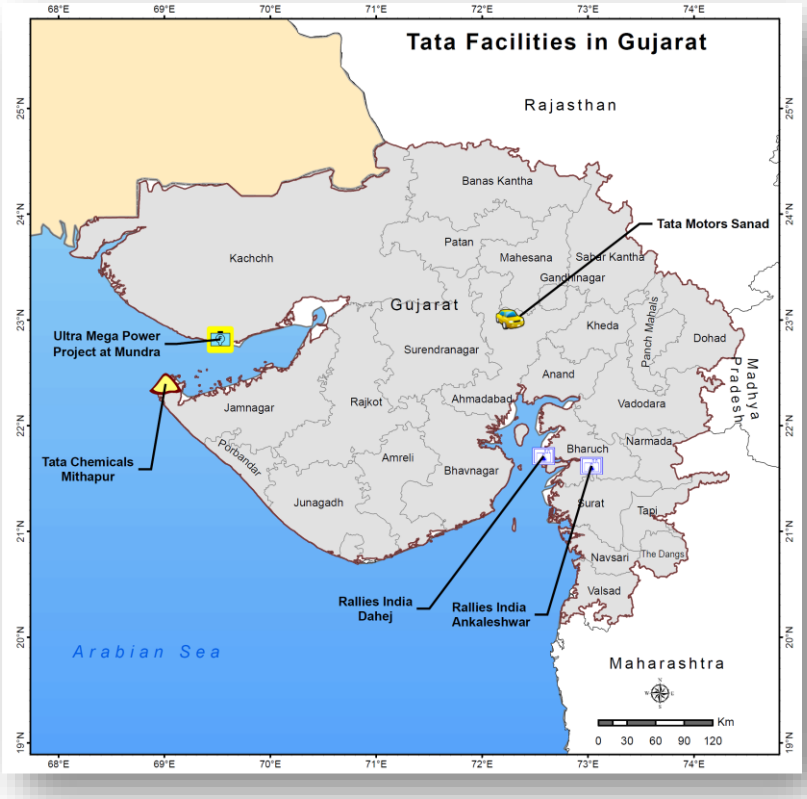
CLIMATE IMPACTS, RISKS AND VULNERABILITY IN THE STATE OF GUJARAT

Climate Impacts, Risks and Vulnerability Assessment in the State of Gujarat

About the Project

Climate change is one of the biggest environmental threats facing the world. Scientists around the world now agree that the climatic changes occurring globally are the result of human activity. Although responsibility for the climate change rests primarily with the developed and industrialized nations, the impacts of climate change will be borne most directly by the poor nations because of their low coping capacity. Concentrations of greenhouse gases (GHG) are likely to rise over the next few decades and over the millennia in spite of the currently agreed regime of emissions control. Moreover, implications of climate change are likely to vary across regions and for sectors within regions.

Tata group acknowledged the need for evaluating the implications of climate change to their business entities and formulated Group Climate Policy in 2010 to address these issues. The Tata Group has made significant progress in the areas of Climate Mitigation and Abatement and is now focusing on exploring range of viable Climate Adaptation options. The first step towards exploring adaptation options is to understand the current and projected future climate and its impact at various spatial and temporal scales. INRM Consultants (incubatee company under Technology Business Incubation Plan of the Indian Institute of Technology Delhi) has been commissioned to conduct climate change vulnerability for Gujarat with special consideration of addressing presence of big Tata facilities in the state viz., Tata Chemicals (at Mithapur, Jamnagar district), Tata Power (at Mundra, Kutch district), Rallis (at Dahej & Ankleshwar, Bharuch district) and Tata Motors (at Sanand, Ahmedabad district).



Methodology Overview

To start with, analysis on the two most important entities of temperature and precipitation has been made using the past historical records of these entities in Gujarat to detect if there are any trends recorded. Latest IPCC AR5 RCP[1] scenarios are being used for climate change study for Gujarat. Climate change scenario used are IPCC AR5 RCP4.5 (moderate emission scenario) and RCP8.5 (a scenario of comparatively high greenhouse gas emissions) over short-term (2021-2050) and long-term (2071-2100) periods.

Climate Change projections are taken from CORDEX South Asia. Ensemble mean from 10 experiments from three regional climate models (RCM) with grid resolution of 50 km x 50 km have been used. Ensemble mean reduces model related uncertainties and in the present case is found to be closer to observed climate than any individual model.

Impact Assessment

The impact models are run using AR5 scenarios. An assessment of the impact of projected climate change shall be done using distributed biophysical models which are best suited for all important sectors, as given below:

- For water resources, the hydrologic model SWAT (Soil and Water Assessment Tool) will be used. The model is capable of quantifying the impact on various components of water balance such as stream flow, actual evapotranspiration (crop water demand), ground water recharge, soil moisture, etc., which in turn can lead to evaluating the severity of floods and droughts with their spatial and temporal character over Gujarat.
- For agriculture, the DSSAT crop model will be used for the major crops of Gujarat. Impact on crop yield and crop water demand shall be evaluated.
- For health, impacts of heat stress on human health, worker's productivity, vector borne disease (malaria) spread, livestock (cattle/milk yield), etc., shall be assessed.

Vulnerability Analysis

Vulnerability shall be assessed with respect to four important indicators namely, climate, water resource, agriculture and health to develop sectoral index at the district level using multivariate analysis of individual indicators. The districts shall be ranked based on the sectoral vulnerability index and categorized into five categories of clusters; very low, low, moderate, high and very high vulnerability. In addition to the vulnerability for each sector, a composite vulnerability shall also be evaluated at the district level for all the sectors put together. District vulnerability profiles for Gujarat shall be derived and presented for current vulnerability as well as for projected future vulnerability due to climate change under the short-term and long-term scenarios.

Preliminary Analysis

Analysis has been made using the historical daily temperature (maximum and minimum) and rainfall data in Gujarat. The analysis on temperature shows that there have been positive trends for both, annual maximum and annual minimum temperature for the state of Gujarat that is statistically

[1] IPCC AR5 RCP: Representative Concentration Pathways (RCP) are four greenhouse gas concentration trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) for its fifth Assessment Report (AR5) in 2014

significant (with greater than 90% confidence level) which means that Gujarat has been definitely experiencing overall warming.

Similar analysis on annual rainfall has also shown positive trend for Gujarat State which means that the amount of rainfall received has been increasing although this trend is statistically not significant. Analysis on the number of rainy days has shown negative trend which means that though the amount of rainfall received slightly increasing over Gujarat yet this rainfall shall be received in fewer days. This has huge implications for Gujarat such as more severe floods, failure of rain-fed crops, lesser groundwater recharge, enhanced soil erosion, etc.

Similar analysis has been performed on the projected daily temperature and rainfall under climate change scenarios. Following are the major inferences of the analysis using ensemble mean of 3 RCMs.

- Mean annual maximum temperature for IPCC AR5 RCP4.5 scenario is projected to increase by about 1.2^{0}C by mid-century and by 1.9^{0}C by end-century while for IPCC AR5 RCP 8.5 scenario it is projected to increase by about 1.5^{0}C by mid-century and 4.1^{0}C by end-century for the State of Gujarat.
- Mean annual minimum temperature for IPCC AR5 RCP4.5 scenario is projected to increase by about 1.3^{0}C by mid-century and by 2.4^{0}C by end-century while for IPCC AR5 RCP 8.5 scenario it is projected to increase by about 1.7^{0}C by mid-century and 4.6^{0}C by end-century.
- Mean annual rainfall for IPCC AR5 RCP4.5 scenario is projected to increase marginally by about 5% in mid-century and increase by about 23% in end-century while for IPCC AR5 RCP 8.5 scenario it is projected to increase by about 7% in mid-century and 11.5% in end-century.

General implications of temperature increase can include heat stress related health impacts, increase in energy demand for cooling, additional evaporation and evapotranspiration losses resulting in enhanced irrigation water requirement for crops. Increase in intensity of rainfall events may lead to floods, urban storms, vector borne diseases, loss of work, transport disruption, additional cost for flood proofing factories and warehouses.

Next Step

Climate Change Impact Assessment

Sectoral impact assessment using biophysical models to assess the impact of climate change using climate data is under progress.

Current and Projected Vulnerability Profile for the Districts of Gujarat

District vulnerability assessment shall be made for identified indicators and composite vulnerability profiles made for the State of Gujarat to identify the 'hotspots'

District vulnerability profiles for Gujarat shall be presented in two parts:

- Current vulnerability profile.
- Projected vulnerability profile due to climate change.

Key messages for Gujarat

Observed Climate over Gujarat (1951-2013:63 years)

1. Increasing trends in maximum and minimum temperature have been observed (high confidence)

2. Increasing trend in annual average precipitation and decreasing trend in annual number of rainy days have been observed (low confidence)

3. Extreme events like 1 day maximum precipitation, warm nights and warm days show increasing trend (high confidence)
Slight increasing trend in the frequency of severe cyclones and cyclonic storm (high confidence)

Projected Climate (near term: 2021-2050; long term: 2071-2100) RCP4.5 (low), RCP8.5 (high)

4. CORDEX multi-model mean projections of annual temperature changes
Near term: Tmax; 1.2^{0}C and 1.5^{0}C Tmin: 1.3^{0}C and 1.7^{0}C under ***RCP4.5 and 8.5***
Long term: Tmax; 1.9^{0}C and 4.1^{0}C Tmin: 2.4^{0}C and 4.6^{0}C under ***RCP4.5 and 8.5***

5. CORDEX multi-model mean projections of annual precipitation changes
Near term: marginal increase and 7% increase under ***RCP4.5 and 8.5***
Long term: 23% and 12% increase under ***RCP4.5 and 8.5***

6. Projected extreme events: heavy rainfall, heat waves, floods and drought, will become increasingly important and will play a more significant role in disaster impacts

Possible Impacts on Water, Agriculture & Health (ongoing)

7. Changes in stream flow and water availability is projected to continue in the future affecting already vulnerable districts
Water scarcity is very likely due to increased water demand and lack of good management

8. Changes in agricultural productivity with consequences for food security are expected to exhibit large spatial variability

9. Extreme climate events (Increases in floods and droughts) will have an increasing impact on human health, security, livelihoods

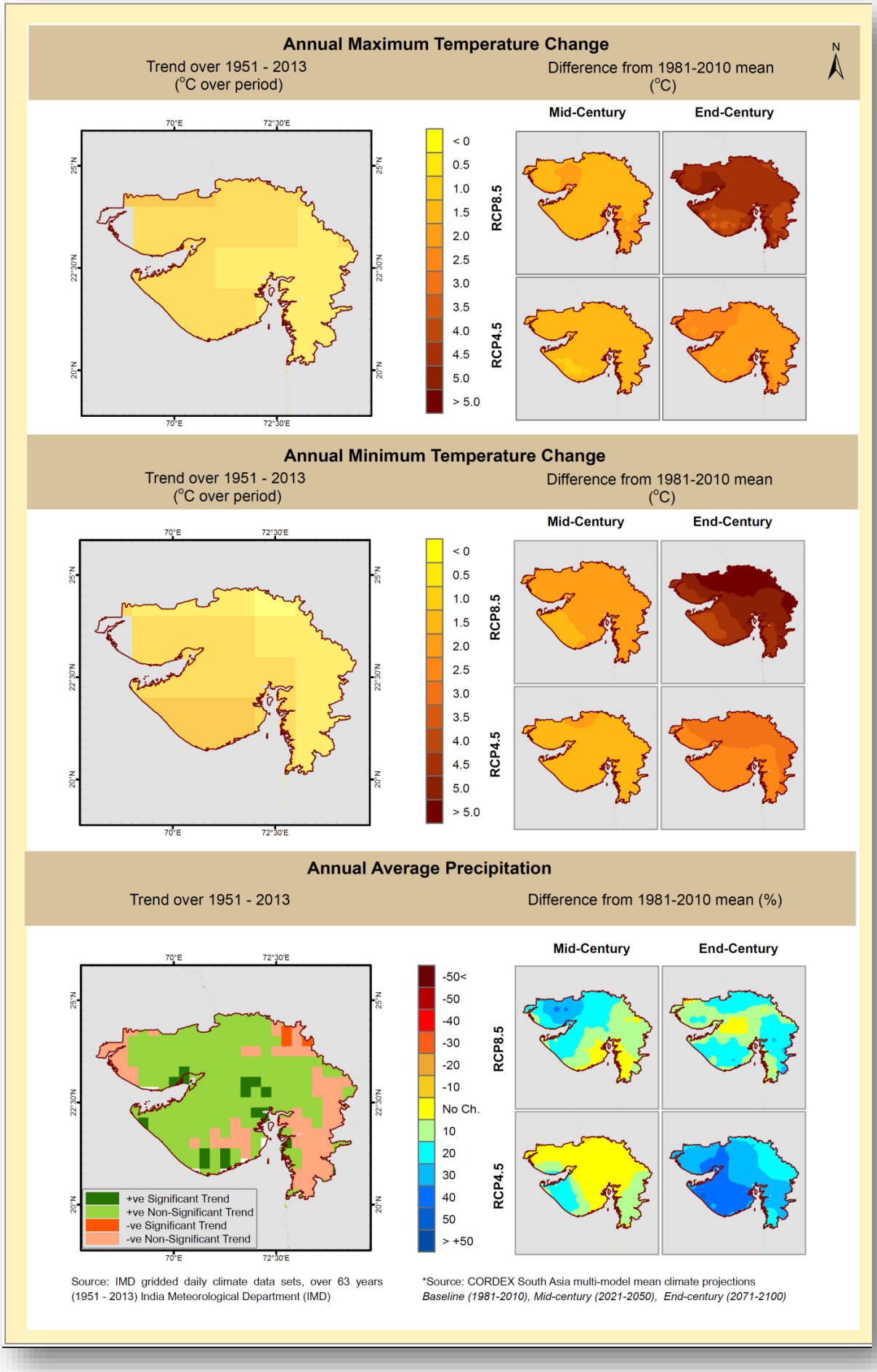
Possible Adaptation (ongoing)

10. Demand management, rain water harvesting, improving irrigation efficiency

11. Less water intensive and heat tolerant crops, resource conserving technology, agriculture extension support

12. Awareness, improved water, sanitation and hygiene, early warning systems

Summary of Current and Projected Climate for Gujarat



Source: IMD gridded daily climate data sets, over 63 years (1951 - 2013) India Meteorological Department (IMD)

*Source: CORDEX South Asia multi-model mean climate projections
Baseline (1981-2010), Mid-century (2021-2050), End-century (2071-2100)