subviridis* | Least Concern |
| **364** | Warbler, Yellow-browed or Inornate Leaf | *Phylloscopus inornatus* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **365** | Warbler, Tickell's or Chinese Leaf | *Phylloscopus affinis* | Least Concern |
| **366** | Warbler, Plain Leaf Warbler or Plain Willow | *Phylloscopus neglectus* | Least Concern |
| **367** | Chiffchaff, Eurasian or Brown Leaf Warbler | *Phylloscopus collybita tristis* | Least Concern |
| **368** | Goldcrest | *Regulus regulus* | Least Concern |
| **369** | Niltava, Rufous-bellied or Beautiful | *Niltava sundara* | Least Concern |
| **370** | Flycatcher, Blue-throated | *Cyomis rubeculoides* | Least Concern |
| **371** | Flycatcher, Verditer | *Muscicapa thalassina* | Least Concern |
| **372** | Flycatcher, Dark-sided or Sooty | *Muscicapa sibirica* | Least Concern |
| **373** | Flycatcher, Rufous-tailed | *Muscicapa ruficauda* | Least Concern |
| **374** | Flycatcher, Asian Brown or Brown | *Muscicapa latirostris* | Least Concern |
| **375** | Flycatcher, spotted | *Muscicapa striata* | Least Concern |
| **376** | Flycatcher, Slaty-blue | *Ficedula tricolor* | Least Concern |
| **377** | Flycatcher, Ultramarine Flycatcher or White-browed Blue | *Ficedula superciliaris* | Least Concern |
| **378** | Flycatcher, Red-breasted Flycatcher or Red-throated | *Ficedula parva* | Least Concern |
| **379** | Flycatcher, Grey-headed Flycatcher or Grey-headed Canary | *Culicicapa ceylonensis* | Least Concern |
| **380** | Fantail, Yellow-bellied | *Rhipidura hypoxantha* | Least Concern |
| **381** | Fantail,White-brested or White-browed | *Rhipidura aureola* | Least Concern |
| **382** | Flycatcher, Asian or Indian Paradise | *Terpsiphone paradisi* | Least Concern |
| **383** | Babbler, Rusty-cheeked Scimitar | *Pomatorhinus erythrogenys* | Least Concern |
| **384** | Babbler, Black-chinned Babbler or Red-billed | *Stachyris pyrrhops* | Least Concern |
| **385** | Babbler, Yellow-eyed | *Chrysomma sinense* | Least Concern |
| **386** | Babbler, Jerdon's Moupinia or Sind | *Chrysomma altirostris* | Least Concern |
| **387** | Babbler, Common | *Turdoides caudatus* | Least Concern |
| **388** | Babbler, striated | *Turdoides earlei* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **389** | Babbler, Large Grey | *Turdoides malcolmi* | Least Concern |
| **390** | Babbler, Jungle | *Turdoides striatus* | Least Concern |
| **391** | Thrilsh, Variegated Laughing | *Garrulax vari'egatus* | Least Concern |
| **392** | Streaked Laughing-thrush | *Garrulax lineatus* | Least Concern |
| **393** | Rufous or Black-capped or Black-headed Sibia | *Heterophasia capistrata* | Least Concern |
| **394** | White-cheeked Tit | *Aegithalos leucogenys* | Least Concern |
| **395** | Black-throated Tit or Red-headed Long-tailed Tit | *Aegithalos concinnus* | Least Concern |
| **396** | Rufous-naped Tit or Simla or Black Crested Tit or Simla Black Tit | *Parus rufonuchalis* | Least Concern |
| **397** | Spot-winged Black Tit or Crested Black Tit | *Parus melanolophus* | Least Concern |
| **398** | Great Tit or Grey Tit | *Parus major* | Least Concern |
| **399** | Green-backed Tit | *Parus monticolus* | Least Concern |
| **400** | Black-lored Tit, or Yellow-cheeked Tit | *Parus xanthogenys* | Least Concern |
| **401** | White-cheecked Nuthach | *Sitta leucopsis* | Least Concern |
| **402** | Chestnut-bellied Nuthatch | *Sitta castanea* | Least Concern |
| **403** | Eurasian or Common Nuthatch or Kashmir Nuthatch | *Sitta europaea* | Least Concern |
| **404** | Eurasian or Common Nuthatch or Kashmir Nuthatch | *Sitta europaea* | Least Concern |
| **405** | Wallcreeper | *Tichodroma muraria* | Least Concern |
| **406** | Bar-tailed or Himalayan Tree Creeper | *Certhia himalayana* | Least Concern |
| **407** | Common Tree Creeper or Northern Tree Creeper | *Certhia familiaris* | Least Concern |
| **408** | Fire-capped Tit | *Cephalopyrus flammiceps* | Least Concern |
| **409** | EurasianPendulineTit | *Remiz pendulinus* | Least Concern |
| **410** | Sunbird Purple | *Nectarinia asiatica* | Least Concern |
| **411** | Thick-billed Flowerpecker | *Dicaeum agile* | Least Concern |
| **412** | Oriental White-eye | *Zosterops palpebrosa* | Least Concern |
| **413** | Golden Oriole | *Oriolus oriolus* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **414** | Shrike, Rufous-tailed or Isabelline or Pale Brown - | *Lanius isabellinus* | Least Concern |
| **415** | Bay-backed Shrike | *Lanius vittatus* | Least Concern |
| **416** | Long-tailed Shrike or Rufous-backed Shrike | *Lanius schach* | Least Concern |
| **417** | Shrike, Great Grey | *Lanius excubitor* | Least Concern |
| **418** | Black Drongo or King Crow | *Dicrurus macrocercus* | Least Concern |
| **419** | Drongo, Ashy or Grey | *Dicrurus leucophaeus* | Least Concern |
| **420** | Jay, Eurasian | *Garrulus glandarius* | Least Concern |
| **421** | Jay, Lanceolated Black-headed or Lanceolated | *Garrulus lanceolatus* | Least Concern |
| **422** | Magpie, Yellow-billed Blue | *Urocissa flavirostris* | Least Concern |
| **423** | Tree Pie, Rufous or Indian - | *Dendrocitta vagabunda* | Least Concern |
| **424** | Tree Pie, Grey or Himalayan - | *Dendrocitta formosae* | Least Concern |
| **425** | Jackdaw, Common | *Corvus monedula* | Least Concern |
| **426** | Crow, House | *Corvus splendens* | Least Concern |
| **427** | Rook | *Corvus frugilegus* | Least Concern |
| **428** | Crow, Large-billed or Jungle | *Corvus macrorhynchos* | Least Concern |
| **429** | Raven, Common | *Corvus corax* | Least Concern |
| **430** | Starling, Brahminy or Myna or Black-headed Starling | *Sturnus pagodarum* | Least Concern |
| **431** | Starling , Common | *Sturnus vulgaris* | Least Concern |
| **432** | Starling, Rose-coloured or Rosy or Rosy Pastor | *Sturnus roseus* | Least Concern |
| **433** | Starling, Asian Pied or Pied Myna | *Sturnus contra* | Least Concern |
| **434** | Myna, Bank | *Acridotheres ginginianus* | Least Concern |
| **435** | Myna, Common or Indian - | *Acridotheres tristis* | Least Concern |
| **436** | Myna, Jungle | *Acridotheres fuscus* | Least Concern |
| **437** | Sparrow, House | *Passer domesticus indicus* | Least Concern |
| **438** | Sparrow, Migratory House | *Passer domesticus parkinii* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **439** | Sparrow, Spanish or Willow or Tschusi's - | *Passer hispaniolensis transcaspicus* | Least Concern |
| **440** | Sparrow, Sind or Sind Jungle - | *Passer pyrrhonotus* | Least Concern |
| **441** | Sparrow, Cinnamon or Russet - | *Passer rutilans* | Least Concern |
| **442** | Sparrow, Chestnut-shouldered Rock or Yellow-throated - | *Petronia xanthocollis* | Least Concern |
| **443** | Sparrow, Streaked Rock | *Petronia petronia* | Least Concern |
| **444** | Weaver, Baya or lndian Baya | *Ploceus philippinus* | Least Concern |
| **445** | Weaver, Black-breasted or Black-throated - | *Ploceus benghalensis* | Least Concern |
| **446** | Weaver, Streaked or Striated - | *Ploceus manyar* | Least Concern |
| **447** | Avadavat, Red or Red Munia | *Amandava amandava* | Least Concern |
| **448** | Silverbill, Indian or White-throated Munia | *Euodice malabarica* | Least Concern |
| **449** | Munia, Scaly-breasted or Spotted or Nutmeg Mannikin | *Lonchura punctulata* | Least Concern |
| **450** | Chaffinch, Common | *Fringilla coelebs* | Least Concern |
| **451** | Brambling | *Fringilla montifringilia* | Least Concern |
| **452** | Finch, Red-browed or Spectacled - | *Callacanthis burtoni* | Least Concern |
| **453** | Greenfinch, Yellow-breasted or Himalayan -, or Himalayan Goldfinch | *Carduelis spinoides* | Least Concern |
| **454** | Goldfinch, Eurasian | *Carduelis carduelis* | Least Concern |
| **455** | Linnet, Brown | *Carduelis cannabina* | Least Concern |
| **456** | Finch, Plain Mountain or Hodgson's Mountain - | *Leucosticte nemoricola* | Least Concern |
| **457** | Finch, Brandt's Mountain | *Leucosticte brandti* | Least Concern |
| **458** | Rosefinch, Common or Scarlet Grosbeak | *Carpodacus erythrinus* | Least Concern |
| **459** | Bullfinch, Orange | *Pyrrhula aurantiaca* | Least Concern |
| **460** | Grosbeak, Black-and-yellow | *Mycerobas icterioides* | Least Concern |
| **461** | Grosbeak, Spot-winged | *Mycerobas melanozanthos* | Least Concern |

| NO. | COMMON NAME | SCIENTIFIC NAME | IUCN GLOBAL STATUS |
|---|---|---|---|
| **462** | Hawfinch | *Coccothraustes coccothraustes* | Least Concern |
| **463** | Bunting, Pine | *Emberiza leucocephalos* | Least Concern |
| **464** | Bunting,White capped | *Emberiza stewarti* | Least Concern |
| **465** | Bunting, Rock or Meadow - | *Emberiza cia* | Least Concern |
| **466** | Bunting, House or Striolated or Striated - | *Emberiza striolata* | Least Concern |
| **467** | Bunting, Grey-necked | *Emberiza buchanani* | Least Concern |
| **468** | Bunting, Reed | *Emberiza schoeniclus* | Least Concern |
| **469** | Bunting, Red-headed | *Emberiza bruniceps* | Least Concern |
| **470** | Bunting, Crested | *Melophus lathami* | Least Concern |

**Mammals**

| # | COMMON NAME | SCIENTIFIC | GLOBAL IUCN RED LIST |
|---|---|---|---|
| **1** | Indus River dolphin | *Platanista gangetica minor* | Endangered |
| **2** | Common Leopard | *Panthera pardus* | Vulnerable |
| **3** | Jungle Cat | *Felis chaus* | Least Concern |
| **4** | Leopard cat | *Prionailurus bengalensis* | Least Concern |
| **5** | Smooth-coated Otter | *Lutrogale perspicillate* | Vulnerable |
| **6** | Yellow-throated Marten | *Martes flavigula* | Least Concern |
| **7** | Small Indian Civet | *Viverricula indica* | Least Concern |
| **8** | Masked palm Civet | *Paguma larvata grayi* | Least Concern |
| **9** | Small Indian Mongoose | *Herpestes auropunctatus* | Least Concern |
| **10** | Indian Wolf | *Canis lupus pallipes* | Least Concern |
| **11** | Golden Jackal | *Canis aureus* | Least Concern |
| **12** | Red fox | *Vulpes vulpes* | Least Concern |
| **13** | Bengal Fox | *Vulpes bengalensis* | Least Concern |
| **14** | Punjab Urial | *Ovis oritentalis punjabensis* | Vulnerable |
| **15** | Himalayan Goral | *Naemorhedus goral* | Near Threatened |
| **16** | Blackbuck | *Antilope cervicapra* | Least Concern |
| **17** | Blue bull/Nilgai | *Boselaphus tragocamelus* | Least Concern |
| **18** | Barking Deer or Northern Red Muntjac | Muntiacus vaginalis | Least Concern |
| **19** | Hog Deer | *Axis porcinus* | Endangered |
| **20** | Chinkara Gazelle | *Gazelle bennettii* | Least Concern |
| **21** | Wild Boar | *Sus scrofa* | LC |
| **22** | Rhesus Monkey | *Macaca mulatta* | Least Concern |

| # | COMMON NAME | SCIENTIFIC | GLOBAL IUCN RED LIST |
|---|---|---|---|
| **23** | Long eared hedgehog | Hemiechinus collaris | Least Concern |
| **24** | House shrew | *Suncus murinus* | Least Concern |
| **25** | Mediterranean pygmy shrew | *Suncus etruscus* | Least Concern |
| **26** | Anderson"s Shrew | *Suncus stoliczkanus* | Least Concern |
| **27** | White-toothed Shrew | *Crocidura suaveolens* | Least Concern |
| **28** | Indian flying fox (Fruit bat) | *Pteropus giganteus* | Least Concern |
| **29** | Fulvous fruit bat | *Rousettus leschenaultii* | Least Concern |
| **30** | Large mouse-tailed bat | *Rhinopoma microphyllum* | Least Concern |
| **31** | Naked rumped bat | *Taphozouus nudiventris* | Least Concern |
| **32** | Egyptian bat | *Taphozouus perforatus* | Least Concern |
| **33** | Indian false vampire | *Megaderma lyra* | Least Concern |
| **34** | Least Leaf - nosed bat | Hipposideros cineraceus | Least Concern |
| **35** | Yellow desert bat | *Scotoecus pallidus* | Least Concern |
| **36** | Least pipistrelle | *Pipistrellus tenuis* | Least Concern |
| **37** | Kuhl pipistrelle | *Pipistrellus kuhlii* | Least Concern |
| **38** | Kelaart pipistrelle | *Pipistrellus ceylonicus* | Least Concern |
| **39** | Dormer's bat | *Scotozous dormeri* | Least Concern |
| **40** | Lesser house bat | *Scotophilus kuhlii* | Least Concern |
| **41** | Greater yellow house bat | *Scotophilus heathii* | Least Concern |
| **42** | Desert hare | *Lepus nigricollis dayanus* | Least Concern |
| **43** | Giant Red flying Squirrel | *Petaurista petaurista* | Least Concern |
| **44** | Small Kashmir flying Squirrel | *Eoglaucomys fimbriatus* | Least Concern |
| **45** | Five-striped palm squirrel | *Funnambulus pennantii* | Least Concern |
| **46** | Indian crested Porcupine | *Hystrix cristatus* | Least Concern |
| **47** | Himalayan wood/Field Mouse | *Apodemus rusiges* | Least Concern |
| **48** | Short-furred field rat | *Millardia meltada* | Least Concern |
| **49** | Sand coloured rat | *Millardia gleadowi* | Least Concern |
| **50** | House rat | *Rattus rattus* | Least Concern |
| **51** | Turkestan rat | *Rattus turkestanicus* | Least Concern |
| **52** | Brown rat | *Rattus norvegicus* | Least Concern |
| **53** | House mouse | *Mus musculus* | Least Concern |
| **54** | Indian bush rat | *Golunda ellioti* | Least Concern |
| **55** | Indian mole rat | *Bandicota bengalensis* | Least Concern |
| **56** | Short tailed Bandicoot rat | *Nesokia indica* | Least Concern |
| **57** | Balochistan gerbil | *Gerbilus nanus* | Least Concern |
| **58** | Indian hairy footed gerbil | *Gerbillis gleadowi* | Least Concern |
| **59** | Indian gerbil | *Tatera indica* | Least Concern |
| **60** | Indian desert jird | *Meriones hurrianae* | Least Concern |
| **61** | Murree or Wynne’s Vole | *Hyperacrius wynnei* | Least Concern |

| # | COMMON NAME | SCIENTIFIC | GLOBAL IUCN RED LIST |
|---|---|---|---|
| 62 | True vole | *Hyperacrius fertilis* | Least Concern |
| 63 | Indian Pangolin | *Manis crassicaudata* | Endangered |

**Amphibian and Reptiles**

| # | COMMON NAME | SCIENTIFIC | GLOBAL IUCN RED LIST |
|---|---|---|---|
| | **Amphibians** | | |
| 1 | Ant frog | *Microhyla ornata* | Least Concern |
| 2 | Marbled balloon frog | *Uperodon systoma* | Least Concern |
| 3 | Common skittering frog | *Euphlyctis cyanophlyctis microspinulata* | Least Concern |
| 4 | Boie's wart frog | *Fejervarya limnocharis* | Least Concern |
| 5 | Wart frog | *Fejervarya syhadrensis* | Least Concern |
| 6 | Indian Bullfrog | *Hoplobatrachus tigerinus* | Least Concern |
| 7 | Stoliczka's frog | Nanorana *vicina* | Least Concern |
| 9 | Burrowing frog | *Sphaeroteca breviceps* | Least Concern |
| | Chelonians: Turtles and tortoises | | |
| 1 | Black spotted pond turtle | *Geoclemys hamiltonii* | Endangered |
| 2 | Brown roofed turtle | *Kachuga smithii* | Near Threatened |
| 3 | Indian softshell turtle | *Nilssonia gangeticus* | Vulnerable |
| 4 | Indian peacock shell turtle | *Nilssonia hurum* | Vulnerable |
| 5 | Indian narrow-headed softshell | *Chitra indica* | Endangered |
| 6 | Indian flapshell turtle | *Lissemys punctata andersoni* | Least Concern |
| 7 | **Lizards** | | |
| 8 | Hardwicke's Bloodsucker | *Brachysaura minor* | Data Deficient |
| 9 | Garden lizard | *Calotes versicolor versicolor* | |
| 10 | Garden lizard | *Calotes versicolor farooqi* | Not evaluated |
| 11 | Agror agama | *Laudakia agrorensis* | Not evaluated |
| 12 | Yellow headed rock agama | *Laudakia nupta fusca* | Not evaluated |
| 13 | Black agama | *Laudakia melanura lirata* | Not evaluated |
| 14 | Black agama | *Laudakia melanura* | Not evaluated |
| 15 | Large-scaled rock agama | *Laudakia nupta nupta* | Not evaluated |
| 16 | Brilliant ground lizard | *Trapelus agilis* | Not evaluated |
| 17 | Brilliant ground lizard | *Trapelus agilis pakistanensis* | Not evaluated |
| 18 | Afghan ground agama | *Trapelus megalonyx* | Not evaluated |
| 19 | Western Indian Leopard Gecko | *Eublepharis macularius* | Least Concern |
| 20 | Sind Sand Gecko | *Crossobamon orientalis* | Not evaluated |

| | | | |
|---|---|---|---|
| **21** | Warty Rock gecko | *Cyrtopodion kachhense ingoldbyi* | Not evaluated |
| **22** | Suleiman range gecko | *Cyrtopodion kohsulaimanai* | Least Concern |
| **23** | Salt Range gecko | *Cyrtopodion montiumsalsorum* | Not evaluated |
| **24** | Potohar gecko | *Cyrtopodion potoharensis* | Least Concern |
| **25** | Rough bent-toed gecko | *Cyrtopodion scabrum* | Least Concern |
| **26** | Watson gecko/Pakistani thin-toed | *Cyrtopodion watsoni* | Not evaluated |
| **27** | Brooke's house gecko | *Hemidactylus brooki* | Least Concern |
| **28** | Yellow-belly gecko | *Hemidactylus flaviviridis* | Not evaluated |
| **29** | Persian leaf-toed gecko | *Hemidactylus persicus* | Not evaluated |
| **30** | Fort munro sandstone gecko | *Cyrtopodion fortmunroi* | Least Concern |
| **31** | Soan gecko | *Cyrtopodion indusoani* | Not evaluated |
| **32** | Rohtas gecko | *Indogekko rohtasfortai* | Not evaluated |
| **33** | Indian fringed finger lizard | *Acanthodactylus cantoris* | Not evaluated |
| **34** | Short nosed desert racer | *Mesalina brevirostris* | Least Concern |
| **35** | Persian long-tailed desert lizard | *Mesalina watsonana* | Not evaluated |
| **36** | Punjab snake eyed lizard | *Ophisops jerdonii* | Least Concern |
| **37** | Minot snake-eyed Skink | *Ablepharus grayanus* | Not evaluated |
| **38** | Asian snake-eyed skink | *Ablepharus pannonicus* | Not evaluated |
| **39** | Striped grass Mabuya/skink | *Eutropis dissimilis* | Not evaluated |
| **40** | Bronze grass skink | *Eutropis macularia* | Not evaluated |
| **41** | Common dotted garden skink | *Lygosoma puncatata* | Not evaluated |
| **42** | Striped mole skink | *Eumeces indothalensis* | Not evaluated |
| **43** | Three fingered sand fish | *Ophiomorus tridactylus* | Least Concern |
| **44** | | *Scincella himalayana* | Not evaluated |
| **45** | Spiny-tailed lizard | *Uromastyx hardwickii* | Not evaluated |
| **46** | Bengal lizard | *Varanus bengalensis* | Least Concern |
| **47** | Monitor Lizard | *Varanus flavescens* | Least Concern |
| | **Snakes** | | |
| **48** | Longnosed worm snake | *Leptotyphlops macrorhynchus* | Not evaluated |
| **49** | Brahminy blind snake | *Ramphotyphlops braminus* | Not evaluated |
| **50** | Slender worm snake | *Typhlops ductuliformes* | Not evaluated |
| **51** | Blind snake | *Typhlops madgemintonae* | Not evaluated |
| **52** | Sand boa | *Eryx johnii* | Not evaluated |
| **53** | Indian rock python | *Python molurus* | Not evaluated |
| **54** | Sikkim keelback | *Herpetoreas sieboldii* | Data Deficient |
| **55** | Buff striped keelback | *Amphiesma stolatum* | Not evaluated |
| **56** | Banded racer | *Argyrogena werner* | Not evaluated |
| **57** | Banded racer | *Argyogena fasciolta* | Not evaluated |
| **58** | Common cat snake | *Boiga trigonata* | Least Concern |
| **59** | Spotted desert racer | *Coluber karelini* | Not evaluated |
| **60** | Sind Awl headed snake | *Lytorynchus paradoxus* | Not evaluated |
| **61** | Kukri snake | *Oligodon arnensis arnensis* | Not evaluated |
| **62** | Kukri snake | *Oligodon taeniolatus taeniolatus* | Not evaluated |

| | | | |
|---|---|---|---|
| **63** | Glossy-bellied racer | *Platyceps ventromaculatus ventromaculatus* | Not evaluated |
| **64** | Glossy-bellied racer | *Platyceps ventromacculatus bengalensis* | Not evaluated |
| **65** | Condanarous sandsnake | *Psammophis condanarus condanarus* | Not evaluated |
| **66** | Pakistan sand racer | *Psammophis leithii leithii gunther* | Not evaluated |
| **67** | Sand snake | *Psammophis schokari schokari* | Not evaluated |
| **68** | Common rat snake | *Ptyas mucosus mucosus* | Not evaluated |
| **69** | Red spotted royal snake | *Spalerosophis arenarius* | Not evaluated |
| **70** | Royal snake | *Spalerosophis diasema diadema* | Not evaluated |
| **71** | Painted Keelback | *Xenochrophis cerasogaster cerasogaster* | Not evaluated |
| **72** | Checkered keelback | *Xenochrophis piscator piscator* | Not evaluated |
| **73** | St. John Keelback | *Xenochrophis sanctijohannis* | Not evaluated |
| **74** | Many banded krait | *Bungarus caeruleus caeruleus* | Not evaluated |
| **75** | Sind Krait | *Bungarus sindanus sindanus* | Not evaluated |
| **76** | Sind Krait | *Bungarus sindanus razai* | Not evaluated |
| **77** | Indian cobra | *Naja naja naja* | Not evaluated |
| **78** | Cental Asian cobra | *Naja oxiana* | Not evaluated |
| **79** | Russell's viper | *Daboia russelii russelii* | Not evaluated |
| **80** | Saw-scaled viper | *Echis carinatus* | Not evaluated |

# Annex - 6

# PAKISTAN

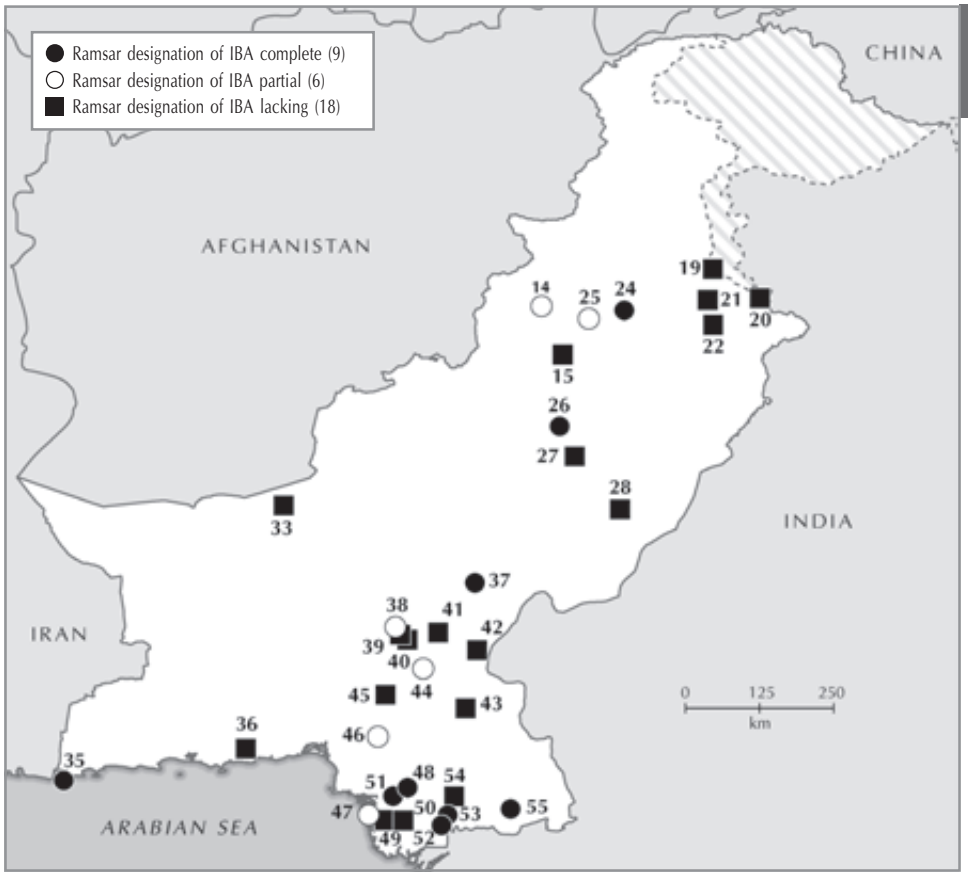
**RAMSAR CONVENTION CAME INTO FORCE** 1976
**NUMBER OF RAMSAR SITES DESIGNATED** (at 31 August 2005) 19
**AREA OF RAMSAR SITES DESIGNATED** (at 31 August 2005) 1,343,627 ha
**ADMINISTRATIVE AUTHORITY FOR RAMSAR CONVENTION**
National Council for Conservation of Wildlife, Ministry of Environment

**RAMSAR DESIGNATION IS:**
Complete in 9 IBAs
Partial in 6 IBAs
Lacking in 18 IBAs

Although predominantly arid and semi-arid, Pakistan possesses a great variety of wetlands, principally in the valleys of the Indus River and its tributaries and near the coast. These wetlands support large numbers of waterbirds, including the largest populations of the globally threatened White-headed Duck *Oxyura leucocephala* and Marbled Teal *Marmaronetta angustirostris* in the Asia region.

The total area of inland waters in Pakistan was estimated at over 7,800,000 ha in 1986, and the area of coastal mangrove swamp at more than 250,000 ha in 1987 (Scott 1989).

Nineteen Ramsar Sites have been designated in Pakistan, 15 of which overlap with IBAs. An additional 18 potential Ramsar Sites have been identified, mainly in the Indus valley.




**Location of Important Bird Areas in Pakistan that contain areas that qualify as Ramsar Sites.**

**Summary of Important Bird Areas that contain areas that qualify as Ramsar Sites in Pakistan.**

**Ramsar designation of IBA complete (9 IBAs)**

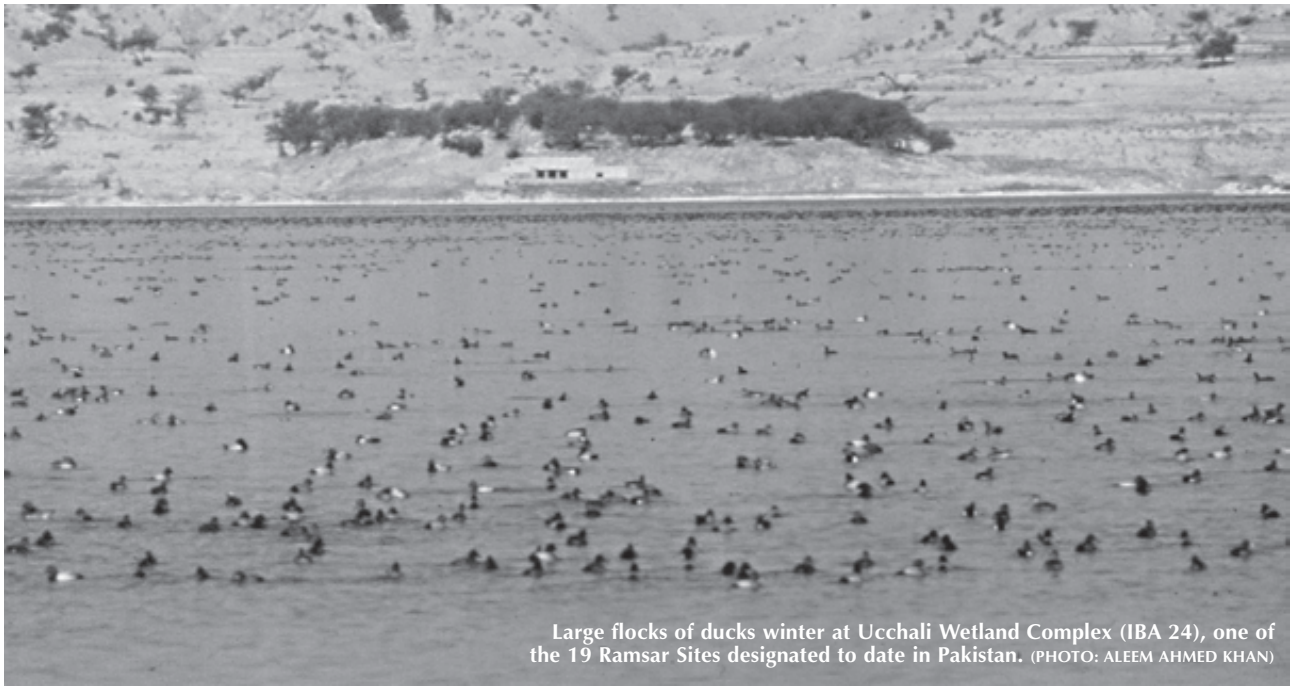
| IBA | IBA name | IBA area (ha) | Ramsar Site name | Ramsar Site area (ha) | Ramsar criteria 2 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| *PUNJAB* | | | | | | | | |
| 24 | Ucchali Wetland Complex | 1,243 | Uchhali Complex (including Khabbaki, Uchhali and Jahlar Lakes) | 1,243 | ✔ | ✔ | ✔ | ✔ |
| 26 | Taunsa Barrage Wildlife Sanctuary | 6,567 | Taunsa Barrage | 6,576 | ✔ | ✔ | ✔ | ✔ |
| *BALUCHISTAN* | | | | | | | | |
| 35 | Jiwani Beaches and Dasht Kaur | 4,600 | Jiwani Coastal Wetland | 4,600 | ✔ | ✔ | ✔ | ✔ |
| *SIND* | | | | | | | | |
| 37 | Indus Dolphin Reserve and Kandhkot wetlands | 125,000 | Indus Dolphin Reserve | 125,000 | ✔ | ✔ | ✔ | ✔ |
| 48 | Kinjhar (Kalri) Wildlife Sanctuary | 13,468 | Kinjhar (Kalri) Lake | 13,468 | ✔ | ✔ | ✔ | ✔ |
| 51 | Haleji Wildlife Sanctuary | 1,704 | Haleji Lake | 1,704 | ✔ | ✔ | ✔ | ✔ |
| 52 | Jubo Ramsar Site | 706 | Jubho Lagoon | 706 | ✔ | | ✔ | ✔ |
| 53 | Nar-ri Ramsar Site | 2,540 | Nurri Lagoon | 2,540 | ✔ | | ✔ | ✔ |
| 55 | Rann of Kutch Wildlife Sanctuary | 566,375 | Runn of Kutch | 566,375 | ✔ | ✔ | ✔ | ✔ |

**Ramsar designation of IBA partial (6 IBAs)**

| IBA | IBA name | IBA area (ha) | Ramsar Site name | Ramsar Site area (ha) | Ramsar criteria 2 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| *NORTH-WEST FRONTIER PROVINCE* | | | | | | | | |
| **14** | Kurram River system | 12,516 | Thanedar Wala | 4,047 | | ✔ | | ✔ |
| *PUNJAB* | | | | | | | | |
| **25** | Chashma Barrage Wildlife Sanctuary | 32,700 | Chashma Barrage | 34,099 | ✔ | ✔ | ✔ | ✔ |
| *SIND* | | | | | | | | |
| **38** | Drigh Wildlife Sanctuary | 182 | Drigh Lake | 164 | ✔ | ✔ | ✔ | ✔ |
| **44** | Deh Akro Wildlife Sanctuary | 20,243 | Deh Akro-II Desert Wetland Complex | 20,500 | ✔ | | ✔ | ✔ |
| **46** | Kirthar National Park (including Hub Dam) | 308,773 | Hub (Hab) Dam | 27,000 | ✔ | ✔ | ✔ | ✔ |
| **47** | Outer Indus delta | 300,000 | Indus Delta | 472,800 | ✔ | | ✔ | ✔ |

**Ramsar designation of IBA lacking (18 IBAs)**

| IBA | IBA name | IBA area (ha) | Ramsar criteria 2 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| *NORTH-WEST FRONTIER PROVINCE* | | | | | | |
| **15** | Indus Waterfowl Refuge | 3,774 | ✔ | | | |
| *KASHMIR ("AZAD KASHMIR")* | | | | | | |
| **19** | Mangla Lake | 26,500 | ✔ | ✔ | ✔ | ✔ |
| *PUNJAB* | | | | | | |
| **20** | Marala Game Reserve | 5,400 | | ✔ | ✔ | ✔ |
| **21** | Rasool Barrage Wildlife Sanctuary | 1,125 | | ✔ | ✔ | ✔ |
| **22** | Head Qadirabad Game Reserve | 2,816 | | ✔ | ✔ | ✔ |
| **27** | Rangla wetland complex | 24,140 | ✔ | | | |
| **28** | Lal Sohanra National Park | 51,588 | ✔ | ✔ | ✔ | ✔ |
| *BALUCHISTAN* | | | | | | |
| **33** | Zangi Nawar | 2,070 | ✔ | ✔ | ✔ | ✔ |
| **36** | Hingol National Park | 699,088 | ✔ | ✔ | | ✔ |
| *SIND* | | | | | | |
| **39** | Hammal Katchery Lake | 1,000 | ✔ | ✔ | ✔ | ✔ |
| **40** | Pugri Lake | 500 | ✔ | ✔ | ✔ | ✔ |
| **41** | Mehrano Reserve Lake and Rohri canal wetlands | 200 | ✔ | | | |
| **42** | Nara Desert Wildlife Sanctuary | 223,590 | ✔ | ✔ | | ✔ |
| **43** | Nara canal wetlands (including Soonhari, Sadhori and Sanghriaro lakes) | 109,966 | ✔ | ✔ | ✔ | ✔ |
| **45** | Manchar Lake | 6,000 | ✔ | ✔ | ✔ | ✔ |
| **49** | Keti Bundar North Wildlife Sanctuary | 8,948 | ✔ | | ✔ | ✔ |
| **50** | Mehboob Shah Lake | 100 | ✔ | ✔ | ✔ | ✔ |
| **54** | Phoosna Wetlands Complex | 800 | ✔ | ✔ | ✔ | ✔ |



**Large flocks of ducks winter at Ucchali Wetland Complex (IBA 24), one of the 19 Ramsar Sites designated to date in Pakistan.** (PHOTO: ALEEM AHMED KHAN)

**Summary of the occurrence of globally threatened wetland-dependent bird species within the selected IBAs in Pakistan.**

| IBA | **Dalmatian Pelican** *Pelecanus crispus* VU | **White-headed Duck** *Oxyura leucocephala* EN | **Marbled Teal** *Marmaronetta angustirostris* VU | **Pallas's Fish-eagle** *Haliaeetus leucoryphus* VU | **Greater Spotted Eagle** *Aquila clanga* VU | **Imperial Eagle** *Aquila heliaca* VU | **Sarus Crane** *Grus antigone* VU | **Sociable Lapwing** *Vanellus gregarius* CR | **Indian Skimmer** *Rynchops albicollis* VU | **Jerdon's Babbler** *Chrysomma altirostre* VU | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **15** | | | | ✔ | ✔ | ✔ | | | ✔ | ✔ | 5 |
| **19** | | | ✔ | | | | | | | | 1 |
| **24** | ✔ | ✔ | ✔ | ✔ | | ✔ | | | | | 5 |
| **25** | | | | | ✔ | | | | ✔ | ✔ | 3 |
| **26** | | | ✔ | ✔ | | | | | | ✔ | 3 |
| **27** | | | ✔ | ✔ | | | | | | | 2 |
| **28** | | | | ✔ | ✔ | ✔ | | | | | 3 |
| **33** | | | ✔ | | | | | | | | 1 |
| **35** | ✔ | | | | | | | | | | 1 |
| **36** | ✔ | | | | | | | | | | 1 |
| **37** | ✔ | | ✔ | ✔ | ✔ | ✔ | | | ✔ | | 6 |
| **38** | | | ✔ | ✔ | ✔ | ✔ | | | | | 4 |
| **39** | | | ✔ | | | | | | | | 1 |
| **40** | | | ✔ | ✔ | ✔ | ✔ | | | | | 4 |
| **41** | | | ✔ | | | | | | | ✔ | 2 |
| **42** | | | ✔ | | | ✔ | | | | | 2 |
| **43** | | | | ✔ | | ✔ | | | | | 2 |
| **44** | | | ✔ | | | | | | | | 1 |
| **45** | ✔ | | ✔ | ✔ | ✔ | ✔ | | | ✔ | | 6 |
| **46** | ✔ | | | ✔ | | ✔ | | ✔ | ✔ | | 5 |
| **47** | ✔ | | | | | | | | | | 1 |
| **48** | ✔ | | | ✔ | ✔ | ✔ | | | | | 4 |
| **49** | ✔ | | ✔ | | ✔ | ✔ | | | ✔ | | 5 |
| **50** | | | ✔ | ✔ | ✔ | | | | | | 3 |
| **51** | ✔ | | | ✔ | ✔ | ✔ | | | ✔ | | 5 |
| **52** | | | ✔ | ✔ | ✔ | ✔ | | | | | 4 |
| **53** | | | ✔ | | | | | | | | 1 |
| **54** | ✔ | | | ✔ | ✔ | | | | | | 3 |
| **55** | | | | | | | ✔ | | | | 1 |
| **Total** | 11 | 1 | 17 | 16 | 13 | 14 | 1 | 1 | 7 | 4 | |

# Annex - 7

# List of Birds of Punjab Province, Pakistan

**Source: The Birds of Pakistan (Vol. 1 & 2) by Dr. T.J. Roberts**

| No. | Order | Family | Status | Scientific Name | Common Name |
|---|---|---|---|---|---|
| 1 | PODICIPEDIFORMES | PODICIPEDIDAE | | *Tachybaptus ruficollis* | Grebe, Little |
| 2 | PODICIPEDIFORMES | PODICIPEDIDAE | | *Podiceps cristatus* | Grebe, Great Crested |
| 3 | PODICIPEDIFORMES | PODICIPEDIDAE | | *Podiceps nigricollis* | Grebe, Black-necked or Eared |
| 4 | PELECANIFORMES | PHALACROCORACIDAE | Least Concern | *Phalacrocorax carbo* | Cormorant, Great |
| 5 | PELECANIFORMES | PHALACROCORACIDAE | Least Concern | *Phalacrocorax fuscicollis* | Cormorant, Indian (Shag) |
| 6 | PELECANIFORMES | PHALACROCORACIDAE | Least Concern | *Phalacrocorax niger* | Cormorant, Little or Javanese |
| 7 | PELECANIFORMES | ANHINGIDAE | Least Concern | *Anhinga melanogaster* | Darter or Snakebird |
| 8 | PELECANIFORMES | PELECANIDAE | Least Concern | *Pelecanus onocrotalus* | Pelican, Great White or Rosy |
| 9 | PELECANIFORMES | PELECANIDAE | Near Threatened | *Pelecanus crispus* | Pelican, Dalmatian or Grey |
| 10 | CICONIIFORMES | ARDEIDAE | Least Concern | *Botaurus stellaris* | Bittern, Great or Eurasian |
| 11 | CICONIIFORMES | ARDEIDAE | Least Concern | *Ixobrychus minutus* | Bittern, Little |
| 12 | CICONIIFORMES | ARDEIDAE | Least Concern | *Ixobrychus sinensis* | Bittern, Yellow or Chinese Little |
| 13 | CICONIIFORMES | ARDEIDAE | Least Concern | *Ixobrychus cinnamomeus* | Bittern, Cinnamon or Chestnut |
| 14 | CICONIIFORMES | ARDEIDAE | Least Concern | *Ixobrychus flavicollis* | Bittern, Black |
| 15 | CICONIIFORMES | ARDEIDAE | Least Concern | *Nycticorax nycticorax* | Heron, Black-crowned Night or Night - |
| 16 | CICONIIFORMES | ARDEIDAE | Least Concern | *Butorides striatus* | Heron, Little or Striated or Green or Green-backed |
| 17 | CICONIIFORMES | ARDEIDAE | Least Concern | *Ardeola grayii* | Heron, Indian Pond |
| 18 | CICONIIFORMES | ARDEIDAE | Least Concern | *Bubulcus ibis* | Egret, Cattle or Buff-backed Heron |
| 19 | CICONIIFORMES | ARDEIDAE | Least Concern | *Egretta garzetta* | Egret, Little |
| 20 | CICONIIFORMES | ARDEIDAE | Least Concern | *Egretta intermedia* | Egret, Intermediate |
| 21 | CICONIIFORMES | ARDEIDAE | Least Concern | *Egretta alba* | Egret, Great or Large - |
| 22 | CICONIIFORMES | ARDEIDAE | Least Concern | *Ardea cinerea* | Heron, Grey |
| 23 | CICONIIFORMES | ARDEIDAE | Least Concern | *Ardea purpurea* | Heron, Purple |
| 24 | CICONIIFORMES | CICONIIDAE | Near Threatened | *Mycteria leucocephala* | Stork, Painted |
| 25 | CICONIIFORMES | CICONIIDAE | Least Concern | *Anastomus oscitans* | Stork, Asian Openbill |
| 26 | CICONIIFORMES | CICONIIDAE | Least Concern | *Ciconia nigra* | Stork, Black |
| 27 | CICONIIFORMES | CICONIIDAE | Vulnerable | *Ciconia episcopus* | Stork, Woolly-necked or White-necked |
| 28 | CICONIIFORMES | CICONIIDAE | Least Concern | *Ciconia ciconia* | Stork, White |
| 29 | CICONIIFORMES | THRESKIORNITHIDAE | Least Concern | *Plegadis falcinellus* | Ibis, Glossy |
| 30 | CICONIIFORMES | THRESKIORNITHIDAE | Least Concern | *Platalea leucorodia* | Spoonbill, White |
| 31 | PHOENICOPTERIFORMES | PHOENICOPTERIDAE | Least Concern | *Phoenicopterus ruber* | Flamingo, Greater |
| 32 | ANSERIFORMES | ANATIDAE | Least Concern | *Dendrocygna javanica* | Duck, Lesser Whistling (Teal) or Tree - |
| 33 | ANSERIFORMES | ANATIDAE | Least Concern | *Anser anser* | Goose, Greylag |
| 34 | ANSERIFORMES | ANATIDAE | Least Concern | *Anser indicus* | Goose, Bar-headed |
| 35 | ANSERIFORMES | ANATIDAE | Least Concern | *Tadorna ferruginea* | Shelduck, Ruddy or Brahminy Duck |
| 36 | ANSERIFORMES | ANATIDAE | Least Concern | *Tadorna tadorna* | Shelduck, Common |
| 37 | ANSERIFORMES | ANATIDAE | Least Concern | *Nettapus coromandelianus* | Goose, Cotton Pygmy or Cotton Teal |
| 38 | ANSERIFORMES | ANATIDAE | Least Concern | *Anas penelope* | Wigeon, Eurasian |
| 39 | ANSERIFORMES | ANATIDAE | Least Concern | *Anas strepera* | Gadwall |
| 40 | ANSERIFORMES | ANATIDAE | Least Concern | *Anas crecca* | Teal, Common |
| 41 | ANSERIFORMES | ANATIDAE | Least Concern | *Anas platyrhynchos* | Mallard |
| 42 | ANSERIFORMES | ANATIDAE | Least Concern | *Anas poecilorhyncha* | Duck, Spot-billed |
| 43 | ANSERIFORMES | ANATIDAE | Least Concern | *Anas acuta* | Pintail, Northern |
| 44 | ANSERIFORMES | ANATIDAE | Least Concern | *Anas querquedula* | Garganey |
| 45 | ANSERIFORMES | ANATIDAE | Least Concern | *Anas clypeata* | Shoveler, Northern or - |

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 48 | 46 | ANSERIFORMES | ANATIDAE | Vulnerable | *Marmaronetta angustirostris* | Teal, Marbled |
| 49 | 47 | ANSERIFORMES | ANATIDAE | Least Concern | *Netta rufina* | Pochard, Red-crested |
| 50 | 48 | ANSERIFORMES | ANATIDAE | Least Concern | *Aythya ferina* | Pochard, Common or - |
| 51 | 49 | ANSERIFORMES | ANATIDAE | Vulnerable | *Aythya nyroca* | Duck, Ferruginous or White-eyed Pochard |
| 52 | 50 | ANSERIFORMES | ANATIDAE | Least Concern | *Aythya fuligula* | Duck, Tufted or Tufted Pochard |
| 53 | 51 | ANSERIFORMES | ANATIDAE | Least Concern | *Bucephala clangula* | Goldeneye, Common |
| 54 | 52 | ANSERIFORMES | ANATIDAE | Least Concern | *Mergus albellus* | Smew |
| 55 | 53 | ANSERIFORMES | ANATIDAE | Least Concern | *Mergus merganser* | Merganser, Goosander or Common |
| 56 | 54 | ANSERIFORMES | ANATIDAE | Endangered | *Oxyura leucocephala* | Duck, White-headed |
| 57 | 55 | ACCIPITRIFORMES | ACCIPITRIDAE | Least Concern | *Pernis ptilorhyncus* | Buzzard, Crested Honey |
| 58 | 56 | ACCIPITRIFORMES | ACCIPITRIDAE | Least Concern | *Elanus caeruleus* | Kite, Black-shouldered or Black-winged - |
| 59 | 57 | ACCIPITRIFORMES | ACCIPITRIDAE | Least Concern | *Milvus migrans* | Kite, Black |
| 60 | 58 | ACCIPITRIFORMES | ACCIPITRIDAE | Least Concern | *Haliastur indus* | Kite, Brahminy |
| 61 | 59 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Haliaeetus leucoryphus* | Eagle, Pallas's or Ring-tailed Fish |
| 62 | 60 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Gypaetus barbatus* | Vulture, Lammergeier or Bearded |
| 63 | 61 | ACCIPITRIFORMES | ACCIPITRIDAE | Endangered | *Neophron percnopterus* | Vulture, Egyptian or Scavenger - |
| 64 | 62 | ACCIPITRIFORMES | ACCIPITRIDAE | Critically Endangered | *Gyps bengalensis* | Vulture, Oriental White-backed |
| 65 | 63 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Gyps fulvus* | Vulture, Eurasian Griffon |
| 66 | 65 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Aegypius monachus* | Vulture, Cinereous or Eurasian Black |
| 67 | 66 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Circaetus gallicus* | Eagle, Short-toed or Snake |
| 68 | 67 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Circus aeruginosus* | Harrier, Marsh |
| 69 | 68 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Circus cyaneus* | Harrier, Hen |
| 70 | 69 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Circus macrourus* | Harrier, Pallid |
| 71 | 70 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Circus pygargus* | Harrier, Montagu's |
| 72 | 71 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Accipiter gentilis* | Goshawk, Northern or - |
| 73 | 72 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Accipiter nisus* | Hawk, Eurasian Sparrow |
| 74 | 73 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Accipiter badius* | Hawk, Shikra or Indian Sparrow |
| 75 | 74 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Butastur teesa* | Eagle, White-eyed Buzzard or Buzzard |
| 76 | 75 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Buteo rufinus* | Buzzard, Long-legged |
| 77 | 76 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Aquila clanga* | Eagle, Greater Spotted Eagle or Spotted |
| 78 | 77 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Aquila rapax* | Eagle, Tawny |
| 79 | 78 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Aquila heliaca* | Eagle, Imperial |
| 80 | 79 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Hieraaetus pennatus* | Eagle, Booted. |
| 81 | 80 | ACCIPITRIFORMES | ACCIPITRIDAE | | *Spizaetus nipalensis* | Eagle, Mountain Hawk-Eagle or Hodgson's Hawk- |
| 82 | 81 | FALCONIFORMES | FALCONIDAE | | *Falco tinnunculus* | Kestrel, Common or Eurasian |
| 83 | 82 | FALCONIFORMES | FALCONIDAE | | *Falco chicquera* | Falcon, Red-necked or Red-headed Merlin or Turumtee |
| 84 | 83 | FALCONIFORMES | FALCONIDAE | | *Falco columbarius* | Merlin |
| 85 | 84 | FALCONIFORMES | FALCONIDAE | | *Falco subbuteo* | Hobby, Northern |
| 86 | 85 | FALCONIFORMES | FALCONIDAE | | *Falco jugger* | Falcon, Laggar |
| 87 | 86 | FALCONIFORMES | FALCONIDAE | | *Falco cherrug* | Falcon, Saker |
| 88 | 87 | FALCONIFORMES | FALCONIDAE | | *Falco cherrug milvipes* | Falcon, Shanghar |
| 89 | 88 | FALCONIFORMES | FALCONIDAE | | *Falco peregrinus* | Falcon, Peregrine |
| 90 | 89 | FALCONIFORMES | FALCONIDAE | | *Falco pelegrinoides* | Falcon, Red-capped |
| 91 | 90 | GALLIFORMES | PHASIANIDAE | | *Alectoris chukar* | Chukar |
| 92 | 91 | GALLIFORMES | PHASIANIDAE | | *Ammoperdix griseogularis* | Partridge, See-See |
| 93 | 92 | GALLIFORMES | PHASIANIDAE | | *Francolinus francolinus* | Francolin, Balck or Partridge |
| 94 | 93 | GALLIFORMES | PHASIANIDAE | | *Francolinus pondicerianus* | Francolin, Grey or Indian Grey Partridge |
| 95 | 94 | GALLIFORMES | PHASIANIDAE | | *Coturnix coturnix* | Quail, Common |
| 96 | 95 | GALLIFORMES | PHASIANIDAE | | *Coturnix coromandelica* | Quail, Rain or Black-breasted - |

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| 97 | 96 | GALLIFORMES | PHASIANIDAE | | *Pucrasia macrolopha* | Pheasant, Koklass |
| 98 | 97 | GALLIFORMES | PHASIANIDAE | | *Lophura leucomelana* | Pheasant, Kalij |
| 99 | 98 | GALLIFORMES | PHASIANIDAE | | *Pavo cristatus* | Peafowl, Indian |
| 100 | 99 | GRUIFORMES | TURNICIDAE | | *Turnix sylvatica* | Buttonquail, Striped, Little Button or Bustard Quail and Hemipode, Andalus |
| 101 | 100 | GRUIFORMES | TURNICIDAE | | *Turnix tanki* | Buttonquail, Yellow-legged |
| 102 | 101 | GRUIFORMES | RALLIDAE | | *Rallus aquaticus* | Rail, Water |
| 103 | 102 | GRUIFORMES | RALLIDAE | | *Porzana porzana* | Crake, Spotted |
| 104 | 103 | GRUIFORMES | RALLIDAE | | *Porzana parva* | Crake, Little |
| 105 | 104 | GRUIFORMES | RALLIDAE | | *Porzana pusilla* | Crake, Baillon's |
| 106 | 105 | GRUIFORMES | RALLIDAE | | *Porzana fusca* | Crake, Ruddy-breasted or Ruddy - |
| 107 | 106 | GRUIFORMES | RALLIDAE | | *Amauromis phoenicurus* | Waterhen, White-breasted |
| 108 | 107 | GRUIFORMES | RALLIDAE | | *Gallinula chloropus* | Moorhen, Common or Common Waterhen |
| 109 | 108 | GRUIFORMES | RALLIDAE | | *Porphyrio prophyrio* | Swamphen, Purple, Purple Gallinule or Purple Coot |
| 110 | 109 | GRUIFORMES | RALLIDAE | | *Gallicrex cinerea* | Watercock or Kora |
| 111 | 110 | GRUIFORMES | RALLIDAE | | *Fulica atra* | Coot, Black or Eurasian |
| 112 | 111 | GRUIFORMES | GRUIDAE | | *Grus grus* | Crane, Common |
| 113 | 112 | GRUIFORMES | GRUIDAE | | *Grus leucogeranus* | Crane, Siberian or Great White - |
| 114 | 113 | GRUIFORMES | GRUIDAE | | *Anthropoides virgo* | Crane, Demoiselle |
| 115 | 114 | GRUIFORMES | OTIDIDAE | | *Tetrax tetrax* | Bustard, Little |
| 116 | 115 | GRUIFORMES | OTIDIDAE | | *Chlamydotis undulata* | Bustard, Houbara |
| 117 | 116 | GRUIFORMES | OTIDIDAE | | *Ardeotis nigriceps* | Bustard, Great Indian |
| 118 | 117 | GRUIFORMES | OTIDIDAE | | *Sypheotides indica* | Florican, Lesser or Likh |
| 119 | 118 | CHARADRIIFORMES | JACANIDAE | | *Hydrophasianus chirurgus* | Jacana, Pheasant-tailed |
| 120 | 119 | CHARADRIIFORMES | ROSTRATULIDAE | | *Rostratula benghalensis* | Snipe, Greater Painted- |
| 121 | 120 | CHARADRIIFORMES | RECURVIROSTRIDAE | | *Himantopus himantopus* | Stilt, Black-winged |
| 122 | 121 | CHARADRIIFORMES | RECURVIROSTRIDAE | | *Recurvirostra avosetta* | Pied Avocet |
| 123 | 122 | CHARADRIIFORMES | BURHINIDAE | | *Burhinus oedicnemus* | Curlew, Stone |
| 124 | 123 | CHARADRIIFORMES | BURHINIDAE | | *Esacus recurvirostris* | Thick-knee, Great or Stone Plover |
| 125 | 124 | CHARADRIIFORMES | GLAREOLIDAE | | *Cursorius cursor* | Courser, Cream-coloured |
| 126 | 125 | CHARADRIIFORMES | GLAREOLIDAE | | *Cursorius coromandelicus* | Courser, Indian |
| 127 | 126 | CHARADRIIFORMES | GLAREOLIDAE | | *Glareola pratincola* | Pratincole, Collared |
| 128 | 127 | CHARADRIIFORMES | GLAREOLIDAE | | *Glareola lactea* | Pratincole, Small or Little |
| 129 | 128 | CHARADRIIFORMES | CHARADRIIDAE | | *Charadrius dubius* | Plover, Little Ringed |
| 130 | 129 | CHARADRIIFORMES | CHARADRIIDAE | | *Charadrius alexandrinus* | Plover, Kentish or Snowy |
| 131 | 130 | CHARADRIIFORMES | CHARADRIIDAE | | *Pluvialis dominica* | Plover, Lesser or American Golden - |
| 132 | 131 | CHARADRIIFORMES | CHARADRIIDAE | | *Pluvialis squatarola* | Plover, Grey or Black-bellied |
| 133 | 132 | CHARADRIIFORMES | CHARADRIIDAE | | *Hoplopterus indicus* | Lapwing, Red-wattled |
| 134 | 133 | CHARADRIIFORMES | CHARADRIIDAE | | *Chettusia gregaria* | Lapwing, Sociable or Sociable Plover |
| 135 | 134 | CHARADRIIFORMES | CHARADRIIDAE | | *Chettusia leucura* | Lapwing, White-tailed |
| 136 | 135 | CHARADRIIFORMES | CHARADRIIDAE | | *Vanellus vanellus* | Lapwing, Northern or Green Plover |
| 137 | 136 | SCOLOPACIDAE | | | *Calidris minuta* | Stint, Little |
| 138 | 137 | SCOLOPACIDAE | | | *Calidris temminckii* | Stint, Temminck's |
| 139 | 138 | SCOLOPACIDAE | | | *Calidris ferruginea* | Sandpiper, Curlew |
| 140 | 139 | SCOLOPACIDAE | | Least Concern | *Calidris alpina* | Dunlin |
| 141 | 140 | SCOLOPACIDAE | | Least Concern | *Philomachus pugnax* | Ruff (and Reeve) |
| 142 | 141 | SCOLOPACIDAE | | Least Concern | *Lymnocryptes minimus* | Snipe, Jack |
| 143 | 142 | SCOLOPACIDAE | | Least Concern | *Gallinago gallinago* | Snipe, Common or Fantail - |
| 144 | 143 | SCOLOPACIDAE | | | *Scolopax rusticola* | Woodcock, Eurasian |
| 145 | 144 | SCOLOPACIDAE | | | *Limosa limosa* | Godwit, Black-tailed |

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| 146 | 145 | SCOLOPACIDAE | | Least Concern | *Numenius arquata* | Curlew, Eurasian |
| 147 | 146 | SCOLOPACIDAE | | | *Tringa erythropus* | Redshank, Spotted or Dusky |
| 148 | 147 | SCOLOPACIDAE | | | *Tringa totanus* | Redshank, Common |
| 149 | 148 | SCOLOPACIDAE | | | *Tringa stagnatilis* | Sandpiper, Marsh |
| 150 | 149 | SCOLOPACIDAE | | | *Tringa nebularia* | Greenshank, Common |
| 151 | 150 | SCOLOPACIDAE | | | *Tringd ochropus* | Sandpiper, Green |
| 152 | 151 | SCOLOPACIDAE | | | *Tringa glareola* | Sandpiper, Wood |
| 153 | 152 | SCOLOPACIDAE | | | *Actitis hypoleucos* | Sandpiper, Common |
| 154 | 153 | SCOLOPACIDAE | | | *Phalaropus lobatus* | Phalarope, Red-necked or Northern |
| 155 | 154 | SCOLOPACIDAE | LARIDAE | | *Larus ichthyaetus* | Gull, Great Black-headed |
| 156 | 155 | SCOLOPACIDAE | LARIDAE | | *Larus ridibundus* | Gull, Common Black-headed |
| 157 | 156 | SCOLOPACIDAE | LARIDAE | | *Larus brunnicephalus* | Gull, Brown-headed or Tibetan |
| 158 | 157 | SCOLOPACIDAE | LARIDAE | | *Larus canus* | Gull, Mew or Common |
| 159 | 158 | SCOLOPACIDAE | LARIDAE | | *Larus argentatus* | Gull, Herring |
| 160 | 159 | SCOLOPACIDAE | STERNIDAE | | *Gelochelidon nilotica* | Tern, Gull-billed |
| 161 | 160 | SCOLOPACIDAE | STERNIDAE | | *Sterna caspia* | Tern, Caspian |
| 162 | 161 | SCOLOPACIDAE | STERNIDAE | | *Sterna bergii* | Tern, Swift or Great Crested |
| 163 | 162 | SCOLOPACIDAE | STERNIDAE | | *Sterna aurantia* | Tern, River |
| 164 | 163 | SCOLOPACIDAE | STERNIDAE | | *Sterna acuticauda* | Tern, Black-bellied |
| 165 | 164 | SCOLOPACIDAE | STERNIDAE | | *Sterna albifrons* | Tern, Little |
| 166 | 165 | SCOLOPACIDAE | STERNIDAE | | *Chlidonias hybridus* | Tern, Whiskered |
| 167 | 166 | SCOLOPACIDAE | RYNCHOPIDAE | | *Rynchops albicollis* | Skimmer, Indian or Scissorbill |
| 168 | 167 | PTEROCLIDIFORMES | PTEROCLIDIDAE | | *Pterocles indicus* | Sandgrouse, Painted |
| 169 | 168 | PTEROCLIDIFORMES | PTEROCLIDIDAE | | *Pterocles coronatus* | Sandgrouse, Crowned or Coronetted |
| 170 | 169 | PTEROCLIDIFORMES | PTEROCLIDIDAE | | *Pterocles senegallus* | Sandgrouse, Spotted |
| 171 | 170 | PTEROCLIDIFORMES | PTEROCLIDIDAE | | *Pterocles exustus* | Sandgrouse, Chestnut-bellied or Indian |
| 172 | 171 | PTEROCLIDIFORMES | PTEROCLIDIDAE | | *Pterocles orientalis* | Sandgrouse, Black-bellied or Imperial |
| 173 | 172 | PTEROCLIDIFORMES | PTEROCLIDIDAE | | *Pterocles alchata* | Sandgrouse, Pin-tailed |
| 174 | 173 | COLUMBIFORMES | COLUMBIDAE | | *Columba livia* | Dove or Rock Pigeon |
| 175 | 174 | COLUMBIFORMES | COLUMBIDAE | | *Columba eversmanni* | Dove, Pale-backed Eastern or Yellow-eyed Stock |
| 176 | 175 | COLUMBIFORMES | COLUMBIDAE | | *Columba palumbus* | Wood-pigeon, Common |
| 177 | 176 | COLUMBIFORMES | COLUMBIDAE | | *Streptopelia decaocto* | Dove, Eurasian Collared or Indian Ring |
| 178 | 177 | COLUMBIFORMES | COLUMBIDAE | | *Streptopelia tranquebarica* | Dove, Red Collared or Turtle |
| 179 | 178 | COLUMBIFORMES | COLUMBIDAE | | *Streptopelia orientalis* | Dove, Oriental Turtle or Eastern Rufous |
| 180 | 179 | COLUMBIFORMES | COLUMBIDAE | | *Streptopelia senegalensis* | Dove, Laughing, Little Brown or Senegal |
| 181 | 180 | COLUMBIFORMES | COLUMBIDAE | | *Streptopelia chinensis* | Dove, Spotted or Chinese |
| 182 | 181 | COLUMBIFORMES | COLUMBIDAE | | *Treron phoenicoptera* | Pigeon, Yellow-footed Green |
| 183 | 182 | COLUMBIFORMES | COLUMBIDAE | | *Treron sphenura* | Pigeon, Wedge-tailed Green |
| 184 | 183 | PSITTACIFORMES | PSITTACIDAE | | *Psittacula eupatria* | Parakeet, Alexandrine or Large Indian |
| 185 | 184 | PSITTACIFORMES | PSITTACIDAE | | *Psittacula krameri* | Parakeet, Rose-ringed |
| 186 | 185 | PSITTACIFORMES | PSITTACIDAE | | *Psittacula cyanocephala* | Parakeet, Plum-headed |
| 187 | 186 | PSITTACIFORMES | PSITTACIDAE | | *Psittacula himalayana* | Parakeet, Slaty-headed |
| 188 | 187 | CUCULIFORMES | CUCULIDAE | | *Clamator jacobinus* | Cuckoo, Pied or Jacobin |
| 189 | 188 | CUCULIFORMES | CUCULIDAE | | *Hierococcyx varius* | Cuckoo, Common Hawk or Brainfever Bird |
| 190 | 189 | CUCULIFORMES | CUCULIDAE | | *Cacomantis passerinus* | Cuckoo, Grey-bellied Plaintive |
| 191 | 190 | CUCULIFORMES | CUCULIDAE | | *Cuculus micropterus* | Cuckoo, Indian or Short-winged |
| 192 | 191 | CUCULIFORMES | CUCULIDAE | | *Cuculus canorus* | Cuckoo, Common |
| 193 | 192 | CUCULIFORMES | CUCULIDAE | | *Cuculus saturatus* | Cuckoo, Oriental or Himalayan |
| 194 | 193 | CUCULIFORMES | CUCULIDAE | | *Cuculus poliocephalus* | Cuckoo, Lesser, Little or Small |

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| 195 | 194 | CUCULIFORMES | CUCULIDAE | | *Eudynamys scolopacea* | Koel, Common |
| 196 | 195 | CUCULIFORMES | CUCULIDAE | | *Taccocua leschenaultii* | Malkoha, Sirkeer or Cuckoo |
| 197 | 196 | CUCULIFORMES | CUCULIDAE | | *Centropus sinensis* | Pheasant, Greater Coucal or Common Crow |
| 198 | 197 | STRIGIFORMES | TYTONIDAE | | *Tyto alba* | Owl, Barn |
| 199 | 198 | STRIGIFORMES | STRIGIDAE | | *Otus bakkamoena* | Owl, Indian or Collared Scops |
| 200 | 199 | STRIGIFORMES | STRIGIDAE | | *Otus sunia* | Owl, Oriental or Indian Scops |
| 201 | 200 | STRIGIFORMES | STRIGIDAE | | *Otus brucei* | Owl, Striated or Pallid Scops |
| 202 | 201 | STRIGIFORMES | STRIGIDAE | | *Otus scops* | Owl, European Scops |
| 203 | 202 | STRIGIFORMES | STRIGIDAE | | *Otus spilocephalus* | Owl, Spotted or Mountain Scops |
| 204 | 203 | STRIGIFORMES | STRIGIDAE | | *Bubo bubo* | Owl, Northern Eagle |
| 205 | 204 | STRIGIFORMES | STRIGIDAE | | *Bubo coromandus* | Owl, Dusky Eagle Owl or Dusky Horned |
| 206 | 205 | STRIGIFORMES | STRIGIDAE | | *Ketupa zeylonensis* | Owl, Brown Fish |
| 207 | 206 | STRIGIFORMES | STRIGIDAE | | *Glaucidium brodiei* | Owl, Collared Pygmy or Collared Owlet |
| 208 | 207 | STRIGIFORMES | STRIGIDAE | | *Glaucidium cuculoides* | Owlet, Asian Barred |
| 209 | 208 | STRIGIFORMES | STRIGIDAE | | *Athene brama* | Owl, Spotted Little or Spotted Owlet |
| 210 | 209 | STRIGIFORMES | STRIGIDAE | | *Strix aluco* | Owl, Tawny, Himalayan and Scully's Wood |
| 211 | 210 | STRIGIFORMES | STRIGIDAE | | *Asio otus* | Owl, Long-eared |
| 212 | 211 | STRIGIFORMES | STRIGIDAE | | *Asio flammeus* | Owl, Short-eared |
| 213 | 212 | CAPRIMULGIFORMES | CAPRIMULGIDAE | | *Caprimulgus affinis* | Nightjar, Savanna, Allied or Franklin's |
| 214 | 213 | CAPRIMULGIFORMES | CAPRIMULGIDAE | | *Caprimulgus mahrattensis* | Nightjar, Sykes's or Sind |
| 215 | 214 | CAPRIMULGIFORMES | CAPRIMULGIDAE | | *Caprimulgus indicus* | Nightjar, Jungle or Grey |
| 216 | 215 | CAPRIMULGIFORMES | CAPRIMULGIDAE | | *Caprimulgus europaeus* | Nightjar, European or Unwin's |
| 217 | 216 | APODIFORMES | APODIDAE | | *Hirundapus caudacutus* | Swift, White-throated Needletail, or White-throated Spinetail |
| 218 | 217 | APODIFORMES | APODIDAE | | *Apus pacificus* | Swift, Pacific, Asian White-rumped or Fork-tailed |
| 219 | 218 | APODIFORMES | APODIDAE | | *Apus melba* | Swift, Alpine |
| 220 | 219 | APODIFORMES | APODIDAE | | *Apus affinis* | Swift, Little, House or Indian House |
| 221 | 220 | CORACIIFORMES | ALCEDINIDAE | | *Halcyon smyrnensis* | Kingfisher, White-throated or Smyrna |
| 222 | 221 | CORACIIFORMES | ALCEDINIDAE | | *Alcedo atthis* | Kingfisher, Common, Eurasian or Small Blue |
| 223 | 222 | CORACIIFORMES | ALCEDINIDAE | | *Ceryle rudis* | Kingfisher, Pied, or Small Pied |
| 224 | 223 | CORACIIFORMES | ALCEDINIDAE | | *Ceryle lugubris* | Kingfisher, Crested, Large Pied, or Himalayan Pied |
| 225 | 224 | CORACIIFORMES | MEROPIDAE | | *Merops orientalis* | Bee-eater, Green, Little Green or Small Green |
| 226 | 225 | CORACIIFORMES | MEROPIDAE | | *Merops superciliosus* | Bee-eater, Blue-cheeked |
| 227 | 226 | CORACIIFORMES | MEROPIDAE | | *Merops philippinus* | Bee-eater, Blue-tailed |
| 228 | 227 | CORACIIFORMES | CORACIIDAE | | *Coracias garrulus* | Roller, European or Kashmir |
| 229 | 228 | CORACIIFORMES | CORACIIDAE | | *Coracias benghalensis* | Roller, Indian or Blue-jay |
| 230 | 229 | CORACIIFORMES | UPUPIDAE | | *Upupa epops* | Hoopoe |
| 231 | 230 | CORACIIFORMES | BUCEROTIDAE | | *Tockus birostris* | Hornbill, Indian Grey |
| 232 | 231 | PICIFORMES | | CAPITONIDAE | *Megalaima virens* | Barbet, Great or Great Himalayan |
| 233 | 232 | PICIFORMES | | CAPITONIDAE | *Megalaima asiatica* | Barbet, Blue-throated |
| 234 | 233 | PICIFORMES | | CAPITONIDAE | *Megalaima haemacephala* | Barbet, Coppersmith or Crimson Breasted |
| 235 | 234 | PICIFORMES | PICIDAE | | *Jynx torquilla* | Wryneck, Eurasian |
| 236 | 235 | PICIFORMES | PICIDAE | | *Picumnus innominatus* | Piculet, Speckled |
| 237 | 236 | PICIFORMES | PICIDAE | | *Picus canus* | Woodpecker, Grey-headed or Black-naped Green |
| 238 | 237 | PICIFORMES | PICIDAE | | *Picus squamatus* | Woodpecker, Scaly-bellied |
| 239 | 238 | PICIFORMES | PICIDAE | | *Dendrocopos assimilis* | Woodpecker, Sind |
| 240 | 239 | PICIFORMES | PICIDAE | | *Dendrocopos himalayensis* | Woodpecker, Himalayan |
| 241 | 240 | PICIFORMES | PICIDAE | | *Dendrocopos hyperythrus* | Woodpecker, Rufous-bellied or Rufous-bellied Sapsucker |
| 242 | 241 | PICIFORMES | PICIDAE | | *Dendrocopos mahrattensis* | Woodpecker, Yellow-fronted, Mahratta Pied or Yellow-crowned Pied |
| 243 | 242 | PICIFORMES | PICIDAE | | *Dendrocopos auriceps* | Woodpecker, Brown-fronted |

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| 244 | 243 | PICIFORMES | PICIDAE | | *Dendrocopos macei* | Woodpecker, Fulvous-breasted |
| 245 | 244 | PICIFORMES | PICIDAE | | *Dendrocopos canicapillus* | Woodpecker, Grey-capped Pygmy or Grey-headed Pied |
| 246 | 245 | PASSERIFORMES | PITTIDAE | | *Pitta brachyura* | Pitta, Indian |
| 247 | 246 | PASSERIFORMES | ALAUDIDAE | | *Mirafra cantillans* | Bushlark, Singing |
| 248 | 247 | PASSERIFORMES | ALAUDIDAE | | *Mirafra erythroptera* | Bushlark, Indian or Red-winged |
| 249 | 248 | PASSERIFORMES | ALAUDIDAE | | *Eremopterix nigriceps* | Finch-Lark, Black-crowned |
| 250 | 249 | PASSERIFORMES | ALAUDIDAE | | *Eremopterix grisea* | Finch-Lark, Ashy-crowned |
| 251 | 250 | PASSERIFORMES | ALAUDIDAE | | *Ammomanes phoenicurus* | Finch, Lark, Rufous-tailed Lark |
| 252 | 251 | PASSERIFORMES | ALAUDIDAE | | *Ammomanes deserti* | Lark, Desert or Finch |
| 253 | 252 | PASSERIFORMES | ALAUDIDAE | | *Alaemon alaudipes* | Lark, Hoopoe or Bifasciated |
| 254 | 253 | PASSERIFORMES | ALAUDIDAE | | *Melanocorypha bimaculata* | Lark, Bimaculated or Eastern Calandra |
| 255 | 254 | PASSERIFORMES | ALAUDIDAE | | *Calandrella brachydactyla* | Lark, Greater Short-toed or Yarkand Short-toed |
| 256 | 255 | PASSERIFORMES | ALAUDIDAE | | *Calandrella rufescens* | Lark, Lesser Short-toed |
| 257 | 256 | PASSERIFORMES | ALAUDIDAE | | *Calandrella raytal* | Lark, Sand or Indus Sand |
| 258 | 257 | PASSERIFORMES | ALAUDIDAE | | *Galerida cristata* | Lark, Crested |
| 259 | 258 | PASSERIFORMES | ALAUDIDAE | | *Alauda gulgula* | Skylark, Oriental or Small or Lesser |
| 260 | 259 | PASSERIFORMES | ALAUDIDAE | | *Alauda arvensis* | Skylark, Eurasian |
| 261 | 260 | PASSERIFORMES | ALAUDIDAE | | *Eremophila alpestris* | Lark, Horned or Shore |
| 262 | 261 | PASSERIFORMES | HIRUNDINIDAE | | *Riparia paludicola* | Martin, Brown-throated or Indian Sand Martin, Plain or African Sand |
| 263 | 262 | PASSERIFORMES | HIRUNDINIDAE | | *Riparia riparia* | Martin, Collared Sand or Bank Swallow |
| 264 | 263 | PASSERIFORMES | HIRUNDINIDAE | | *Ptyonoprogne fuligula* | Martin, Pale Crag or African Rock |
| 265 | 264 | PASSERIFORMES | HIRUNDINIDAE | | *Ptyonoprogne rupestris* | Martin, Northern Crag |
| 266 | 265 | PASSERIFORMES | HIRUNDINIDAE | | *Hirundo rustics* | Swallow, Barn |
| 267 | 266 | PASSERIFORMES | HIRUNDINIDAE | | *Hirundo smithii* | Swallow, Wire-tailed |
| 268 | 267 | PASSERIFORMES | HIRUNDINIDAE | | *Hirundo daurica* | Swallow, Red-rumped |
| 269 | 268 | PASSERIFORMES | HIRUNDINIDAE | | *Hirundo fluvicola* | Swallow, Indian Cliff |
| 270 | 269 | PASSERIFORMES | HIRUNDINIDAE | | *Delichon dasypus* | Martin, Asian House |
| 271 | 270 | PASSERIFORMES | MOTACILLIDAE | | *Anthus novaeseelandiae* | Pipit, Richard's Pipit or Paddyfield |
| 272 | 271 | PASSERIFORMES | MOTACILLIDAE | | *Anthus sylvanus* | Pipit, Upland |
| 273 | 272 | PASSERIFORMES | MOTACILLIDAE | | *Anthus campestris* | Pipit, Tawny |
| 274 | 273 | PASSERIFORMES | MOTACILLIDAE | | *Anthus similis* | Pipit, Long-billed or Indian or Persian Rock |
| 275 | 274 | PASSERIFORMES | MOTACILLIDAE | | *Anthus trivialis* | Pipit, Tree Pipit or Brown Tree |
| 276 | 275 | PASSERIFORMES | MOTACILLIDAE | | *Anthus pratensis* | Pipit, Meadow |
| 277 | 276 | PASSERIFORMES | MOTACILLIDAE | | *Anthus roseatus* | Pipit, Rosy or Vinous-breasted Pipit or Hodgson's |
| 278 | 277 | PASSERIFORMES | MOTACILLIDAE | | *Anthus spinoletta* | Pipit, Water |
| 279 | 278 | PASSERIFORMES | MOTACILLIDAE | | *Motacilla citreola* | Wagtail, Citrine Wagtail or Yellow-headed |
| 280 | 279 | PASSERIFORMES | MOTACILLIDAE | | *Motacilla cinerea* | Wagtail, Grey |
| 281 | 280 | PASSERIFORMES | MOTACILLIDAE | | *Motacilla maderaspatensis* | Wagtail, White-browed Wagtail or Large Pied |
| 282 | 281 | PASSERIFORMES | CAMPEPHAGIDAE | | *Tephrodornis pondicerianus* | shrike, CommonWoodshrike or Lesser Wood |
| 283 | 282 | PASSERIFORMES | CAMPEPHAGIDAE | | *Coracina novaehollandiae* | Shrike, Large Cuckoo Shrike or Black-faced Cuckoo |
| 284 | 283 | PASSERIFORMES | CAMPEPHAGIDAE | | *Coracina melaschistos* | Shrike, Black-winged Cuckoo Shrike or Lesser Grey, or Dark Grey Cuckoo |
| 285 | 284 | PASSERIFORMES | CAMPEPHAGIDAE | | *Pericrocotus ethologus* | Minivet, Long-tailed |
| 286 | 285 | PASSERIFORMES | CAMPEPHAGIDAE | | *Pericrocotus cinnamomeus* | Minivet, Small or Wandering |
| 287 | 286 | PASSERIFORMES | CAMPEPHAGIDAE | | *Pericrocotus roseus* | Minivet, Rosy |
| 288 | 287 | PASSERIFORMES | PYCNONOTIDAE | | *Pycnonotus leucogenys* | Bulbul, White-Cheecked |
| 289 | 288 | PASSERIFORMES | PYCNONOTIDAE | | *Pycnonotus cafer* | Bulbul, Red-vented |
| 290 | 289 | PASSERIFORMES | PYCNONOTIDAE | | *Hypsipetes madagascariensis* | Bulbul, Black Bulbul or Grey |
| 291 | 290 | PASSERIFORMES | CINCLIDAE | | *Cinclus cinclus* | Dipper, White-throated Dipper or Common |
| 292 | 291 | PASSERIFORMES | CINCLIDAE | | *Cinclus pallasii* | Dipper, Brown or Asiatic |

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| 293 | 292 | PASSERIFORMES | TROGLODYTIDAE | | *Troglodytes troglodytes* | America, Northern Wren or Winter Wren in North |
| 294 | 293 | PASSERIFORMES | PRUNELLIDAE | | *Prunella strophiata* | Accentor, Rufous-breasted Accentor or Jerdon's |
| 295 | 294 | PASSERIFORMES | PRUNELLIDAE | | *Prunella atrogularis* | Accentor, Black-throated |
| 296 | 295 | PASSERIFORMES | PRUNELLIDAE | | *Prunella rubeculoides* | Accentor, Robin |
| 297 | 296 | PASSERIFORMES | PRUNELLIDAE | | *Prunella himalayana* | Accentor, Altai or Himalayan |
| 298 | 297 | PASSERIFORMES | PRUNELLIDAE | | *Pranella collaris* | Accentor, Alpine |
| 299 | 298 | PASSERIFORMES | TURDIDAE | TURDINAE | *Cercotrichas galactotes* | Rufous-tailed Scrub-robin or Bush Chat or Grey-backed Warbler or Robin |
| 300 | 299 | PASSERIFORMES | TURDIDAE | TURDINAE | *Luscinia svecica* | Blue-throat |
| 301 | 300 | PASSERIFORMES | TURDIDAE | TURDINAE | *Luscinia pectoralis* | Rubythroat, White-tailed or Himalayan - or Black-breasted - |
| 302 | 301 | PASSERIFORMES | TURDIDAE | TURDINAE | *Luscinia brunnea* | Chat, Indian Blue Robin or Indian Blue |
| 303 | 302 | PASSERIFORMES | TURDIDAE | TURDINAE | *Tarsiger cyanurus* | Blue-tail, Orange-flanked Bush-robin or Red-flanked |
| 304 | 303 | PASSERIFORMES | TURDIDAE | TURDINAE | *Tarsiger chrysaeus* | Golden Bush-robin |
| 305 | 304 | PASSERIFORMES | TURDIDAE | TURDINAE | *Copsychus saularis* | Magpie-robin or Dhyal |
| 306 | 305 | PASSERIFORMES | TURDIDAE | TURDINAE | *Phoenicurus erythronotus* | Redstart, Eversmann's or Rufous-backed |
| 307 | 306 | PASSERIFORMES | TURDIDAE | TURDINAE | *Phoenicurus caeruleocephalus* | Redstart, Blue-headed or Blue-capped |
| 308 | 307 | PASSERIFORMES | TURDIDAE | TURDINAE | *Phoenicurus ochruros* | Redstart, Redstart, Black or Indian |
| 309 | 308 | PASSERIFORMES | TURDIDAE | TURDINAE | *Phoenicurus frontalis* | Redstart, Blue-fronted |
| 310 | 309 | PASSERIFORMES | TURDIDAE | TURDINAE | *Rhyacornis fuliginosus* | Redstart, Plumbeous or Slaty-blue |
| 311 | 310 | PASSERIFORMES | TURDIDAE | TURDINAE | *Cercomela fusca* | Chat, Brown Rock |
| 312 | 311 | PASSERIFORMES | TURDIDAE | TURDINAE | *Saxicola torquata* | chat, Common Stone-chat or Collared Bush |
| 313 | 312 | PASSERIFORMES | TURDIDAE | TURDINAE | *Saxicola leucura* | chat, White-tailed Stone-chat, White-tailed Bush- |
| 314 | 313 | PASSERIFORMES | TURDIDAE | TURDINAE | *Saxicola caprata* | chat, Pied Stone-chat or Pied Bush- |
| 315 | 314 | PASSERIFORMES | TURDIDAE | TURDINAE | *Saxicola ferrea* | chat, Grey Bush-chat or Dark-grey Bush- |
| 316 | 315 | PASSERIFORMES | TURDIDAE | TURDINAE | *Oenanthe isabellina* | Wheatear, Isabelline |
| 317 | 316 | PASSERIFORMES | TURDIDAE | TURDINAE | *Oenanthe pleschanka* | Wheatear, PiedWheatearorPleschanka's |
| 318 | 317 | PASSERIFORMES | TURDIDAE | TURDINAE | *Oenanthe deserti* | Wheatear, Desert |
| 319 | 318 | PASSERIFORMES | TURDIDAE | TURDINAE | *Oenanthe xanthoprymna* | Chat, Red-tailed Wheatear or Golden-tailed Wheatear or Red-rumped |
| 320 | 319 | PASSERIFORMES | TURDIDAE | TURDINAE | *Chaimarrornis leucocephalus* | Chat, White-capped Redstart or Water Redstart or River |
| 321 | 320 | PASSERIFORMES | TURDIDAE | TURDINAE | *Saxicoloides fulicata* | Chat, Indian Robin or Indian |
| 322 | 321 | PASSERIFORMES | TURDIDAE | TURDINAE | *Monticola solitarius* | Rock, Thrush, Blue |
| 323 | 322 | PASSERIFORMES | TURDIDAE | TURDINAE | *Myiophoneus caeruleus* | Whistling, Thrush, Blue |
| 324 | 323 | PASSERIFORMES | TURDIDAE | TURDINAE | *Zoothera citrina* | Thrush, Orange-headed Ground |
| 325 | 324 | PASSERIFORMES | TURDIDAE | TURDINAE | *Zoothera dauma* | Scaly Thrush, White's/ Golden/Small-billed Mountain Thrush, Tiger Thrush |
| 326 | 325 | PASSERIFORMES | TURDIDAE | TURDINAE | *Turdus unicolor* | Thrush, Tickell's |
| 327 | 326 | PASSERIFORMES | TURDIDAE | TURDINAE | *Turdus boulboul* | Blackbird, Grey-winged |
| 328 | 327 | PASSERIFORMES | TURDIDAE | TURDINAE | *Turdus merula* | Blackbird, Eurasian |
| 329 | 328 | PASSERIFORMES | TURDIDAE | TURDINAE | *Turdus rubrocanus* | Thrush, Chestnut Thrush or Grey-headed |
| 330 | 329 | PASSERIFORMES | TURDIDAE | TURDINAE | *Turdus naumanni* | Thrush, Naumann's Thrush or Dusky Thrush or Rufous-tailed |
| 331 | 330 | PASSERIFORMES | TURDIDAE | TURDINAE | *Turdus ruficollis* | Dark-throated Thrush (Red and Black-throated Thrushes) |
| 332 | 331 | PASSERIFORMES | TURDIDAE | TURDINAE | *Turdus viscivorus* | Thrush, Mistle |
| 333 | 332 | PASSERIFORMES | TURDIDAE | ENICURINAE | *Enicurus scouleri* | Forktail, Little |
| 334 | 333 | PASSERIFORMES | TURDIDAE | ENICURINAE | *Enicurus maculatus* | Forktail, Spotted |
| 335 | 334 | PASSERIFORMES | SYLVIIDAE | | *Cettia fortipes* | Warbler, Strong-footed Bush |
| 336 | 335 | PASSERIFORMES | SYLVIIDAE | | *Cettia brunnifrons* | Warbler, Grey-sided or Rufous-capped Bush |
| 337 | 336 | PASSERIFORMES | SYLVIIDAE | | *Cettia cetti* | Warbler, Cetti's |
| 338 | 337 | PASSERIFORMES | SYLVIIDAE | | *Bradypterus major* | Warbler, Large-billed Bush |
| 339 | 338 | PASSERIFORMES | SYLVIIDAE | | *Cisticola juncidis* | Warbler, Zitting Cisticola, Fan-tailed Warbler or Streaked Fantail |
| 340 | 339 | PASSERIFORMES | SYLVIIDAE | | *Prinia gracilis* | Warbler, Graceful Stripe-backed Prinia or Streaked Wren |
| 341 | 340 | PASSERIFORMES | SYLVIIDAE | | *Prinia hodgsonii* | Warbler, Grey-breasted Prinia, Franklin's or Ashy-grey Wren |

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| 342 | 341 | PASSERIFORMES | SYLVIIDAE | | *Prinia buchanani* | Warbler, Rufous-fronted Prinia, or Wren |
| 343 | 342 | PASSERIFORMES | SYLVIIDAE | | *Prinia socialis* | Warbler, Ashy Prinia, Ashy Wren-warbler or Ashy Longtail |
| 344 | 343 | PASSERIFORMES | SYLVIIDAE | | *Prinia flaviventris* | Warbler, Yellow-bellied Prinia or Yellow-bellied Wren |
| 345 | 344 | PASSERIFORMES | SYLVIIDAE | | *Prinia criniger* | Warbler, Striated Prinia or Brown Hill |
| 346 | 345 | PASSERIFORMES | SYLVIIDAE | | *Scotocerca inquieta* | Warbler, Scrub Warbler or Streaked Scrub |
| 347 | 346 | PASSERIFORMES | SYLVIIDAE | | *Orthotomus sutorius* | Tailorbird, Common |
| 348 | 347 | PASSERIFORMES | SYLVIIDAE | | *Locustella naevia* | Warbler, Grasshopper |
| 349 | 348 | PASSERIFORMES | SYLVIIDAE | | *Megaluru palustris* | Warbler, triated Warbler or Striated Marsh |
| 350 | 349 | PASSERIFORMES | SYLVIIDAE | | *Acrocephalus melanopogon* | Warbler, Moustached |
| 351 | 350 | PASSERIFORMES | SYLVIIDAE | | *Acrocephalus concinens* | Warbler, Blunt-winged or Swinhoe's Reed |
| 352 | 351 | PASSERIFORMES | SYLVIIDAE | | *Acrocephalus agricola* | Warbler, Paddyfield |
| 353 | 352 | PASSERIFORMES | SYLVIIDAE | | *Acrocephalus stentoreus* | Warbler, Clamorous or Southern Great Reed Warbler or Indian Great Reed |
| 354 | 353 | PASSERIFORMES | SYLVIIDAE | | *Hippolais caligata* | Warbler, Booted |
| 355 | 354 | PASSERIFORMES | SYLVIIDAE | | *Sylvia nana* | Warbler, Desert |
| 356 | 355 | PASSERIFORMES | SYLVIIDAE | | *Sylvia hortensis* | Warbler, Orphean |
| 357 | 356 | PASSERIFORMES | SYLVIIDAE | | *Sylvia curruca* | Whitethroat, Lesser |
| 358 | 357 | PASSERIFORMES | SYLVIIDAE | | *Sylvia communes* | Whitethroat, Common |
| 359 | 358 | PASSERIFORMES | SYLVIIDAE | | *Seicercus xanthoschistos* | warbler, Grey-hooded Warbler or Gray-headed Flycatcher- |
| 360 | 359 | PASSERIFORMES | SYLVIIDAE | | *Seicercus burkii* | Warbler, Golden-spectacled or Yellow-eyed - or Black-browed Flycatcher- |
| 361 | 360 | PASSERIFORMES | SYLVIIDAE | | *Phylloscopus reguloides* | Warbler Blyth's or Greater White-tailed Leaf, Small Crowned |
| 362 | 361 | PASSERIFORMES | SYLVIIDAE | | *Phylloscopus occipitalis* | Warbler, Western Crowned or Large Crowned Leaf |
| 363 | 362 | PASSERIFORMES | SYLVIIDAE | | *Phylloscopus tytleri* | Warbler, Tytler's or Slender-billed Leaf |
| 364 | 363 | PASSERIFORMES | SYLVIIDAE | | *Phylloscopus nitidus* | Warbler, Green Warbler or Bright Green Leaf |
| 365 | 364 | PASSERIFORMES | SYLVIIDAE | | *Phylloscopus trochiloides* | Warbler, Sundevall Greenish Warbler or Dull Green Leaf |
| 366 | 365 | PASSERIFORMES | SYLVIIDAE | | *Phylloscopus magnirostris* | Warbler, Large-billed Leaf |
| 367 | 366 | PASSERIFORMES | SYLVIIDAE | | *Phylloscopus proregulus* | Warbler, Pallas'sorYellow-rumpedLeaf |
| 368 | 367 | PASSERIFORMES | SYLVIIDAE | | *Phylloscopus subviridis* | Warbler, Brooks's Leaf |
| 369 | 368 | PASSERIFORMES | SYLVIIDAE | | *Phylloscopus inornatus* | Warbler, Yellow-browed or Inornate Leaf |
| 370 | 369 | PASSERIFORMES | SYLVIIDAE | | *Phylloscopus affinis* | Warbler, Tickell's or Chinese Leaf |
| 371 | 370 | PASSERIFORMES | SYLVIIDAE | | *Phylloscopus neglectus* | Warbler, Plain Leaf Warbler or Plain Willow |
| 372 | 371 | PASSERIFORMES | SYLVIIDAE | | *Phylloscopus collybita tristis* | Chiffchaff, Eurasian or Brown Leaf Warbler |
| 373 | 372 | PASSERIFORMES | SYLVIIDAE | | *Regulus regulus* | Goldcrest |
| 374 | 373 | PASSERIFORMES | MUSCICAPIDAE | | *Niltava sundara* | Niltava, Rufous-bellied or Beautiful |
| 375 | 374 | PASSERIFORMES | MUSCICAPIDAE | | *Cyomis rubeculoides* | Flycatcher, Blue-throated |
| 376 | 375 | PASSERIFORMES | MUSCICAPIDAE | | *Muscicapa thalassina* | Flycatcher, Verditer |
| 377 | 376 | PASSERIFORMES | MUSCICAPIDAE | | *Muscicapa sibirica* | Flycatcher, Dark-sided or Sooty |
| 378 | 377 | PASSERIFORMES | MUSCICAPIDAE | | *Muscicapa ruficauda* | Flycatcher, Rufous-tailed |
| 379 | 378 | PASSERIFORMES | MUSCICAPIDAE | | *Muscicapa latirostris* | Flycatcher, Asian Brown or Brown |
| 380 | 379 | PASSERIFORMES | MUSCICAPIDAE | | *Muscicapa striata* | Flycatcher, spotted |
| 381 | 380 | PASSERIFORMES | MUSCICAPIDAE | | *Ficedula tricolor* | Flycatcher, Slaty-blue |
| 382 | 381 | PASSERIFORMES | MUSCICAPIDAE | | *Ficedula superciliaris* | Flycatcher, Ultramarine Flycatcher or White-browed Blue |
| 383 | 382 | PASSERIFORMES | MUSCICAPIDAE | | *Ficedula parva* | Flycatcher, Red-breasted Flycatcher or Red-throated |
| 384 | 383 | PASSERIFORMES | MUSCICAPIDAE | | *Culicicapa ceylonensis* | Flycatcher, Grey-headed Flycatcher or Grey-headed Canary |
| 385 | 384 | PASSERIFORMES | RHIPIDURIDAE | | *Rhipidura hypoxantha* | Fantail, Yellow-bellied |
| 386 | 385 | PASSERIFORMES | RHIPIDURIDAE | | *Rhipidura aureola* | Fantail,White-brested or White-browed |
| 387 | 386 | PASSERIFORMES | MONARCHIDAE | | *Terpsiphone paradisi* | Flycatcher, Asian or Indian Paradise |
| 388 | 387 | PASSERIFORMES | TIMALIIDAE | | *Pomatorhinus erythrogenys* | Babbler, Rusty-cheeked Scimitar |
| 389 | 388 | PASSERIFORMES | TIMALIIDAE | | *Stachyris pyrrhops* | Babbler, Black-chinned Babbler or Red-billed |
| 390 | 389 | PASSERIFORMES | TIMALIIDAE | | *Chrysomma sinense* | Babbler, Yellow-eyed |

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| 391 | 390 | PASSERIFORMES | TIMALIIDAE | | *Chrysomma altirostris* | Babbler, Jerdon's Moupinia or Sind |
| 392 | 391 | PASSERIFORMES | TIMALIIDAE | | *Turdoides caudatus* | Babbler, Common |
| 393 | 392 | PASSERIFORMES | TIMALIIDAE | | *Turdoides earlei* | Babbler, striated |
| 394 | 393 | PASSERIFORMES | TIMALIIDAE | | *Turdoides malcolmi* | Babbler, Large Grey |
| 395 | 394 | PASSERIFORMES | TIMALIIDAE | | *Turdoides striatus* | Babbler, Jungle |
| 396 | 395 | PASSERIFORMES | TIMALIIDAE | | *Garrulax vari'egatus* | Thrilsh, Variegated Laughing |
| 397 | 396 | PASSERIFORMES | TIMALIIDAE | | *Garrulax lineatus* | Streaked Laughing-thrush |
| 398 | 397 | PASSERIFORMES | TIMALIIDAE | | *Heterophasia capistrata* | Rufous or Black-capped or Black-headed Sibia |
| 399 | 398 | PASSERIFORMES | AEGITHALIDAE | | *Aegithalos leucogenys* | White-cheeked Tit |
| 400 | 399 | PASSERIFORMES | AEGITHALIDAE | | *Aegithalos concinnus* | Black-throated Tit or Red-headed Long-tailed Tit |
| 401 | 400 | PASSERIFORMES | PARIDAE | | *Parus rufonuchalis* | Rufous-naped Tit or Simla or Black Crested Tit or Simla Black Tit |
| 402 | 401 | PASSERIFORMES | PARIDAE | | *Parus melanolophus* | Spot-winged Black Tit or Crested Black Tit |
| 403 | 402 | PASSERIFORMES | PARIDAE | | *Parus major* | Great Tit or Grey Tit |
| 404 | 403 | PASSERIFORMES | PARIDAE | | *Parus monticolus* | Green-backed Tit |
| 405 | 404 | PASSERIFORMES | PARIDAE | | *Parus xanthogenys* | Black-lored Tit, or Yellow-cheeked Tit |
| 406 | 405 | PASSERIFORMES | SITTIDAE | | *Sitta leucopsis* | White-cheecked Nuthach |
| 407 | 406 | PASSERIFORMES | SITTIDAE | | *Sitta castanea* | Chestnut-bellied Nuthatch |
| 408 | 407 | PASSERIFORMES | SITTIDAE | | *Sitta europaea* | Eurasian or Common Nuthatch or Kashmir Nuthatch |
| 409 | 408 | PASSERIFORMES | SITTIDAE | | *Sitta europaea* | Eurasian or Common Nuthatch or Kashmir Nuthatch |
| 410 | 409 | PASSERIFORMES | TICHODROMADIDAE | | *Tichodroma muraria* | Wallcreeper |
| 411 | 410 | PASSERIFORMES | CERTHIIDAE | | *Certhia himalayana* | Bar-tailed or Himalayan Tree Creeper |
| 412 | 411 | PASSERIFORMES | CERTHIIDAE | | *Certhia familiaris* | Common Tree Creeper or Northern Tree Creeper |
| 413 | 412 | PASSERIFORMES | REMIZIDAE | | *Cephalopyrus flammiceps* | Fire-capped Tit |
| 414 | 413 | PASSERIFORMES | REMIZIDAE | | *Remiz pendulinus* | EurasianPendulineTit |
| 415 | 414 | PASSERIFORMES | NECTARINIIDAE | | *Nectarinia asiatica* | Sunbird Purple |
| 416 | 415 | PASSERIFORMES | DICAEIDAE | | *Dicaeum agile* | Thick-billed Flowerpecker |
| 417 | 416 | PASSERIFORMES | ZOSTEROPIDAE | | *Zosterops palpebrosa* | Oriental White-eye |
| 418 | 417 | PASSERIFORMES | ORIOLIDAE | | *Oriolus oriolus* | Golden Oriole |
| 419 | 418 | PASSERIFORMES | LANIIDAE | | *Lanius isabellinus* | Shrike, Rufous-tailed or Isabelline or Pale Brown - |
| 420 | 419 | PASSERIFORMES | LANIIDAE | | *Lanius vittatus* | Bay-backed Shrike |
| 421 | 420 | PASSERIFORMES | LANIIDAE | | *Lanius schach* | Long-tailed Shrike or Rufous-backed Shrike |
| 422 | 421 | PASSERIFORMES | LANIIDAE | | *Lanius excubitor* | Shrike, Great Grey |
| 423 | 422 | PASSERIFORMES | DICRURIDAE | | *Dicrurus macrocercus* | Black Drongo or King Crow |
| 424 | 423 | PASSERIFORMES | DICRURIDAE | | *Dicrurus leucophaeus* | Drongo, Ashy or Grey |
| 425 | 424 | PASSERIFORMES | CORVIDAE | | *Garrulus glandarius* | Jay, Eurasian |
| 426 | 425 | PASSERIFORMES | CORVIDAE | | *Garrulus lanceolatus* | Jay, Lanceolated Black-headed or Lanceolated |
| 427 | 426 | PASSERIFORMES | CORVIDAE | | *Urocissa flavirostris* | Magpie, Yellow-billed Blue |
| 428 | 427 | PASSERIFORMES | CORVIDAE | | *Dendrocitta vagabunda* | Tree Pie, Rufous or Indian - |
| 429 | 428 | PASSERIFORMES | CORVIDAE | | *Dendrocitta formosae* | Tree Pie, Grey or Himalayan - |
| 430 | 429 | PASSERIFORMES | CORVIDAE | | *Corvus monedula* | Jackdaw, Common |
| 431 | 430 | PASSERIFORMES | CORVIDAE | | *Corvus splendens* | Crow, House |
| 432 | 431 | PASSERIFORMES | CORVIDAE | | *Corvus frugilegus* | Rook |
| 433 | 432 | PASSERIFORMES | CORVIDAE | | *Corvus macrorhynchos* | Crow, Large-billed or Jungle |
| 434 | 433 | PASSERIFORMES | STURNIDAE | | *Corvus corax* | Raven, Common |
| 435 | 434 | PASSERIFORMES | STURNIDAE | | *Sturnus pagodarum* | Starling, Brahminy or Myna or Black-headed Starling |
| 436 | 435 | PASSERIFORMES | STURNIDAE | | *Sturnus vulgaris* | Starling , Common |
| 437 | 436 | PASSERIFORMES | STURNIDAE | | *Sturnus roseus* | Starling, Rose-coloured or Rosy or Rosy Pastor |
| 438 | 437 | PASSERIFORMES | STURNIDAE | | *Sturnus contra* | Starling, Asian Pied or Pied Myna |
| 439 | 438 | PASSERIFORMES | STURNIDAE | | *Acridotheres ginginianus* | Myna, Bank |

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| 440 | 439 | PASSERIFORMES | STURNIDAE | | *Acridotheres tristis* | Myna, Common or Indian - |
| 441 | 440 | PASSERIFORMES | STURNIDAE | | *Acridotheres fuscus* | Myna, Jungle |
| 442 | 441 | PASSERIFORMES | PASSERIDAE | | *Passer domesticus indicus* | Sparrow, House |
| 443 | 442 | PASSERIFORMES | PASSERIDAE | | *Passer domesticus parkinii* | Sparrow, Migratory House |
| 444 | 443 | PASSERIFORMES | PASSERIDAE | | *Passer hispaniolensis transcaspicus* | Sparrow, Spanish or Willow or Tschusi's - |
| 445 | 444 | PASSERIFORMES | PASSERIDAE | | *Passer pyrrhonotus* | Sparrow, Sind or Sind Jungle - |
| 446 | 445 | PASSERIFORMES | PASSERIDAE | | *Passer rutilans* | Sparrow, Cinnamon or Russet - |
| 447 | 446 | PASSERIFORMES | PASSERIDAE | | *Petronia xanthocollis* | Sparrow, Chestnut-shouldered Rock or Yellow-throated - |
| 448 | 447 | PASSERIFORMES | PASSERIDAE | | *Petronia petronia* | Sparrow, Streaked Rock |
| 449 | 448 | PASSERIFORMES | PLOCEIDAE | | *Ploceus philippinus* | Weaver, Baya or Indian Baya |
| 450 | 449 | PASSERIFORMES | PLOCEIDAE | | *Ploceus benghalensis* | Weaver, Black-breasted or Black-throated - |
| 451 | 450 | PASSERIFORMES | PLOCEIDAE | | *Ploceus manyar* | Weaver, Streaked or Striated - |
| 452 | 451 | PASSERIFORMES | ESTRILDIDAE | | *Amandava amandava* | Avadavat, Red or Red Munia |
| 453 | 452 | PASSERIFORMES | ESTRILDIDAE | | *Euodice malabarica* | Silverbill, Indian or White-throated Munia |
| 454 | 453 | PASSERIFORMES | ESTRILDIDAE | | *Lonchura punctulata* | Munia, Scaly-breasted or Spotted or Nutmeg Mannikin |
| 455 | 454 | PASSERIFORMES | FRINGILLIDAE | FRINGILLINAE | *Fringilla coelebs* | Chaffinch, Common |
| 456 | 455 | PASSERIFORMES | FRINGILLIDAE | FRINGILLINAE | *Fringilla montifringilia* | Brambling |
| 457 | 456 | PASSERIFORMES | FRINGILLIDAE | CARDUELINAE | *Callacanthis burtoni* | Finch, Red-browed or Spectacled - |
| 458 | 457 | PASSERIFORMES | FRINGILLIDAE | CARDUELINAE | *Carduelis spinoides* | Greenfinch, Yellow-breasted or Himalayan -, or Himalayan Goldfinch |
| 459 | 458 | PASSERIFORMES | FRINGILLIDAE | CARDUELINAE | *Carduelis carduelis* | Goldfinch, Eurasian |
| 460 | 459 | PASSERIFORMES | FRINGILLIDAE | CARDUELINAE | *Carduelis cannabina* | Linnet, Brown |
| 461 | 460 | PASSERIFORMES | FRINGILLIDAE | CARDUELINAE | *Leucosticte nemoricola* | Finch, Plain Mountain or Hodgson's Mountain - |
| 462 | 461 | PASSERIFORMES | FRINGILLIDAE | CARDUELINAE | *Leucosticte brandti* | Finch, Brandt's Mountain |
| 463 | 462 | PASSERIFORMES | FRINGILLIDAE | CARDUELINAE | *Carpodacus erythrinus* | Rosefinch, Common or Scarlet Grosbeak |
| 464 | 463 | PASSERIFORMES | FRINGILLIDAE | CARDUELINAE | *Pyrrhula aurantiaca* | Bullfinch, Orange |
| 465 | 464 | PASSERIFORMES | FRINGILLIDAE | CARDUELINAE | *Mycerobas icterioides* | Grosbeak, Black-and-yellow |
| 466 | 465 | PASSERIFORMES | FRINGILLIDAE | CARDUELINAE | *Mycerobas melanozanthos* | Grosbeak, Spot-winged |
| 467 | 466 | PASSERIFORMES | FRINGILLIDAE | CARDUELINAE | *Coccothraustes coccothraustes* | Hawfinch |
| 468 | 467 | PASSERIFORMES | EMBERIZIDAE | | *Emberiza leucocephalos* | Bunting, Pine |
| 469 | 468 | PASSERIFORMES | EMBERIZIDAE | | *Emberiza stewarti* | Bunting,White capped |
| 470 | 469 | PASSERIFORMES | EMBERIZIDAE | | *Emberiza cia* | Bunting, Rock or Meadow - |
| 471 | 470 | PASSERIFORMES | EMBERIZIDAE | | *Emberiza striolata* | Bunting, House or Striolated or Striated - |
| 472 | 471 | PASSERIFORMES | EMBERIZIDAE | | *Emberiza buchanani* | Bunting, Grey-necked |
| 473 | 472 | PASSERIFORMES | EMBERIZIDAE | | *Emberiza schoeniclus* | Bunting, Reed |
| 474 | 473 | PASSERIFORMES | EMBERIZIDAE | | *Emberiza bruniceps* | Bunting, Red-headed |
| 475 | 474 | PASSERIFORMES | EMBERIZIDAE | | *Melophus lathami* | Bunting, Crested |

# Annex - 8

## List of Protected Sites and Monuments in Punjab

**List of Protected Sites and Monuments In Punjab**

| Sr/No | Name of Monument/Site | Protected Under |
|---|---|---|
| 1. | A Buddhist Stupa with a surrounding area on River Indus to the north of village Rokhri | Antiquities Act, 1975 |
| 2. | A Mughal Period Tomb | Antiquities Act, 1975 |
| 3. | A red sandstone temple, Sodhi Zarin | Antiquities Act, 1975 |
| 4. | A ruined and un-identified tomb | Special Premises, 1985 |
| 5. | Administrative Staff College | Special Premises, 1985 |
| 6. | Ahmadpur Lamma Fortress | Special Premises, 1985 |
| 7. | Aitchison College | Special Premises, 1985 |
| 8. | Akbari Baoli in for Gujrat city | Antiquities Act, 1975 |
| 9. | Akbari Hammam | Special Premises, 1985 |
| 10. | Akbari Sarai and mosque | Antiquities Act, 1975 |
| 11. | Allama Iqbal Museum | |
| 12. | An un-identified tomb of Suri's period | Special Premises, 1985 |
| 13. | An unknown and ruined tomb near the Shrine of Mirza Ali Beg | Special Premises, 1985 |
| 14. | Anarkali tomb (Civil Secretariat) | Special Premises, 1985 |
| 15. | Ancient Mosque at Eminabad (Wando Road) | Special Premises, 1985 |
| 16. | Angori Bagh | Antiquities Act, 1975 |

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| 17. | Animal Husbandry College | Special Premises, 1985 |
| 18. | Another Gate to north-east of Wazir Khan Mosque, Chowk Wazir Khan | Antiquities Act, 1975 |
| 19. | Archaeological Sites of Harappa, Sahiwal | Antiquities Act, 1975 |
| 20. | Armory Gallery Lahore Fort | |
| 21. | Assembly Chambers | Special Premises, 1985 |
| 22. | Attock Fort | Antiquities Act, 1975 |
| 23. | Attock tomb, on G.T. Road near Ziarat Hazrat Baba Sahib | Antiquities Act, 1975 |
| 24. | ayal Singh Library | Special Premises, 1985 |
| 25. | Badi Palice at Kallet Sayydian | Special Premises, 1985 |
| 26. | Badshahi Masjid | Special Premises, 1985 |
| 27. | Badshahi Mosque | Antiquities Act, 1975 |
| 28. | Badshahi Mosque | Antiquities Act, 1975 |
| 29. | Bahar Wali Baoli, Kharian Town | Antiquities Act, 1975 |
| 30. | Baoli | Special Premises, 1985 |
| 31. | Baoli (Kharian) | Special Premises, 1985 |
| 32. | Baoli and Mosque | Antiquities Act, 1975 |
| 33. | Baoli and Mosque, JandialaSher Khan, Sheikhupura | Antiquities Act, 1975 |
| 34. | Baoli Rajgah | Special Premises, 1985 |

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| 35. | Baradari and Samadh of Maharaja Sher Singh, Kot Khawaja Saeed, Lahore | Antiquities Act, 1975 |
| 36. | Baradari attached to the Shrine of Hafiz Muhammad Hayat | Special Premises, 1985 |
| 37. | Baradari in Sheranwala garden | Antiquities Act, 1975 |
| 38. | Barkat Ali Hall, Circular Road | Special Premises, 1985 |
| 39. | Barkat Ali Islamia Hall | Special Premises, 1985 |
| 40. | Begum ki Sarai, on left bank of Indus River near Attock Fort | Antiquities Act, 1975 |
| 41. | Behram ki Baradari | Antiquities Act, 1975 |
| 42. | Bhati Gate | Antiquities Act, 1975 |
| 43. | Bhir Mound | Antiquities Act, 1975 |
| 44. | Bredlaw Hall | Special Premises, 1985 |
| 45. | Buddha ka Awa | Antiquities Act, 1975 |
| 46. | Buddhist site (Behari Colony) Hasan Abdal Town, Behari Colony | Antiquities Act, 1975 |
| 47. | Buddho's Tomb | Antiquities Act, 1975 |
| 48. | Camp (Paraoo or Bardashat Khana) | Special Premises, 1985 |
| 49. | Central Model High School | Special Premises, 1985 |
| 50. | Chamba House (GOR Estate) | Special Premises, 1985 |
| 51. | Chauburji | Antiquities Act, 1975 |

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| 52. | Chauburji, Mozang, Lahore. | Antiquities Act, 1975 |
| 53. | Chillah-gah of Hazrat Sakhi Sarwar | Special Premises, 1985 |
| 54. | Chirtope Site | Antiquities Act, 1975 |
| 55. | Chitta Gate, Chowk Wazir Khan, inside Delhi Gate | Antiquities Act, 1975 |
| 56. | Chitti Baoli, Pindi Suleman Makhan | Antiquities Act, 1975 |
| 57. | Chobara Chajju Bhagat near Mayor Hospital | Special Premises, 1985 |
| 58. | Chowk Masjid Wazir Khan occupied by Khokhawalas | Special Premises, 1985 |
| 59. | Civil Lines Police Station | Special Premises, 1985 |
| 60. | Cricket Pavillion | Special Premises, 1985 |
| 61. | Dai Anga's Mosque | Antiquities Act, 1975 |
| 62. | Dai Anga's Tomb | Antiquities Act, 1975 |
| 63. | Dak Chowki of Sher Shah Suri's period | Special Premises, 1985 |
| 64. | Delhi Gate | Antiquities Act, 1975 |
| 65. | Derawar and the Desert Forts, Cholistan | Antiquities Act, 1975 |
| 66. | Entrance gate of Sarai Kala | Special Premises, 1985 |
| 67. | Ewing Hall, Neela Gumbad | Special Premises, 1985 |
| 68. | Faqir Khana Museum (inside Bhati Gate) | Special Premises, 1985 |
| 69. | Faridi Mahal | Special Premises, 1985 |
| 70. | Farudgah-e-Shahan-e-Mughlia Tank and Garden | Antiquities Act, 1975 |

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| 71. | Farudgah-e-Shahan-e-Mughlia Tank and Garden, Wah, Rawalpindi | Antiquities Act, 1975 |
| 72. | Fateh Garh Gardens near Shalamar Garden | Special Premises, 1985 |
| 73. | Ferozesons Building, Shahrah-e-Quaid-e-Azam | Special Premises, 1985 |
| 74. | Fortification wall of Shuja Abad city | Special Premises, 1985 |
| 75. | Free Masons Hall | Special Premises, 1985 |
| 76. | Gate, Adjoining Building and Front Wall of Punjab Institute of Mental Health | Special Premises, 1985 |
| 77. | General Post Office | Special Premises, 1985 |
| 78. | Ghazi Khan's Tomb, Mohalla Zamindaran, village Chirotta, Dera Ghazi Khan | Antiquities Act, 1975 |
| 79. | Ghazi Khan's Tomb, MohallaZamindaran, village Chirotta, Dera Ghazi Khan. | Antiquities Act, 1975 |
| 80. | Ghulabi Bagh Gateway & Tomb of Dai Anga, G.T Road Lahore | Antiquities Act, 1975 |
| 81. | Giri remains | Antiquities Act, 1975 |
| 82. | Government House | Special Premises, 1985 |
| 83. | Government College | Special Premises, 1985 |
| 84. | Government College Hostel | Special Premises, 1985 |
| 85. | Gujrat Fort | Special Premises, 1985 |
| 86. | Gulzar Mahal, Chiniot | Antiquities Act, 1975 |

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| 87. | Gulzar Mahal, Chiniot | Special Premises, 1985 |
| 88. | Gurdawara (D-Block Model Town) | Special Premises, 1985 |
| 89. | Hakim's tomb, Hasan Abdal | Antiquities Act, 1975 |
| 90. | Harand Fort | Special Premises, 1985 |
| 91. | Harappa Museum | |
| 92. | Haveli Dhayan Singh | Special Premises, 1985 |
| 93. | Haveli Dhayan Singh | Antiquities Act, 1975 |
| 94. | Haveli Nau Nihal Singh including garden, quarters, latrine etc. inside Bhati Gate, Kucha Nau Nihal Singh | Antiquities Act, 1975 |
| 95. | Haveli Nau-Nihal Singh, inside Bhati Gate, Lahore | Antiquities Act, 1975 |
| 96. | Haveli Nawab Sahib | Special Premises, 1985 |
| 97. | Haveli Sheikh Rukandin | Special Premises, 1985 |
| 98. | Hayat House No.14 | Special Premises, 1985 |
| 99. | Hazuri Bagh, Baradari | Antiquities Act, 1975 |
| 100. | Hill measuring 25 ft. long and 190 ft. broad, Murti in Tehsil Pind Dadan Khan | Antiquities Act, 1975 |
| 101. | Hiran Minar and Tank, Sheikhupura | Antiquities Act, 1975 |
| 102. | Hujra Mir Mehdi (Janazgah) Kot Khawaja Saeed | Antiquities Act, 1975 |
| 103. | Inayat Bagh | Antiquities Act, 1975 |
| 104. | Inderkot mosque, Fateh Jang, Inderkot | Antiquities Act, 1975 |

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| 105. | Iqbal Manzil (Birth Place of Dr. Muhammad Iqbal), Sialkot | Antiquities Act, 1975 |
| 106. | Islamia College | Special Premises, 1985 |
| 107. | Islamic College | Special Premises, 1985 |
| 108. | Jahangir's Tomb and compound | Antiquities Act, 1975 |
| 109. | Jahangir's Tomb, Asif Khan and Akbari Sarai, Lahore | Antiquities Act, 1975 |
| 110. | Jame Masjid Al-Sadiq | Special Premises, 1985 |
| 111. | Jame Masjid, Bhera | Special Premises, 1985 |
| 112. | Jamia Mosque | Special Premises, 1985 |
| 113. | Jani Khan tomb | Antiquities Act, 1975 |
| 114. | Javed Manzil | Antiquities Act, 1975 |
| 115. | Javed Manzil Lahore | Antiquities Act, 1975 |
| 116. | Jhando ki Sarai | Special Premises, 1985 |
| 117. | Kalawan Site, Mauza Karawal | Antiquities Act, 1975 |
| 118. | Kallar (temple) or Sassi da Kallara, village Shah Muhammad Wali, Tehsil Talagang | Antiquities Act, 1975 |
| 119. | Kamran Baradari at Ravi | Special Premises, 1985 |
| 120. | Kashmiri Gate | Antiquities Act, 1975 |
| 121. | Kasur Museum | |
| 122. | Katas Raj including the Sacred Pool of Water and some temples also known as Satghhara temples | Special Premises, 1985 |

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| 123. | Katas Raj Temples Complex, Chakwal | Antiquities Act, 1975 |
| 124. | Kinnard College | Special Premises, 1985 |
| 125. | Kos Minar | Antiquities Act, 1975 |
| 126. | Kos Minar, near Golra Railway Station | Antiquities Act, 1975 |
| 127. | Lahore Fort | Antiquities Act, 1975 |
| 128. | Lahore High Court | Special Premises, 1985 |
| 129. | Lahori known as Lohari Gate | Antiquities Act, 1975 |
| 130. | Lakshami Building | Special Premises, 1985 |
| 131. | Lala Rukh Tomb and Hakeem Khan Tomb, Hassan Abdal, Attock | Antiquities Act, 1975 |
| 132. | Lala Rukh's tomb, Hasan Abdal | Antiquities Act, 1975 |
| 133. | Losar Baoli | Antiquities Act, 1975 |
| 134. | Loser Boali, Wah Cantt, Rawalpindi | Antiquities Act, 1975 |
| 135. | Mariam Zamani Mosque | Antiquities Act, 1975 |
| 136. | Maryala Mound | Antiquities Act, 1975 |
| 137. | Maryam Zamani Mosque, Near Masti Gate Lahore | Antiquities Act, 1975 |
| 138. | Masjid Afghana | Special Premises, 1985 |
| 139. | Masjid Chinian Wali | Special Premises, 1985 |
| 140. | Masjid Khudakka | Special Premises, 1985 |

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| 141. | Masjid Mai Lado | Special Premises, 1985 |
| 142. | Masjid Maulvi Abaid Ullah | Special Premises, 1985 |
| 143. | Masjid Maulvi Taj Din | Special Premises, 1985 |
| 144. | Masjid Moran Tawaif | Special Premises, 1985 |
| 145. | Masjid Patolian | Special Premises, 1985 |
| 146. | Masjid Sahibzadgan | Special Premises, 1985 |
| 147. | Masjid Saleh Muhammad Kanboh | Special Premises, 1985 |
| 148. | Masjid Wazir Khan | Special Premises, 1985 |
| 149. | Masjid Wazir Khan | Special Premises, 1985 |
| 150. | Masjid-I-Hajaat, Uch | Special Premises, 1985 |
| 151. | Masjid-I-Khanan at Khairpur Tamiwali | Special Premises, 1985 |
| 152. | Masti Gate | Antiquities Act, 1975 |
| 153. | Mausoleum of Hazrat Daud Bandgi | Special Premises, 1985 |
| 154. | Mausoleum of Syed Daud Gardezi, Adam Wahan | Special Premises, 1985 |
| 155. | Mausoleum of Syed Qambar Shah | Special Premises, 1985 |
| 156. | Mazar of Hazrat Bibi Pak Daman | Special Premises, 1985 |
| 157. | Mazar-e-Iqbal, Lahore | Antiquities Act, 1975 |
| 158. | Mirza Kamran's Baradari | Antiquities Act, 1975 |
| 159. | Mirza Kamran's Baradari, Lahore | Antiquities Act, 1975 |

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| 160. | Mohra Moradu Site | Antiquities Act, 1975 |
| 161. | Montgomery Hall (Quaid-e-Azam Library) | Special Premises, 1985 |
| 162. | Mosque and temple at Nandna | Special Premises, 1985 |
| 163. | Mosque at Basti Zirakhwah | Special Premises, 1985 |
| 164. | Mosque attached to the Shrine of Hafiz Muhammad Hayat | Special Premises, 1985 |
| 165. | Mosque near the tomb of Hazrat Ali Akbar at Sura Miana | Special Premises, 1985 |
| 166. | Mosque of Khawaja Ayaz | Special Premises, 1985 |
| 167. | Mosque of Khawaja Ayaz | Special Premises, 1985 |
| 168. | Mosque of Nawab Ali Muhammad Khan | Special Premises, 1985 |
| 169. | Mosque of Nawab Zakariya Khan | Antiquities Act, 1975 |
| 170. | Mosque of Sher Shah Suri | Special Premises, 1985 |
| 171. | Mosque of Sher Shah Suri's period known as Jinnowali Mosque | Special Premises, 1985 |
| 172. | Mosque of Tahir Khan Nahar | Special Premises, 1985 |
| 173. | Mosque with glazed tile work | Antiquities Act, 1975 |
| 174. | Mound Mian Ali Sahib | Antiquities Act, 1975 |
| 175. | Mound Ratti Khari | Antiquities Act, 1975 |
| 176. | Mounds | Antiquities Act, 1975 |
| 177. | Mubarik Haveli | Special Premises, 1985 |

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| 178. | Mughal Gallery Lahore Fort | |
| 179. | Museum and National College of Arts | Special Premises, 1985 |
| 180. | Nadira Begum Tomb and tank | Antiquities Act, 1975 |
| 181. | Nicholson Column | Antiquities Act, 1975 |
| 182. | Nicholson Column, Margala Pass, Rawalpindi | Antiquities Act, 1975 |
| 183. | Nila Gumbad mosque | Special Premises, 1985 |
| 184. | Old Fort | Antiquities Act, 1975 |
| 185. | Old Mosque at Basti Hasil Wali | Special Premises, 1985 |
| 186. | Old Mosque at Basti Mansoor Shah Wali | Special Premises, 1985 |
| 187. | Old Mosque at Khairpur Sadat | Special Premises, 1985 |
| 188. | Old Mosque at Mauza Khichi, Tehsil Tala Gang | Special Premises, 1985 |
| 189. | Old Mosque Muhammad pur Ghote | Special Premises, 1985 |
| 190. | Old Mosque near Bela Wagha | Special Premises, 1985 |
| 191. | Old Ruined Mosque, Mauza Khatti Chore, Tehsil Kabirwala | Special Premises, 1985 |
| 192. | One Kos Minar | Antiquities Act, 1975 |
| 193. | Patiala Block, King Edward College | Special Premises, 1985 |
| 194. | PattanMinara, Rahimyar Khan District | Antiquities Act, 1975 |
| 195. | Perhalad Temple | Special Premises, 1985 |

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| 196. | Pharwala Fort, Pharwala | Special Premises, 1985 |
| 197. | Platform of the grave of Mian Mir's sister | Special Premises, 1985 |
| 198. | Prof. Abdus Salam's House, Jhang | Antiquities Act, 1975 |
| 199. | Punjab University (Old) | Special Premises, 1985 |
| 200. | Qadim Masjid | Special Premises, 1985 |
| 201. | Qadim Masjid in graveyard Maloak Shah | Special Premises, 1985 |
| 202. | Queen Marry College | Special Premises, 1985 |
| 203. | Railway Station | Special Premises, 1985 |
| 204. | Raja Mansingh's Haveli, Rohtas | Antiquities Act, 1975 |
| 205. | Ratta Pind | Antiquities Act, 1975 |
| 206. | Rawat Fort | Antiquities Act, 1975 |
| 207. | Resident's of late Dr. Muhammad Iqbal | Antiquities Act, 1975 |
| 208. | Rohtas Fort | Antiquities Act, 1975 |
| 209. | Rohtas Fort 5 miles from Dina Railway Station | Antiquities Act, 1975 |
| 210. | Roshnai Gate | Antiquities Act, 1975 |
| 211. | Ruined Buddhist Stupa area around it, Ketas, Tehsil Pind Dadan Khan | Antiquities Act, 1975 |
| 212. | Ruined Mosque near Tomb of Hazrat Sheikh Ahmad Kabir at Dhanot | Special Premises, 1985 |
| 213. | Ruined Mosque village Sargana | Antiquities Act, 1975 |

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| 214. | Ruined Temple with gateway, Melot | Antiquities Act, 1975 |
| 215. | Ruined Temple with gateway, Melot, Chakwal | Antiquities Act, 1975 |
| 216. | Ruins of Nandana Fort, Bhagan Wala | Antiquities Act, 1975 |
| 217. | Saidan Baoli, Hatti | Antiquities Act, 1975 |
| 218. | Samdh of Ghhajju Bhagat | Special Premises, 1985 |
| 219. | Sangar Wala Tibba, Chak No.742, Tehsil Toba Tek Singh | Antiquities Act, 1975 |
| 220. | Sarai Kharbuza | Special Premises, 1985 |
| 221. | Sardar of Hari Singh's Haveli, Ketas | Antiquities Act, 1975 |
| 222. | Sarwala Maqbara | Antiquities Act, 1975 |
| 223. | Satghara temple village Ketas, Tehsil Pind Dadan Khan | Antiquities Act, 1975 |
| 224. | Sawi Masjid and graves | Antiquities Act, 1975 |
| 225. | Seetla Mandir (outside Shahalami Gate) | Special Premises, 1985 |
| 226. | Shah Ghiragh Chambears | Special Premises, 1985 |
| 227. | Shahdin Building | Special Premises, 1985 |
| 228. | Shahi Masjid Qasim Bela | Special Premises, 1985 |
| 229. | Shahi Masjid, Chiniot | Antiquities Act, 1975 |
| 230. | Shahi Masjid, Chiniot | Special Premises, 1985 |
| 231. | Shahzadi Ka Maqbara near it on its north surrounded by residential houses | Special Premises, 1985 |

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| 232. | Shalamar Garden | Antiquities Act, 1975 |
| 233. | Shalimar Garden including Baradari gateway, kiosks, pavillions, well, Naqqar Khana, asmani well and garden | Antiquities Act, 1975 |
| 234. | Sheikhupura Fort | Antiquities Act, 1975 |
| 235. | Sheikhupura Fort, Sheikhupura | Antiquities Act, 1975 |
| 236. | Sher Shah Baoli, Nizamabad, Wazirabad-Dhonkal Road, Wazirabad | Special Premises, 1985 |
| 237. | Sher Shah Mosque, Nizamabad, Wazirabad-Dhonkal Road, Wazirabad | Antiquities Act, 1975 |
| 238. | Sher Shah Suri Mosque/Jamia Masjid Bhera | Antiquities Act, 1975 |
| 239. | Sheranwala Gate | Antiquities Act, 1975 |
| 240. | Shershah's baoli | Antiquities Act, 1975 |
| 241. | Shrine and Mosque of Syed Jan Muhmmad Hazoori | Special Premises, 1985 |
| 242. | Shrine of Baba Kamal Chishti | Special Premises, 1985 |
| 243. | Shrine of Hafiz Jamal | Special Premises, 1985 |
| 244. | Shrine of Hafiz Muhammad Hayat | Special Premises, 1985 |
| 245. | Shrine of Hazrat Abdul Razzaq Maki | Special Premises, 1985 |
| 246. | Shrine of Hazrat Abdul Salam Chishti known as (Bara Bhai) | Special Premises, 1985 |
| 247. | Shrine of Hazrat Abdul Wahab Bukhari | Special Premises, 1985 |
| 248. | Shrine of Hazrat Abul Khair Nau Lakh Hazari | Special Premises, 1985 |

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| 249. | Shrine of Hazrat Abul Ma'ali | Special Premises, 1985 |
| 250. | Shrine of Hazrat Aishan Sahib | Special Premises, 1985 |
| 251. | Shrine of Hazrat Ala-ud-Din Mauj Darya | Special Premises, 1985 |
| 252. | Shrine of Hazrat Ali Sarwar | Special Premises, 1985 |
| 253. | Shrine of Hazrat Badshahan | Special Premises, 1985 |
| 254. | Shrine of Hazrat Baha-ud-Din Zakariya | Special Premises, 1985 |
| 255. | Shrine of Hazrat Bibi Pak Damna | Special Premises, 1985 |
| 256. | Shrine of Hazrat Bibi Tigni, Uch | Special Premises, 1985 |
| 257. | Shrine of Hazrat Bulley Shah | Special Premises, 1985 |
| 258. | Shrine of Hazrat Data Ganj Bakhsh | Special Premises, 1985 |
| 259. | Shrine of Hazrat Diwan Chawali Mashaikh | Special Premises, 1985 |
| 260. | Shrine of Hazrat Fazal Din Ladla, Uch | |
| 261. | Shrine of Hazrat Hamid Gilani | Special Premises, 1985 |
| 262. | Shrine of Hazrat Hasan Darya Kabir | Special Premises, 1985 |
| 263. | Shrine of Hazrat Hoo-Ba-Hoo | Special Premises, 1985 |
| 264. | Shrine of Hazrat Hussain Shah | Special Premises, 1985 |
| 265. | Shrine of Hazrat Imam Ali-ul-Haq | Special Premises, 1985 |
| 266. | Shrine of Hazrat Imam Gamun | Special Premises, 1985 |
| 267. | Shrine of Hazrat Inayat Walait | Special Premises, 1985 |

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| 268. | Shrine of Hazrat Jalal-ud-Din Bukhari and attached Mosque, Uch | Special Premises, 1985 |
| 269. | Shrine of Hazrat Jamal Khandan Darvaish | Special Premises, 1985 |
| 270. | Shrine of Hazrat Khawaja Ghulam Farid | Special Premises, 1985 |
| 271. | Shrine of Hazrat Khwaja Behari | Special Premises, 1985 |
| 272. | Shrine of Hazrat Madho Lal Hussain | Special Premises, 1985 |
| 273. | Shrine of Hazrat Makhdum Jahanian Jahangasht and attached Mosque, Uch | Special Premises, 1985 |
| 274. | Shrine of Hazrat Makhdum Rashid | Special Premises, 1985 |
| 275. | Shrine of Hazrat Mauj Darya Bukhari | Special Premises, 1985 |
| 276. | Shrine of Hazrat Mian Meer Sahib | Special Premises, 1985 |
| 277. | Shrine of Hazrat Mir Muhammad Zarif | Special Premises, 1985 |
| 278. | Shrine of Hazrat Miran Hussain Janjani | Special Premises, 1985 |
| 279. | Shrine of Hazrat Musa Pak Shaheed and attached mosque | Special Premises, 1985 |
| 280. | Shrine of Hazrat Nur Muhammad Hasan | Special Premises, 1985 |
| 281. | Shrine of Hazrat Pir Abdur Razzaq | Special Premises, 1985 |
| 282. | Shrine of Hazrat Pir Abdur Rehman Qureshi | Special Premises, 1985 |
| 283. | Shrine of Hazrat Pir Ghazi | Special Premises, 1985 |
| 284. | Shrine of Hazrat Pir Mallah Rahim Pur Kuchian | Special Premises, 1985 |

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| 285. | Shrine of Hazrat Qutab Shah Wali | Special Premises, 1985 |
| 286. | Shrine of Hazrat Rajan Qattal, Uch | Special Premises, 1985 |
| 287. | Shrine of Hazrat Rajan Shah | Special Premises, 1985 |
| 288. | Shrine of Hazrat Razi-ud-Din Ganj Alam Darya | Special Premises, 1985 |
| 289. | Shrine of Hazrat Sadiq Nihang | Special Premises, 1985 |
| 290. | Shrine of Hazrat Sadr-ud-din Sadr Jahan | Special Premises, 1985 |
| 291. | Shrine of Hazrat Saidan Shah | Special Premises, 1985 |
| 292. | Shrine of Hazrat Sakhi Sarwar | Special Premises, 1985 |
| 293. | Shrine of Hazrat Salis Bil Khair | Special Premises, 1985 |
| 294. | Shrine of Hazrat Shah Chiragh and attached mossque | Special Premises, 1985 |
| 295. | Shrine of Hazrat Shah Dana Shaheed | Special Premises, 1985 |
| 296. | Shrine of Hazrat Shah Daula | Special Premises, 1985 |
| 297. | Shrine of Hazrat Shah Hussain Sadozai | Special Premises, 1985 |
| 298. | Shrine of Hazrat Shah Jamal | Special Premises, 1985 |
| 299. | Shrine of Hazrat Shah Kamal | Special Premises, 1985 |
| 300. | Shrine of Hazrat Shah Rukn-I-Alam | Special Premises, 1985 |
| 301. | Shrine of Hazrat Shah Shams Sabzwari | Special Premises, 1985 |
| 302. | Shrine of Hazrat Shah Suleman Paras | Special Premises, 1985 |
| 303. | Shrine of Hazrat Sheikh Ludho | Special Premises, 1985 |

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| 304. | Shrine of Hazrat Sheikh Sadan Shaheed | Special Premises, 1985 |
| 305. | Shrine of Hazrat Sikandar Shah | Special Premises, 1985 |
| 306. | Shrine of Hazrat Sultan Ahmad Qattal | Special Premises, 1985 |
| 307. | Shrine of Hazrat Sultan Bahu | Special Premises, 1985 |
| 308. | Shrine of Hazrat Syed Mahmmad Hazoori | Special Premises, 1985 |
| 309. | Shrine of Hazrat Syed Maulvi Nizam-ud-Din | Special Premises, 1985 |
| 310. | Shrine of Hazrat Syed Murad Ali Shah | Special Premises, 1985 |
| 311. | Shrine of Hazrat Taj Muhammad | Special Premises, 1985 |
| 312. | Shrine of Hazrat Taj-ud-Din Makhdum | Special Premises, 1985 |
| 313. | Shrine of Hazrat Tawakkal Shah Rehman | Special Premises, 1985 |
| 314. | Shrine of Hazrat Yahya Nawab | Special Premises, 1985 |
| 315. | Shrine of Khwaja Awais Khagga | Special Premises, 1985 |
| 316. | Shrine of Mai Mehrban | Special Premises, 1985 |
| 317. | Shrine of Mian Sher Muhammad | Special Premises, 1985 |
| 318. | Shrine of Mian Wadda Sahib | Special Premises, 1985 |
| 319. | Shrine of Nawab Saeed Qureshi | Special Premises, 1985 |
| 320. | Shrine of Rukn-e-Alam | Special Premises, 1985 |
| 321. | Shrines of Hazrat Pir Adil and Hazrat Imam Ali | Special Premises, 1985 |
| 322. | Sikh Gallery Lahore Fort | |

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| 323. | Sirkap Site | Antiquities Act, 1975 |
| 324. | Site at Garhi, village Malak Mala, 6 miles east of Hasan Abdal | Antiquities Act, 1975 |
| 325. | Site of ancient city, Bhera | Antiquities Act, 1975 |
| 326. | Site of ancient city, vijjhi 2 miles south west Miani known as Sabzal Pind | Antiquities Act, 1975 |
| 327. | Smadh of Bhai Wasti Ram, outside Lahore Fort | Antiquities Act, 1975 |
| 328. | Smadh of Bhai Wasti Ram, Taxali Gate near Shahi Qila | Antiquities Act, 1975 |
| 329. | Smadh of Jhingar Shah Suthra (Suthron ka Asthana) Suthron | Antiquities Act, 1975 |
| 330. | Smadh of Ranjit Singh, Kharak Singh and Nau Nihal Singh | Antiquities Act, 1975 |
| 331. | Smadh of Ranjit Singh, Kharak Singh and NauNihal Singh, Lahore | Antiquities Act, 1975 |
| 332. | Smadh of Sir Ganga Ram | Special Premises, 1985 |
| 333. | Small Mosque near the Shrine of Hazrat Behari | Special Premises, 1985 |
| 334. | Small Mosque of Wazir Khan inside Taxali Gate known as the mosque of ladies of Wazir Khan | Special Premises, 1985 |
| 335. | So called Suri period Mosque | Special Premises, 1985 |
| 336. | Sonehri Masjid, Inside Walled City, Lahore | Antiquities Act, 1975 |
| 337. | State Bank of Pakistan | Special Premises, 1985 |
| 338. | Sultanate Period Tomb at Thatta Gurmani | Special Premises, 1985 |

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| 339. | Summit Minar, Lahore | Antiquities Act, 1975 |
| 340. | Suraj Kund Temple | Special Premises, 1985 |
| 341. | Taj Palace | Special Premises, 1985 |
| 342. | Takhat-e-Babri, Kallar Kahar, Chakwal | Antiquities Act, 1975 |
| 343. | Tank and Tower | Antiquities Act, 1975 |
| 344. | Taxila Museum | |
| 345. | Taxila Sites & Monuments | Antiquities Act, 1975 |
| 346. | Temple and tank of Bherron ka Than in Ichra | Special Premises, 1985 |
| 347. | Temple at Hajipur | Special Premises, 1985 |
| 348. | The area of Track known as Babar Khana | Antiquities Act, 1975 |
| 349. | The enclosure and Grave of Mian Natha and his Goat in the General Graveyard of Mian Mir | Special Premises, 1985 |
| 350. | The Grave of Mulla Hamid Gujar and his relatives | |
| 351. | The Mughal Garden at Fatehgarh | Antiquities Act, 1975 |
| 352. | The remaining entrance gate and baradari of the garden of Khawaja Ayaz,who was the Governer of Lahore. | Special Premises, 1985 |
| 353. | Ther Dallu Roy, Dajal, Dera Ghazi Khan | Antiquities Act, 1975 |
| 354. | Three temple inside Fort Amb | Antiquities Act, 1975 |
| 355. | Tibba (Mound) | Antiquities Act, 1975 |
| 356. | Tibba Jolian | Antiquities Act, 1975 |

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| 357. | Tiled Gateway and two bastions | Antiquities Act, 1975 |
| 358. | Tollinton Market | Special Premises, 1985 |
| 359. | Tomb & Garden of Mian Khan S/o Gald Ullah Khan,the Prime Minsiter of Shahjahan | Special Premises, 1985 |
| 360. | Tomb of Abdul Ghani, Shalamar Garden | Special Premises, 1985 |
| 361. | Tomb of Abdul Nabi Kotli Maqbara | Antiquities Act, 1975 |
| 362. | Tomb of Abdullah Shah | Antiquities Act, 1975 |
| 363. | Tomb of Abu Hanifa, Uch Sharif | Antiquities Act, 1975 |
| 364. | Tomb of Ali Mardan | Antiquities Act, 1975 |
| 365. | Tomb of Ali Mardan Khan and gateway | Antiquities Act, 1975 |
| 366. | Tomb of Allah Dad Gormani | Special Premises, 1985 |
| 367. | Tomb of Anarkali | Antiquities Act, 1975 |
| 368. | Tomb of Anarkali, Lahore | Antiquities Act, 1975 |
| 369. | Tomb of Asif Khan and compound | Antiquities Act, 1975 |
| 370. | Tomb of Bahawal Haleem, Uch Shairf | Antiquities Act, 1975 |
| 371. | Tomb of Bibi Jawandi, Baha'al Halim and Ustad and Tomb and Mosque of Jalal ud Din Bukhari, Uch Sharif | Antiquities Act, 1975 |
| 372. | Tomb of Bibi Jawindi, Uch Sharif | Antiquities Act, 1975 |
| 373. | Tomb of Dr. Muhammad Iqbal | Antiquities Act, 1975 |
| 374. | Tomb of French Officer's daughter | Special Premises, 1985 |

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| 375. | Tomb of Hafiz Burkhurdar | Antiquities Act, 1975 |
| 376. | Tomb of Hazrat Abu-Bakar Warraq Mailsi | Special Premises, 1985 |
| 377. | Tomb of Hazrat Bugha Sher | Special Premises, 1985 |
| 378. | Tomb of Hazrat Ghous Muhammad Bala Pir at Sat Garah | Special Premises, 1985 |
| 379. | Tomb of Hazrat Handira Pir, Karor Pucca. | Special Premises, 1985 |
| 380. | Tomb of Hazrat Khawaja Mahmood at Taunsa Sharif | Special Premises, 1985 |
| 381. | Tomb of Hazrat Khawaja Suleman Taunsvi at Taunsa Sharif | Special Premises, 1985 |
| 382. | Tomb of Hazrat Muhammad Anwar at Kunnal Sharif | Special Premises, 1985 |
| 383. | Tomb of Hazrat Mullah Badakhshi and its surrounding area specially the corner Burja | Special Premises, 1985 |
| 384. | Tomb of Hazrat Noor Muhammad at Hajipur | Special Premises, 1985 |
| 385. | Tomb of Hazrat Pir Makki | Special Premises, 1985 |
| 386. | Tomb of Hazrat Sabir Shah on the West of Badshahi Mosque | Special Premises, 1985 |
| 387. | Tomb of Hazrat Sadar-ud-Din Shamsi at Tarandah | Special Premises, 1985 |
| 388. | Tomb of Hazrat Shah Ismail | Special Premises, 1985 |
| 389. | Tomb of Hazrat Shah Muhammad Ismail Gilani | Special Premises, 1985 |
| 390. | Tomb of Hazrat Shah Rukn-e-Alam, Multan | Antiquities Act, 1975 |
| 391. | Tomb of Hazrat Shah Shams-ud-Din | Special Premises, 1985 |

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| 392. | Tomb of Hazrat Sheikh Ahmad Kabir at Dhanot | Special Premises, 1985 |
| 393. | Tomb of Hazrat Sheikh Muhammad Ismail Qureshi at Basti Umar Pur | Special Premises, 1985 |
| 394. | Tomb of Hazrat Sultan Manjhan at Basti Sultan Manjhan | Special Premises, 1985 |
| 395. | Tomb of Kh. Khuda Bux at Khairpur Tamiwali | Special Premises, 1985 |
| 396. | Tomb of Khalid Waleed, Kabirwala, Khanewal | Antiquities Act, 1975 |
| 397. | Tomb of Khalid Walid village Kabirwala, Khanewal | Antiquities Act, 1975 |
| 398. | Tomb of Khawaja Ghulam Farid, Kot Mitthan, Rajanpur | Antiquities Act, 1975 |
| 399. | Tomb of Khawaja Sabir (Nawab Nusrat Khan) inside Railway Mechanical Workshop | Antiquities Act, 1975 |
| 400. | Tomb of Khwaja Muhammad Saeed within the enclosure opposite Nila Gumbad | Special Premises, 1985 |
| 401. | Tomb of Mahabat Khan and boundary wall | Antiquities Act, 1975 |
| 402. | Tomb of Mai Dai (Dar-ul-Shako) Fazalpura, Kot Khwaja Saeed | Special Premises, 1985 |
| 403. | Tomb of Mai Mehrban | Antiquities Act, 1975 |
| 404. | Tomb of Malik Ayaz (Rang Mahal) | Special Premises, 1985 |
| 405. | Tomb of Mian Dalail | Special Premises, 1985 |
| 406. | Tomb of Muhammad Saleh Kamboh | Special Premises, 1985 |
| 407. | Tomb of Musa Pak Shaheed, Uch Sharif | Antiquities Act, 1975 |
| 408. | Tomb of Nadra Begum, Lahore | Antiquities Act, 1975 |

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| 409. | Tomb of Nawab Abdul Samad Khan and his family | Special Premises, 1985 |
| 410. | Tomb of Nawab Bahadur Khan, Lahore | Antiquities Act, 1975 |
| 411. | Tomb of Nawab Khan-I-Dauran Nusrat Jang Bahadurr lying within the area of Railway Workshop | Special Premises, 1985 |
| 412. | Tomb of Nawab Wakil Khan | Special Premises, 1985 |
| 413. | Tomb of Nur Jehan | Antiquities Act, 1975 |
| 414. | Tomb of Nur Muhammad | Antiquities Act, 1975 |
| 415. | Tomb of Nuria, Uch Sharif | Antiquities Act, 1975 |
| 416. | Tomb of Patrick Alexander Vana, Andrew & William Anderson | Antiquities Act, 1975 |
| 417. | Tomb of Pir Aulia-e-Ghauri at Bahaderpur | Special Premises, 1985 |
| 418. | Tomb of Pir Luddan Kuddan | Special Premises, 1985 |
| 419. | Tomb of Prince Pervez | Antiquities Act, 1975 |
| 420. | Tomb of Qutab-ud-Din Aibak, Anarkali Bazar Lahore | Antiquities Act, 1975 |
| 421. | Tomb of Safi-ud-Din Garzoni at Uch Sharif | Special Premises, 1985 |
| 422. | Tomb of Sakhi Dalail village 184/WB | Special Premises, 1985 |
| 423. | Tomb of Shah Ali Akbar & His Mother, Multan | Antiquities Act, 1975 |
| 424. | Tomb of Shah Ali Akbar, Sura Miani | Antiquities Act, 1975 |
| 425. | Tomb of Shah Ali Akbar's Mother | Antiquities Act, 1975 |
| 426. | Tomb of Shah Ali Mardan | Special Premises, 1985 |

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| 427. | Tomb of Shah Burhan, Chiniot, Jhang | Antiquities Act, 1975 |
| 428. | Tomb of Shah Jahangir and attached mosque | Special Premises, 1985 |
| 429. | Tomb of Shah Rustam Ghazi | Special Premises, 1985 |
| 430. | Tomb of Shah Sharf Iying on the north of Khawaja Muhammad Saeed'sTomb | Special Premises, 1985 |
| 431. | Tomb of Shah Yousuf Gardezi | Antiquities Act, 1975 |
| 432. | Tomb of Shams Tabriz | Antiquities Act, 1975 |
| 433. | Tomb of Sheikh Ali Baig, locally called Hanjeera village Hailan, Tehsil Phalia | Antiquities Act, 1975 |
| 434. | Tomb of Sheikh Musa Ahangar, Mosque and House | Antiquities Act, 1975 |
| 435. | Tomb of Sheikh Sadan Shaheed | Special Premises, 1985 |
| 436. | Tomb of Son of Hazrat Sadar-ud-Din Shamsi at Tarandah | Special Premises, 1985 |
| 437. | Tomb of Syed Daud Kirmani | Antiquities Act, 1975 |
| 438. | Tomb of Tahir Khan Nahar | Special Premises, 1985 |
| 439. | Tomb of Tahir Khan Nahar, Muzafargarh | Antiquities Act, 1975 |
| 440. | Tomb of Wakeel Khan, Kasur | Antiquities Act, 1975 |
| 441. | Tomb of Zaib Un Nisa, Multan Road, Lahore | Antiquities Act, 1975 |
| 442. | Tope and Monastery (Buddhist remains), 5 miles east of Hasan Abdal Baoli Pind | Antiquities Act, 1975 |
| 443. | Tope or Stupa (Buddhist) | Antiquities Act, 1975 |

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|---|---|---|
| 444. | Tope or Stupa (Buddhist) | Antiquities Act, 1975 |
| 445. | Town Hall, Shahrah-e-Quaid-e-Azam | Special Premises, 1985 |
| 446. | Two ancient temples, Bhagan Wala, 11 miles from Haranpur Railway Station | Antiquities Act, 1975 |
| 447. | Two Historical Sites (Rocks) one at Alif Mohalla and other Chungi No.1, Tehsil Chiniot | Special Premises, 1985 |
| 448. | Two Kos Minars, Minola | Antiquities Act, 1975 |
| 449. | Unchi Masjid | Special Premises, 1985 |
| 450. | Wazir Khan Bardari, Lahore | Antiquities Act, 1975 |
| 451. | Wazir Khan Hammam, inside Delhi Gate, Chowk Wazir Khan | Antiquities Act, 1975 |
| 452. | Wazir Khan Hammams, Lahore | Antiquities Act, 1975 |
| 453. | Wazir Khan Mosque | Antiquities Act, 1975 |
| 454. | Wazir Khan Mosque, Lahore | Antiquities Act, 1975 |
| 455. | Wazir Khan's Baradari old Anarkali behind Lahore Museum | Antiquities Act, 1975 |
| 456. | Well of Raja Dina Nath, Chowk Wazir Khan | Antiquities Act, 1975 |

# Annex - 9

# Stakeholder Consultation
# Key Informant Interview

My name is [_____], representative of Strategic Environmental Assessment Consultant. The Urban Unit in coordination with aligned government departments plans to implement Punjab Spatial Strategy with a focus on eight development sectors i.e., tourism, industry, agriculture etc. in Punjab region to enhance economic its growth. Punjab Spatial Strategy (PSS) is a long-term spatial planning framework for the province of Punjab. The objective of the strategy is to reflect current trends and functional relationships across multiple sectors throughout the province. The proposed development is expected to improve the socioeconomic growth in a sustainable, clean & green environment. It may also help achieve sustainable development goals at country level. We are conducting stakeholder consultations and socioeconomic survey for the strategy. The information collected will help the ECSP and Urban Unit to achieve a consistent data on the socioeconomic and environmental condition of the selected sites.

To address the complexity in implementing such a broad concept, a Strategic Environment Assessment will likely to ensure that the environmental, climate change and socio-economic factors, along with gender aspects, are appropriately integrated and main streamed to achieve development agenda of PSS.

We understand that you have the right to choose, whether to participate or not in this survey. If you wish to participate, you are free to withdraw from the survey at any time. If you choose not to participate or withdraw, your decision will not adversely affect your position in community/ organization.

**Name: _____ Designation: _____ Department: _____ District: _____**

**Date: ____/____/_____ Time: ____:_____ Location: _____**

**Contact Detail: _____**

Q-1: Can you please introduce yourself and your role at District level?

_____

_____

_____

Q-2: Can you tell us a little about your department, its mandate and activities?

_____

_____

_____

Q-3: As a part of your department focus/agenda, what are the key development opportunities in your area?

_____

_____

_____

Q-4: What are some of the key gaps and how can these be addressed?

_____

_____

_____

Q-5: The new development will involve construction work in various areas of Punjab, what are your concerns regarding negative or positive environmental impact in your area?

_____

_____

_____

Q-6: The new development will involve construction work in various areas of Punjab and in your district, what are your concerns regarding negative or positive impacts on people and their daily lives?

_____

_____

_____

Q-7: Can you please share your suggestions about new development opportunities in your area?

_____

_____

Q-8: Do have any other concerns?

_____

_____

_____

**Public Consultation Tool**
**(FGD)**

**Place of FGD: _____ District: _____ Tehsil: _____ Time: _____**

## Consent Form

My name is [_____], Strategic Environmental Assessment (SEA) consultant representative. Task of doing SEA of Punjab Spatial Strategy (PSS) vision 2017-2047, has been assigned to consultant i.e. Engineering Consultancy Services Punjab (Pvt.) Ltd (ECSP) in JV with Associates in Development Pvt. Ltd (AiD) by the Urban Unit. PSS is developed by the Urban Unit and has been approved by the Provincial Cabinet. This spatial strategy is providing an organizing framework for long term development planning and reflects current trends and functional relationships throughout the province.The proposed development is expected to improve the socioeconomic and environmental conditions for the residents of Punjab. It will also help to achieve sustainable development goals at country level.

To address the complexity in implementing such a broad concept, a Strategic Environment Assessment will likely to ensure that the environmental, climate change and socio-economic factors, along with gender aspects, are appropriately integrated and main streamed to achieve development agenda of PSS.

These stakeholder consultations, baseline environmental and socioeconomic survey is a part of SEA for collection of baseline line data. The information collected will help the consultant to gauge the concerns and reservations of the communities and institutional stakeholders regarding proposed development. This is an opportunity for you to raise your concerns at an early stage. Your concerns will be documented, responded and addressed in the strategy at its implementation stage.

We understand that you have the right to choose, whether to participate or not in this survey. If you wish to participate, you are free to withdraw from the survey at any time. If you choose not to participate or withdraw, your decision will not adversely affect your position in community/ organization.

| S# | Name | Age | Education | Profession | Contact |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
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| 6 | | | | | |
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| 8 | | | | | |

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| 9 | | | | | |
| 10 | | | | | |

**1) The new development is likely to upgrade the existing infrastructure in the transport, industry, cities, urban centres, agriculture, livestock, skills, health, education, environment, demography and population planning. Do you think this is a good intitiative by the government of Punjab and will help improve socio-economic and environmental conditions of Punjab?**

**2) The new development will involve construction work in various areas of Punjab and in your district, what are your concerns regarding negative or positive environmental impacts?**

**3) The new development will involve construction work in various areas of Punjab and in your district, what are your concerns regarding negative or positive impacts on people and their daily lives?**

**4) What are your suggestions about the proposed Project?**

## Public Consultation
## Focused Group Discussion

**Place of FGD: _____ District: _____ Tehsil: _____ Time: __:___**

My name is [_____], representative of Strategic Environmental Assessment Consultant. The Urban Unit in coordination with aligned government departments plans to implement Punjab Spatial Strategy with a focus on eight development sectors i.e., tourism, industry, agriculture etc. in Punjab region to enhance economic its growth. Punjab Spatial Strategy (PSS) is a long-term spatial planning framework for the province of Punjab. The objective of the strategy is to reflect current trends and functional relationships across multiple sectors throughout the province. The proposed development is expected to improve the socioeconomic growth in a sustainable, clean & green environment. It may also help achieve sustainable development goals at country level. We are conducting stakeholder consultations and socioeconomic survey for the strategy. The information collected will help the ECSP and Urban Unit to achieve a consistent data on the socioeconomic and environmental condition of the selected sites.

To address the complexity in implementing such a broad concept, a Strategic Environment Assessment will likely to ensure that the environmental, climate change and socio-economic factors, along with gender aspects, are appropriately integrated and main streamed to achieve development agenda of PSS.

We understand that you have the right to choose, whether to participate or not in this survey. If you wish to participate, you are free to withdraw from the survey at any time. If you choose not to participate or withdraw, your decision will not adversely affect your position in community/ organization.

**Detail of participants:**

| S# | Name | Age | Education | Profession | Contact | CNIC No. |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
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| 9 | | | | | | |
| 10 | | | | | | |

1) The new development is likely to upgrade the existing infrastructure in the transport, industry, cities, urban centers, agriculture, livestock, skills, health, education, environment, demography and population planning. Do you think this is a good initiative by the government of Punjab and will help improve socio-economic and environmental conditions of Punjab?

2) The new development will involve construction work in various areas of Punjab and in your district, what are your concerns regarding negative or positive environmental impacts?

3) The new development will involve construction work in various areas of Punjab and in your district, what are your concerns regarding negative or positive impacts on people and their daily lives?

4) What are your suggestions about the proposed Project?

# Annex - 10

# Field photographs

## Ecological Survey

# MARALA HEADWORKS

Upstream Headwork Habitat

Wild Board Footprints

Riverine Forest Thickets

Jackal Footprints

**CHASHMA WILDLIFE SANCTUARY**

Migratory Birds - Coot

Coot

River Tern

Upstream Chashma Barrage

River Tern Over Coot

**KUNDIAN PLANTATON**

Black kite

Shrike

Treepie

Forest

Deforestation

Deforested areas

Bare Forest and Euclaptus Plantations

**RANGLA WELTANDS COMPLEX**

REEDS

Burnt Habitat in Rangla


Thick Reeds Providing Habitat For Birds


Footprints of Jungle Cat and Jackals

## CHANGA MANGA FOREST

Local Harvesting Wood

Forest Adjacent Canal

Thickets -Habitat of Wild boar & Jackals

Plantation Around The Train Track

wildlife park

WILDLIFE Park

Degradation


Night Heron

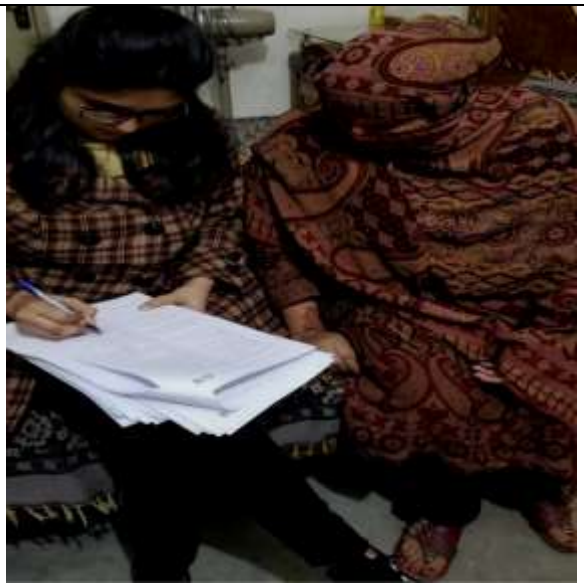
# Field photographs

Focused Group Discussions
Key Interviews With Various Departments

## Socio Economic Survey Photographs In Various Urban & Rural Union Councils of Selected Districts of Punjab

**District Faisalabad**


**District Sialkot**



**District Chakwal**

**District Rawalpindi**

**District Chakwal**


**District Lahore**

**District Dera Ghazi Khan**

**District Rahim Yar Khan**

**District Multan**

## Consultation with Various Department

Environmental Protection Department, Lahore

Tourism Department, Lahore

Solid Waste Management Department, Gujranwala

Fisheries and Wildlife Department, Gujranwala

| | |
|---|---|
|  |  |
| At Office of Local Government, Gujranwala | Environment Protection Department, Gujranwala |
|  |  |
| Deputy Director SWD, Rawalpindi | Environment Protection Department, Faisalabad |

<table>
<tr><td> 
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<tr><td>Wildlife and Fisheries Department, Faisalabad</td><td>Deputy Director Community Development, Chakwal</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td colspan="2">Consultation in Sialkot (EPD and SWM) Officials</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td colspan="2">Consultation in Rahim-Yar-Khan</td></tr>
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<tr><td>  </td><td>  </td></tr>
<tr><td>Deputy Director Social Welfare, Atock</td><td>Deputy Director Social Welfare, Faisalabad</td></tr>
<tr><td>  </td><td></td></tr>
<tr><td>Director Social & Environment Management-SPRU, Irrigation Department,</td><td></td></tr>
</table>

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