Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra State

Government of Maharashtra Project on Climate Change for the Preparation of the Maharashtra State Adaptation Action Plan

Photo credits: Siddharth Edake, TERI

Presentation- October 7, 2013, Mumbai

Structure of the presentation

- Summary of activities carried out so far
- Approach
- Key Observations
  - Climate Model output
  - MMR- A coastal case study
  - Health
  - Ecosystems
  - Agriculture, Livelihoods and Risk Management
  - Water
- Key Recommendations
  - Adaptation strategy
  - Action Plan
- Way Forward
  - Institutional and financial implications

Post July 12th, 2013... Summary of activities

- Revisited methods being used and results projected for all components of the study
- Analysed the data procured from different departments
- Cross validated the results of model output with data where so ever
- Approached various departments including Water Resources (CAD) and Disaster Management cells of ULBs (specific for MMR).
- Consultations with Departments- Health, UD (I), Environment and BMC
  - Flood map for Mumbai/ MMR
- Shared basic data and data gaps with Dept. of Environment
- Shared the district proposals with DCs and revisited the recommendations.
- Circulated the sector wise background information, literature review, key observations and recommendations.

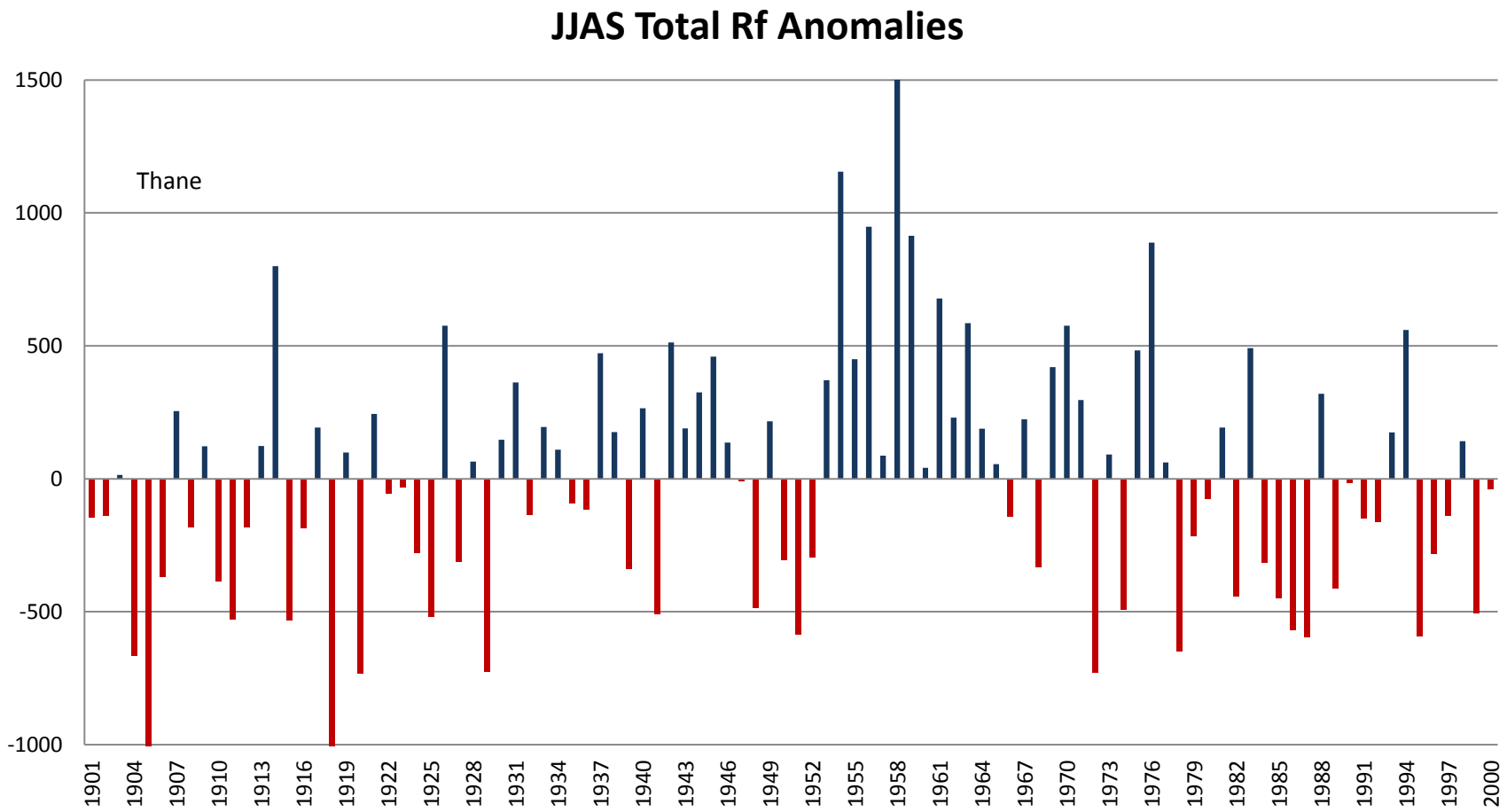
Approach

- There are two sets of information
  - Sector wise background information, literature review and key observations
  - Action plan and recommendations
- The presentation focusses on the Action plan and way forward

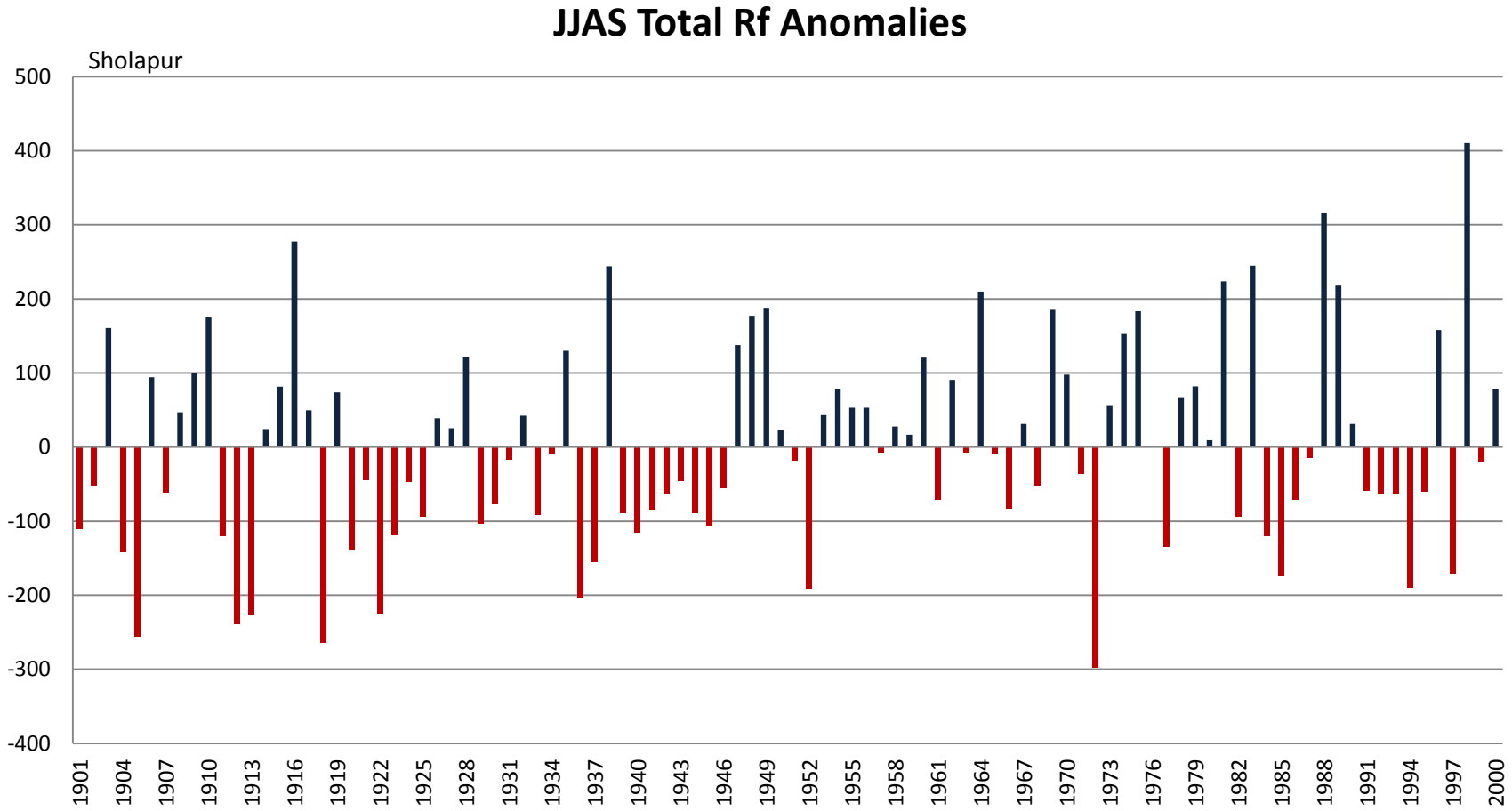
Key Observations

- Climate Model Output
  - Rainfall and temperature changes have been projected for three time slices- 2030, 2050 and 2070.
  - There is an increase in rainfall and temperature in the range of 10- 40% for the rainfall and 1-3°C for temperature.
  - Northern Maharashtra, Marathwada and Vidarbha region may experience increase in rainfall and temperature in the next 20-60 years.
  - Sea level rise projection indicates 2 cm rise by 2050.
- Flood Mapping for MMR
  - Scenarios of inundation studied for events of different magnitude indicate certain vulnerable areas prone to water logging.

Approach to assess rainfall variations
Example- Thane, 100 years (0 line- long term average of observed data: 1980 mm)



Approach to assess rainfall variations
Example- Solapur, 100 years (0 line- long term average of observed data:550 mm)



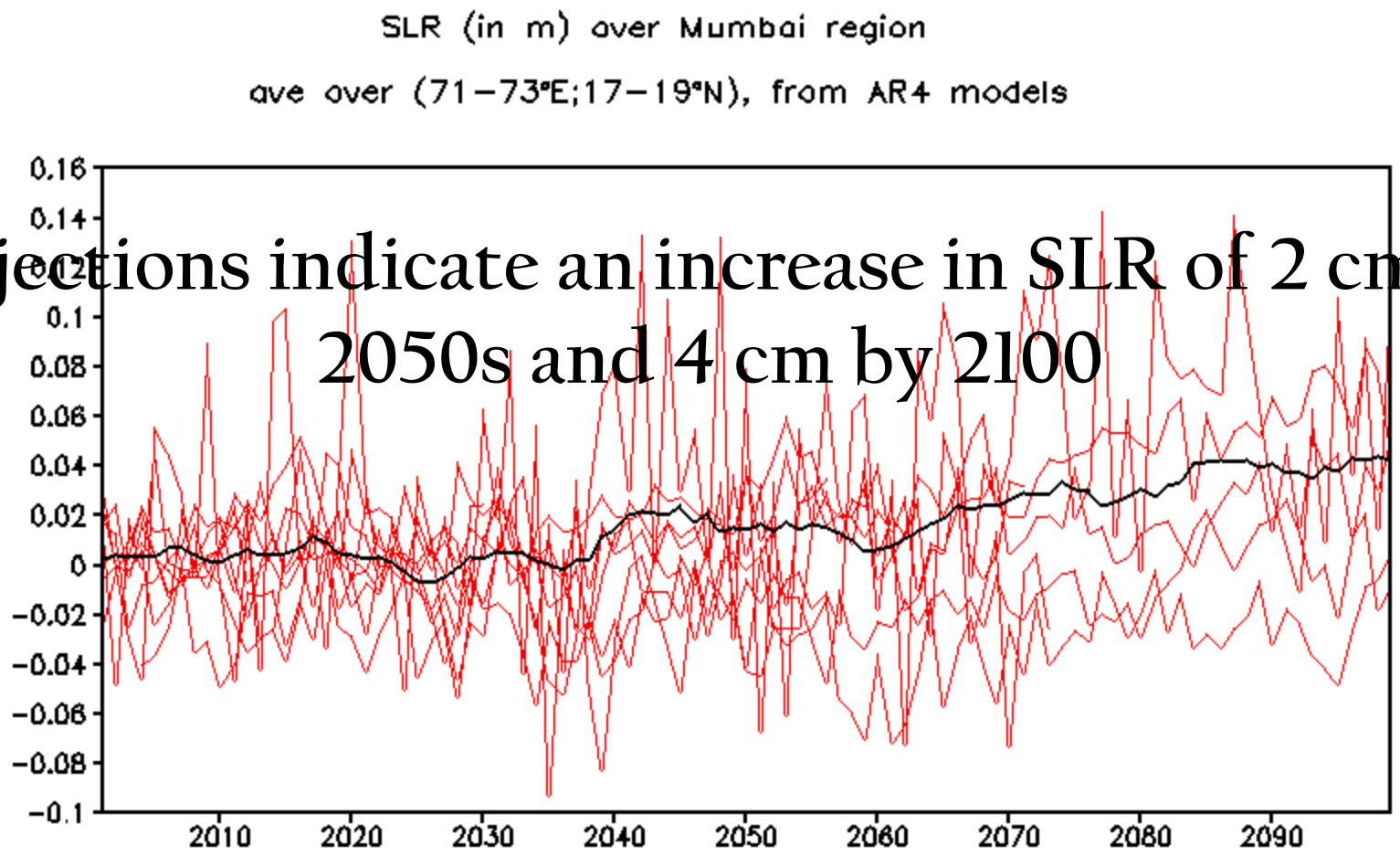
Frequency of rainfall variations- Thane

Thane		
	Rainfall in mm	
Baseline	**Classification**	**Number of events**
Above normal	Class I- (250-500)	11
	Class II- (500-1000)	9
	Class III- (1000 & above)	2
Below normal	Class I- (250-500)	13
	Class II- (500-1000)	14
Solapur		
Baseline	**Classification**	**Number of events**
Above normal	Class I- (150-300)	12
	Class II- (300-500)	2
Below normal	Class I- (100-200)	14
	Class II- (200-300)	6

Coastal impacts assessment
Compounded Impacts on MMR- A case study

- Sea level rise
- High tide levels
- Intensity of Precipitation

Out of 15 models, 9 models were selected which had over 30 years of data available.



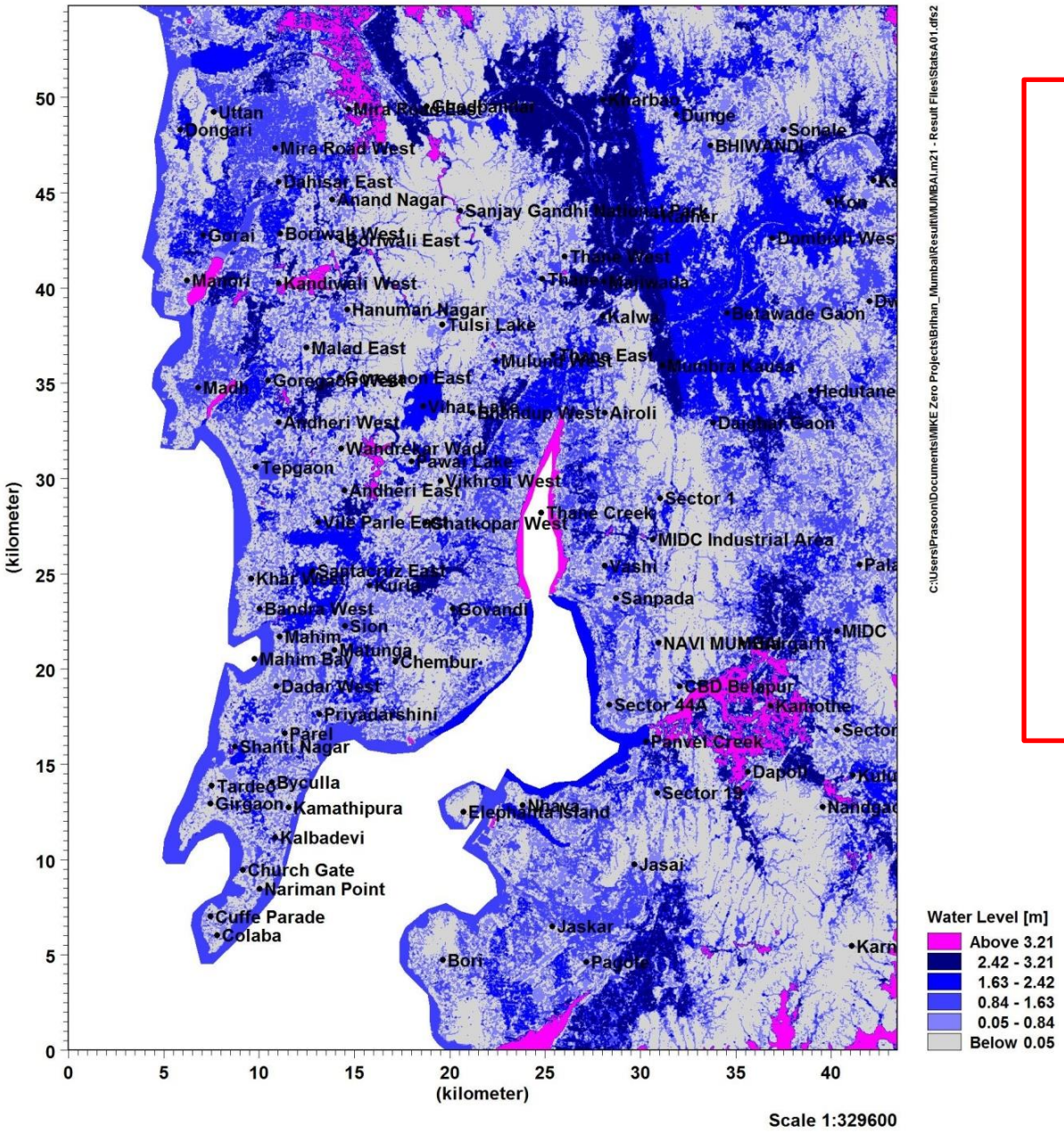
Projections indicate an increase in SLR of 2 cm by 2050s and 4 cm by 2100

Due to the coarse global model resolution ~300km, Krigging methodology applied to interpolate the data onto 1degree or 100km resolution, bringing closer to the coast

2. High Tide Level (HTL) –MMR

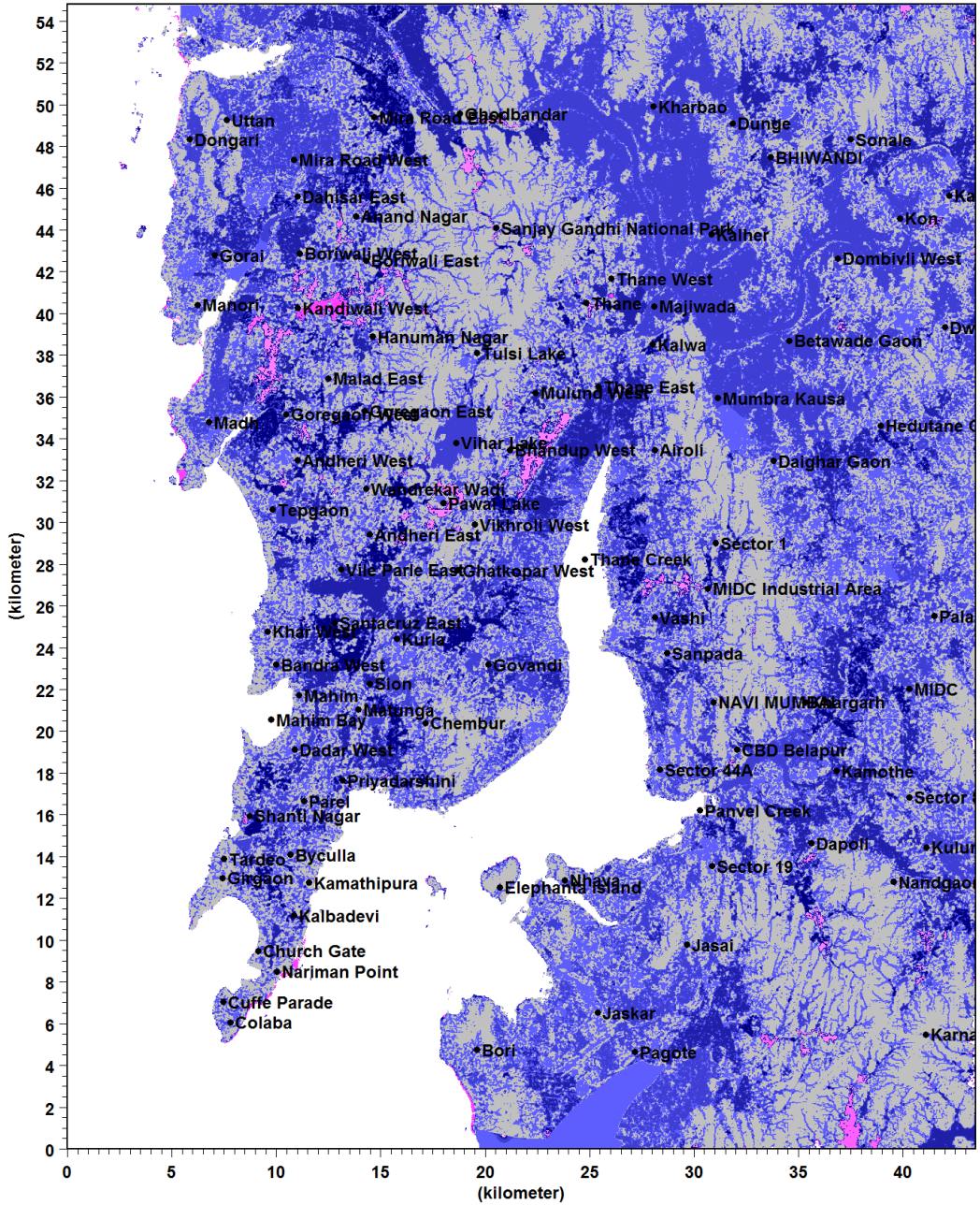
Year	Highest rainfall in mm	Date of highest rainfall	Station	High tide level in mtrs	Time of high tide	Post Event Headlines in Media
2005	944.2	7/27/2005	Santacruz, Mumbai	3.7	4:13 AM	Rains wreak havoc in Mumbai; 150 killed in Konkan
				4.1	4:16 PM	
2006	231	7/5/2006	Santacruz, Mumbai	3.1	7:05 AM	Heavy rains lash Mumbai, schools remain close Rain causes havoc in Mumbai, 24 killed
				3.4	6:15 PM	
2008	249.7	7/28/2008	Colaba, Mumbai	3.7	8:17 AM	Wet weekend spells good news for lake levels Waterlogging, during the high tide in the afternoon, was reported.
				3.4	7:24 PM	
2009	439.1	7/16/2009	Dahanu, Thane	3.4	5:51 AM	Heavy rains lashed the city
				3.6	5:20 PM	
2010	236	6/24/2010	Dahanu, Thane	4.2	10:56 AM	The city also witnessed waterlogging and wall collapses in several areas following the downpour
				3.5	10:22 PM	
2011	232.6	8/29/2011 (New Moon)	Santacruz, Mumbai	4.7	11:58 AM	Mumbai weather: Incessant rainfall leaves city in deep water

Flood Map for 900 mm and above rainfall

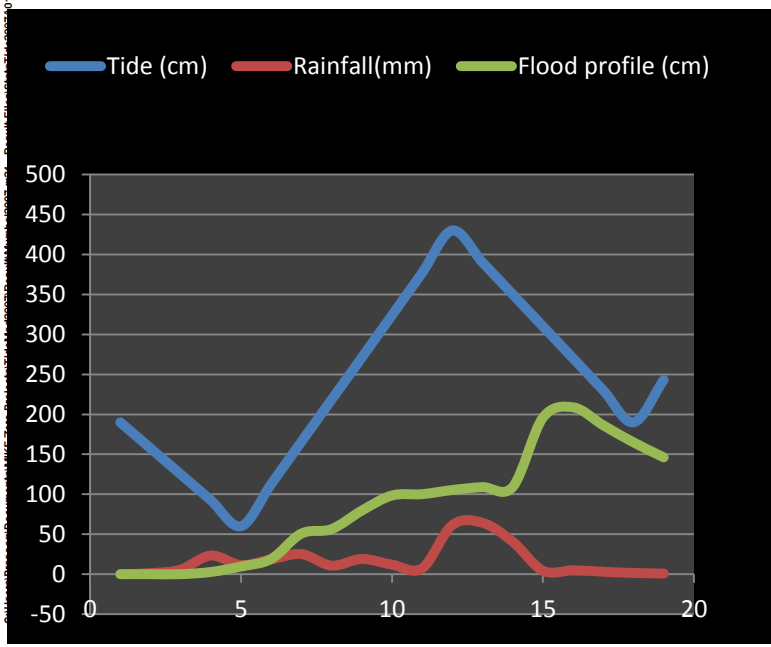


- Maximum intensity was 190.3 mm/hr
- Total Rainfall 944.42 mm over 24 Hrs period

Flood Map 2007



T-R-F Relation



Point near Mahim Creak
(X axis- Time is hours)

Specific Recommendations for MMR

- Strict compliance with CRZ norms.
- Preservation of mangroves, salt pans, coastal wetlands and lakes.
- Protection of native species in these zones.
- Re-naturalization of Mithi River.
- Removal of plastic and unnatural debris from the wetland areas.
- Retain and conserve the Riparian buffer zone around wetlands for improved surface runoff.

Integrated Flood Management Plan for Mumbai

Key components of the action

Establish flood rescue center at flood hot spots
Networking flood rescue centers with other service providers in the city
Use porous asphalt surfaces to increase GW recharge
Map identified **flood hot spots** and share maps with communities to include their inputs
Train the community on actions in case of a flood event
Maintenance of storm water drains and drainage systems

Timeframe

Short Term: 1-2 years
Mapping of identified flood hot spots and sharing maps with the community so as to include their inputs on possible spots of flooding in their area.
Training the community on actions to be taken in case of a flood event
Medium Term: 3-5 years
Establishing a flood rescue center at each of the flood hot spots
Networking the flood rescue centers with other service providers in the city
Using porous asphalt to increase groundwater recharge

Integrated Flood Management Plan for Sub-urban and Peri-urban areas

Key components of the action

Establish flood management department in suburban and peri-urban municipal corporations/ councils of MMR.

- **storm water drainage**: develop storm water drainage network, clean-up drainage network, maintenance and other related tasks.
- **rain water harvesting** : mandate rainwater harvesting structures, regulate and implement permeable surfaces/ roads to increase groundwater percolation
- **weather forecasts**: disseminate real time weather forecast information in monsoons

Publish annual flood management reports to keep a check on the status of the infrastructure.

Regulate conversion of agriculture and forest land into non-agricultural land

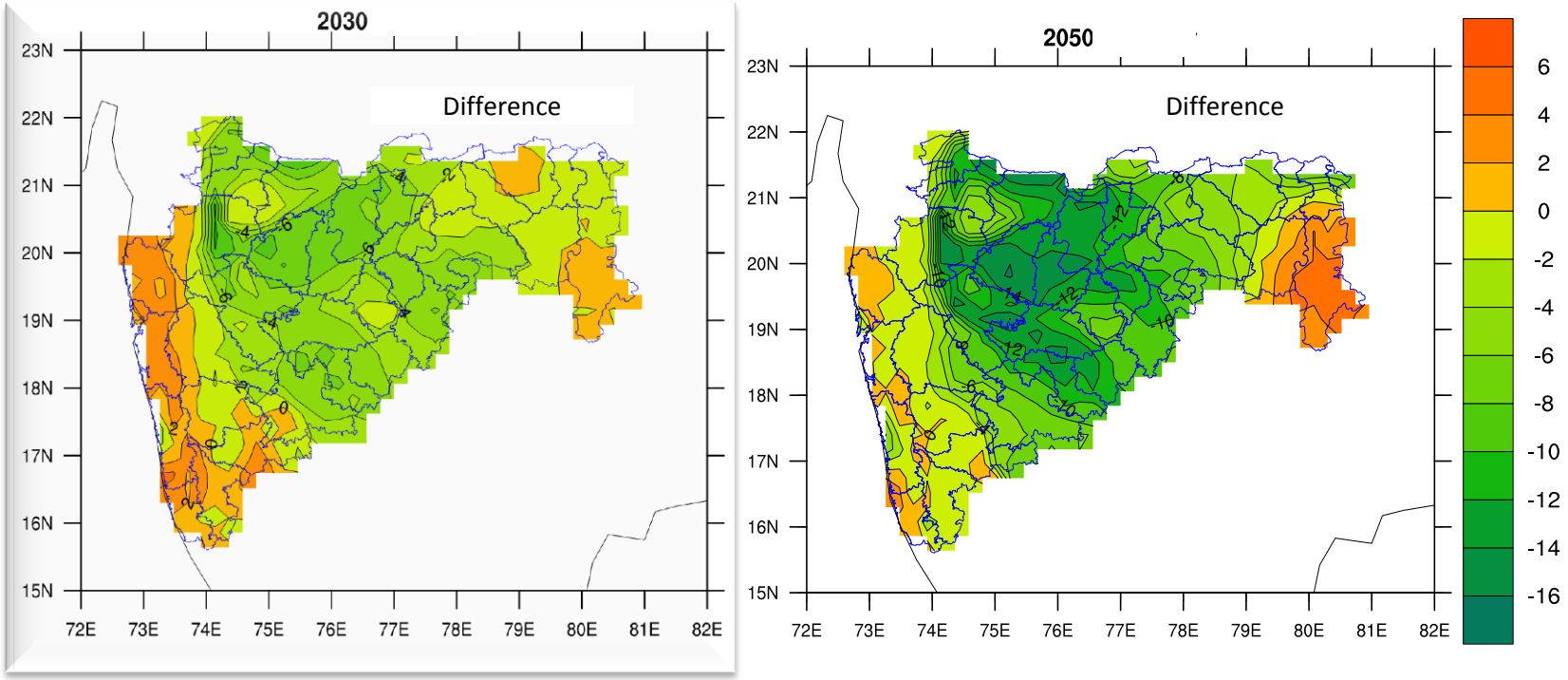
Timeframe

Short-term (1 to 2 years): Establishing flood management department in the municipal corporations/ councils of MMR; Publishing annual flood management reports; Regulating conversion of agriculture and forest land

Medium-term (3 to 5 years): Increasing tree cover in the region

Health

Difference in average number of Conducive Days for spread of Malaria (a) between 2030s and Baseline (b) between 2050s and Baseline



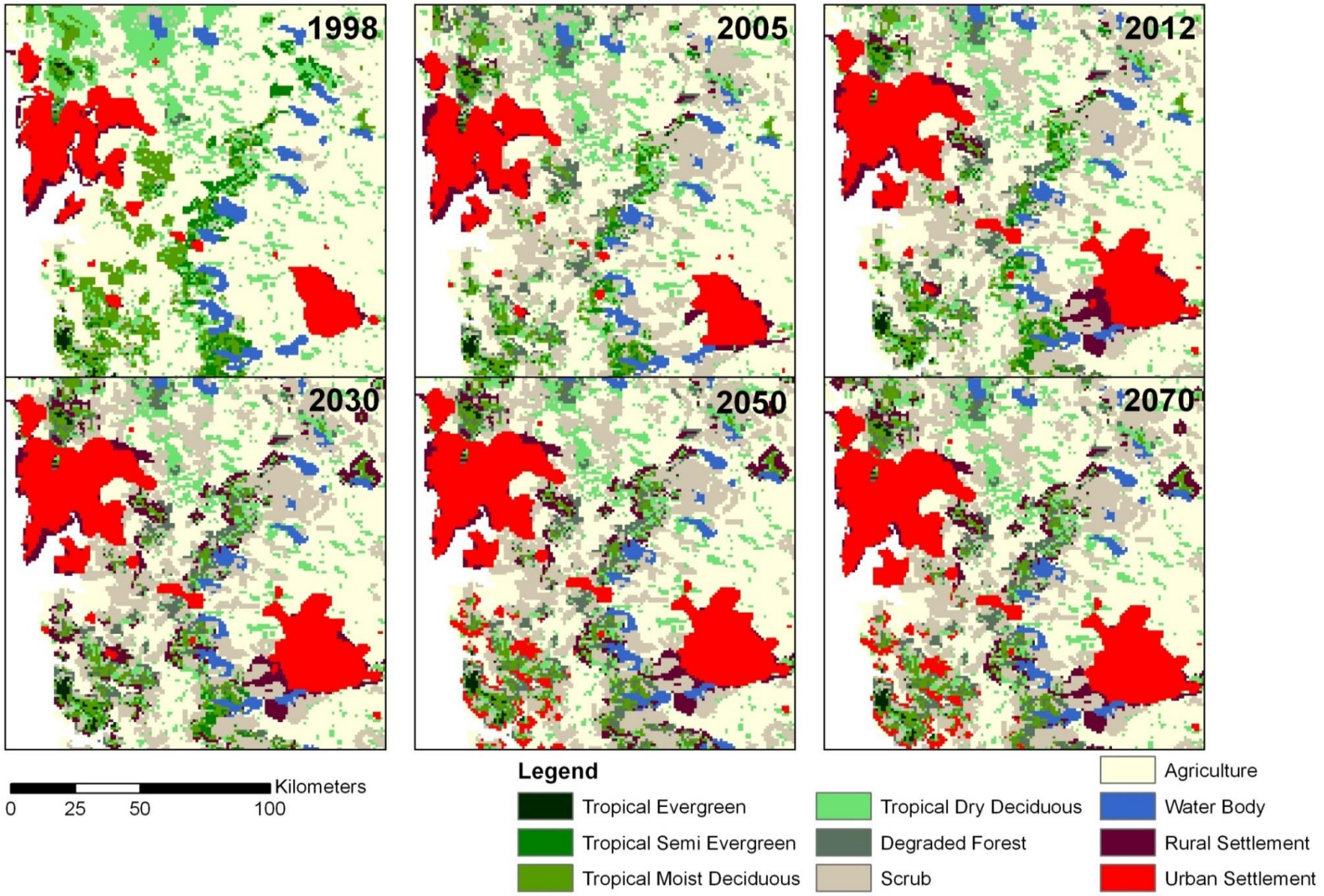
- When compared to the Baseline, some regions (mostly in coastal and eastern tip of Maharashtra) are seen to be showing an increase in average number of conducive days (positive difference) while other regions (mostly Northern, central and south-eastern Maharashtra) show varying degrees of reduction (negative difference) in both 2030s and 2050s.
- The negative difference (reduction in number of conducive days) is seen to be larger in 2050s than 2030s, since the projected rise in mean temperature in 2050s is high enough to exceed the specified temperature criteria for parasite development

Recommendations - Health

- Address data gaps for improved assessments on health. eg., cases reported daily, mortality and morbidity information
- Continue with monitoring & surveillance of climate-sensitive diseases. May cover diseases like dengue and leptospirosis
- Develop systems to adapt to conditions of extreme heat for instance fix certain work hours preventing direct exposure to heat, construct shelters near farm areas
- Invest in health research - Promote research on mutations and its impacts due to changes in temperatures and humidity patterns for emergence of new diseases

ECOSYSTEMS

Fragmentation captured by land use land cover model for parts of the Western Ghats.



Vulnerable Terrestrial biodiversity in Maharashtra

•Biodiversity Hotspots: Total 32 identified sites. Examples include.

•Kalasubai- Harishchandragad WS (Wild life Sanctuary).

•Bhimashankar WS

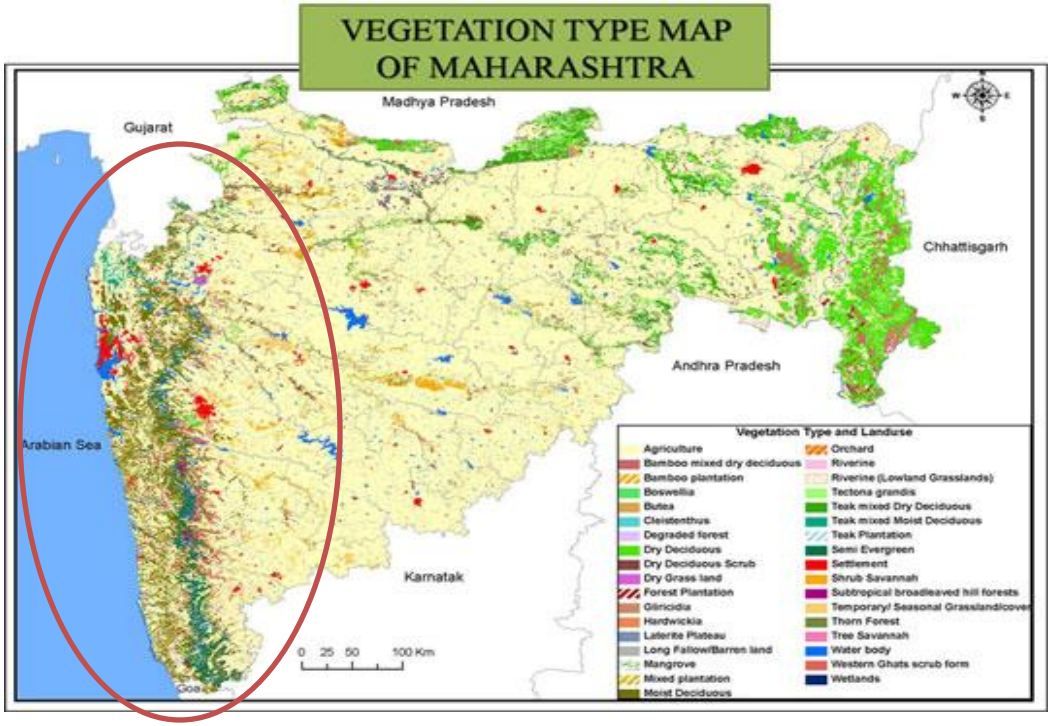
•Amboli – Sawantwadi.

•Ambavane-Khandala Valley.

•Koyana WS

•Mahabaleshwar plateau and Hill Complex.

•Marleshwar



Great Indian Bustard (*Ardeotis nigriceps*)

Indian Black buck (*Antilope cervicapra*)

Bengal Florican (*Houbaropsis bengalensis*)

Recommendation 1 – Ecosystems

- Revival of existing forest monitoring plots at places such as Bhimashankar, Mahabaleshwar, several protected areas, etc. (SFD could undertake this activity collaboratively).
- Need to have genetic prospecting of coastal biota for various purposes e.g. salinity tolerant alleles, etc.
- Diversification of fisheries-based livelihoods

Recommendation 2 – Ecosystems

- Data compilation for detailed analysis of climate impacts
  - Season-wise sea surface temperatures to correlate with season-wise landings
  - Time series data on net primary productivity
  - Data on coastal upwelling and chlorophyll
  - Reasonably long time series data on climatic and oceanographic parameters to detect displacement of stocks and changes in productivity
  - Non-climatic variables that might be responsible for changing composition of fish catch and distributions (e.g. changing tastes and markets, price paid for various fish species, change in type of gear and effort, level of mechanization, location of the actual catch, etc.)

Recommendation 3 – Ecosystems

- Model development for climate change impacts on fish species
  - Need to develop simulation models
  - Regional models are required to assess the implications of climate change on tropical marine fish to understand dispersal patterns, spatial and temporal patterns of various fish species, and ability of fish to cope with a changing climate (thresholds).
  - To run various models like Ecopath, Ecosim and Ecospace, detailed data like biomass, production rates, consumption rates, physiological efficiencies and diet consumption needed

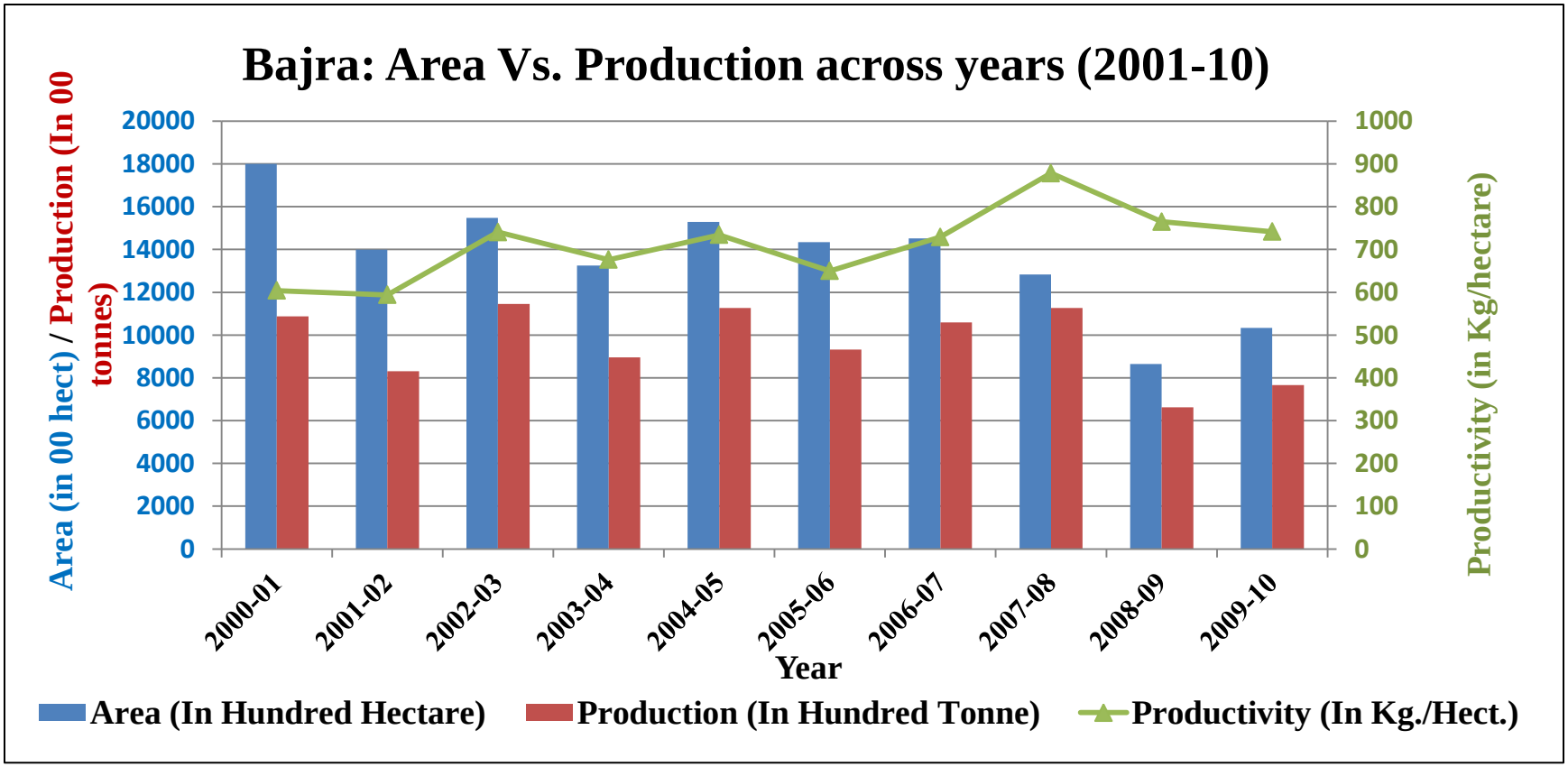

Agriculture, Livelihoods, and Risk Management




Approach 1: Trend analysis
Observation

- Observed that in the year 2007-08, majority of the crops have given good yields.
- We observed strong correlation with rainfall pattern.
- There is a possibility that consecutive good rainfall years has an influence on overall productivity.

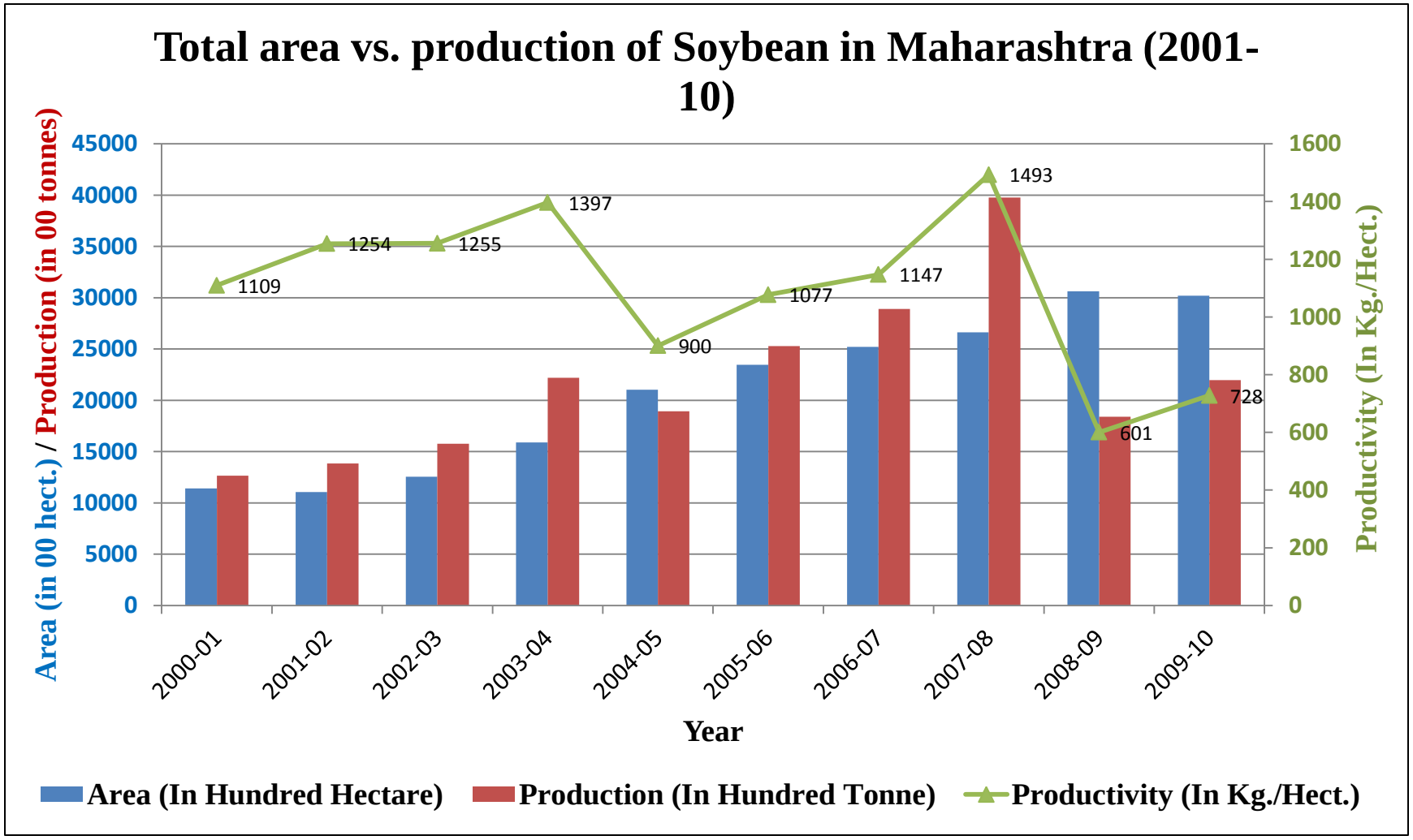
Status of Bajra production across years (2001-10)



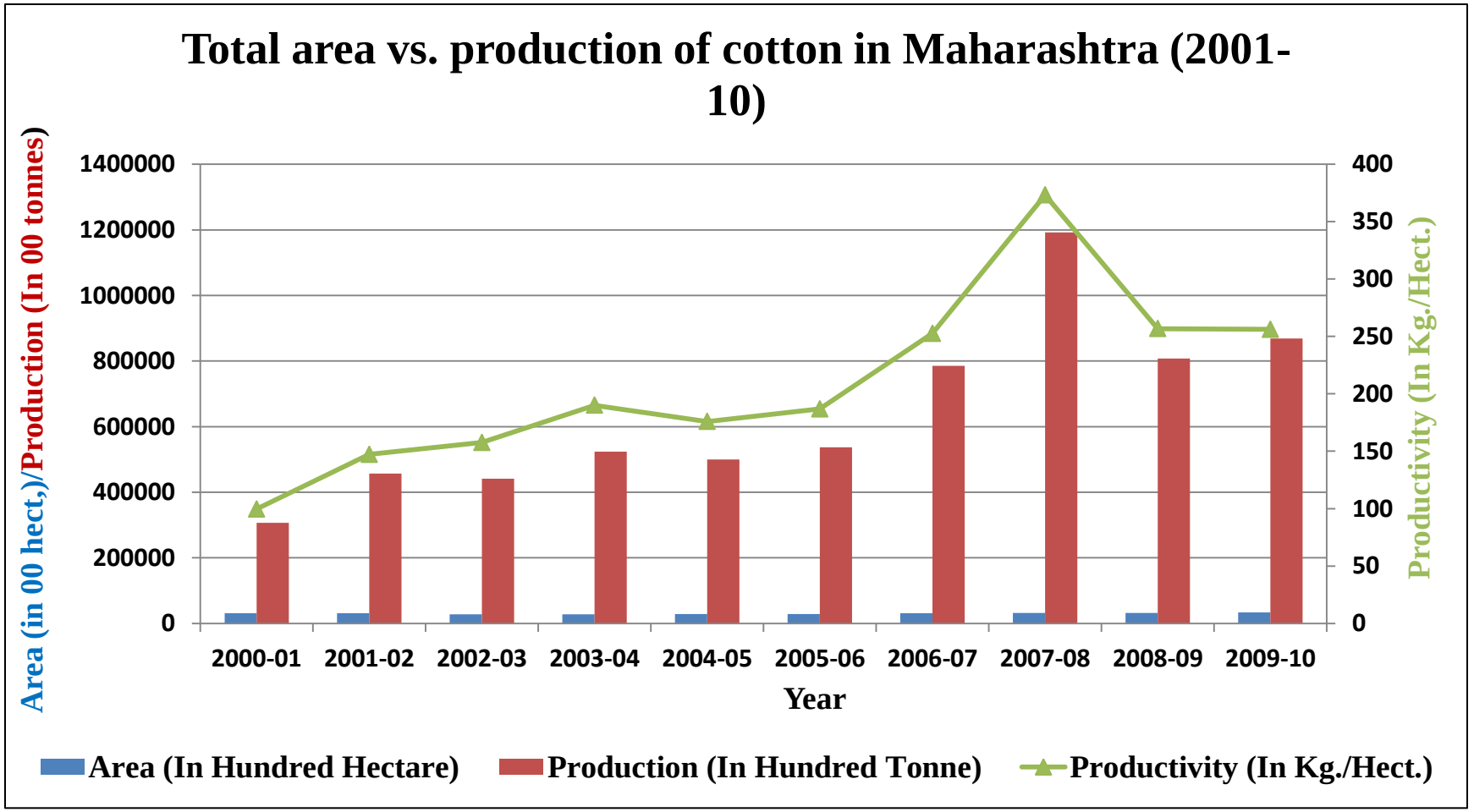
Productivity trend shows increase till the year 2007-08 and then there is a decline. Area under cultivation varies across the years.

Similar Observations for the production trend have been noticed for the year 2007-08

Soybean: Area Vs. Production across years (2001-10)

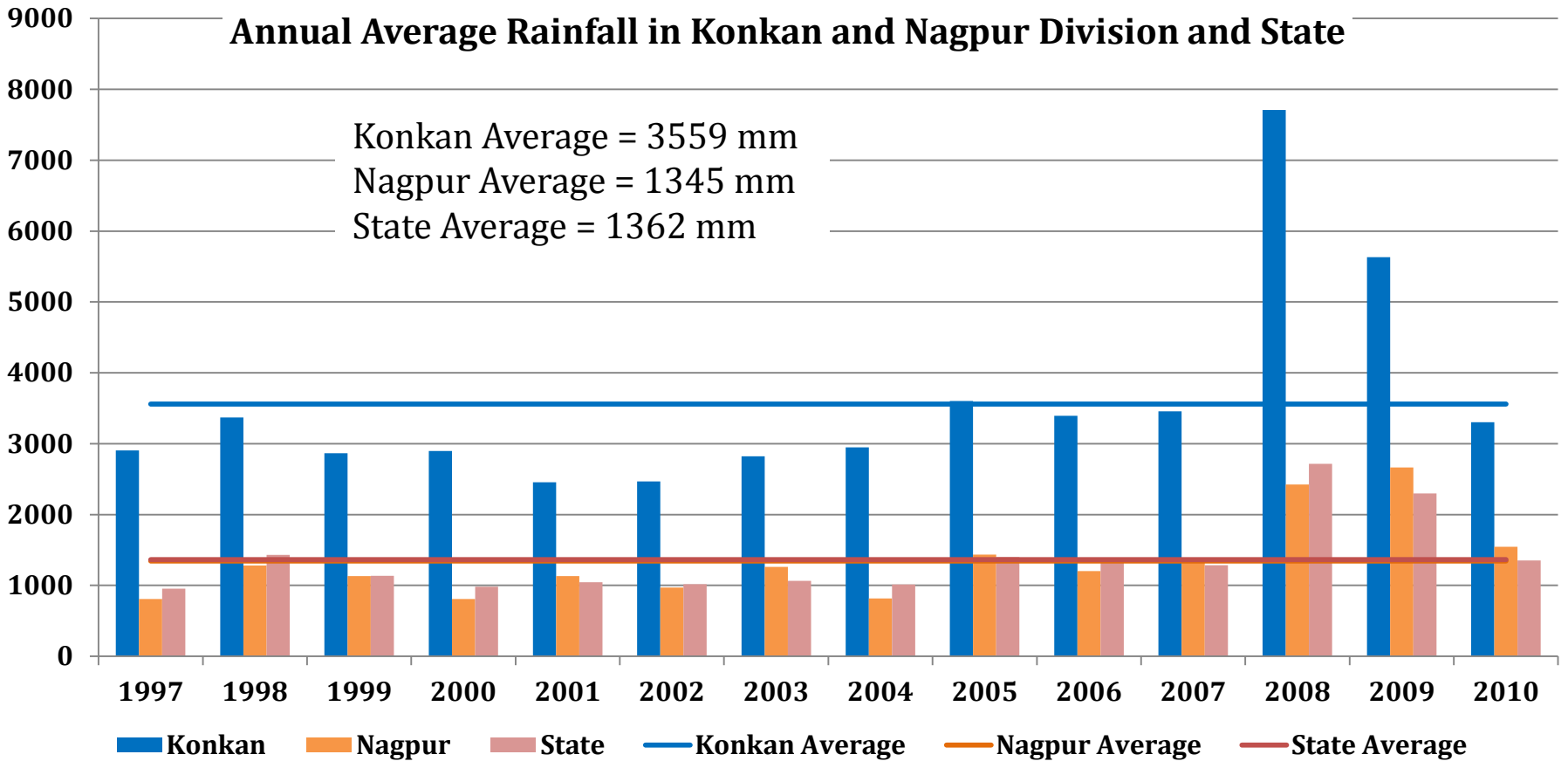


Cotton: Area Vs. Production across years (2001-10)



Note:
Production of Cotton in "00" Bales of 170 kg each.

RAINFALL FROM 2000-10: TO ASSESS THE CORRELATION BETWEEN PRODUCTION AND RAINFALL



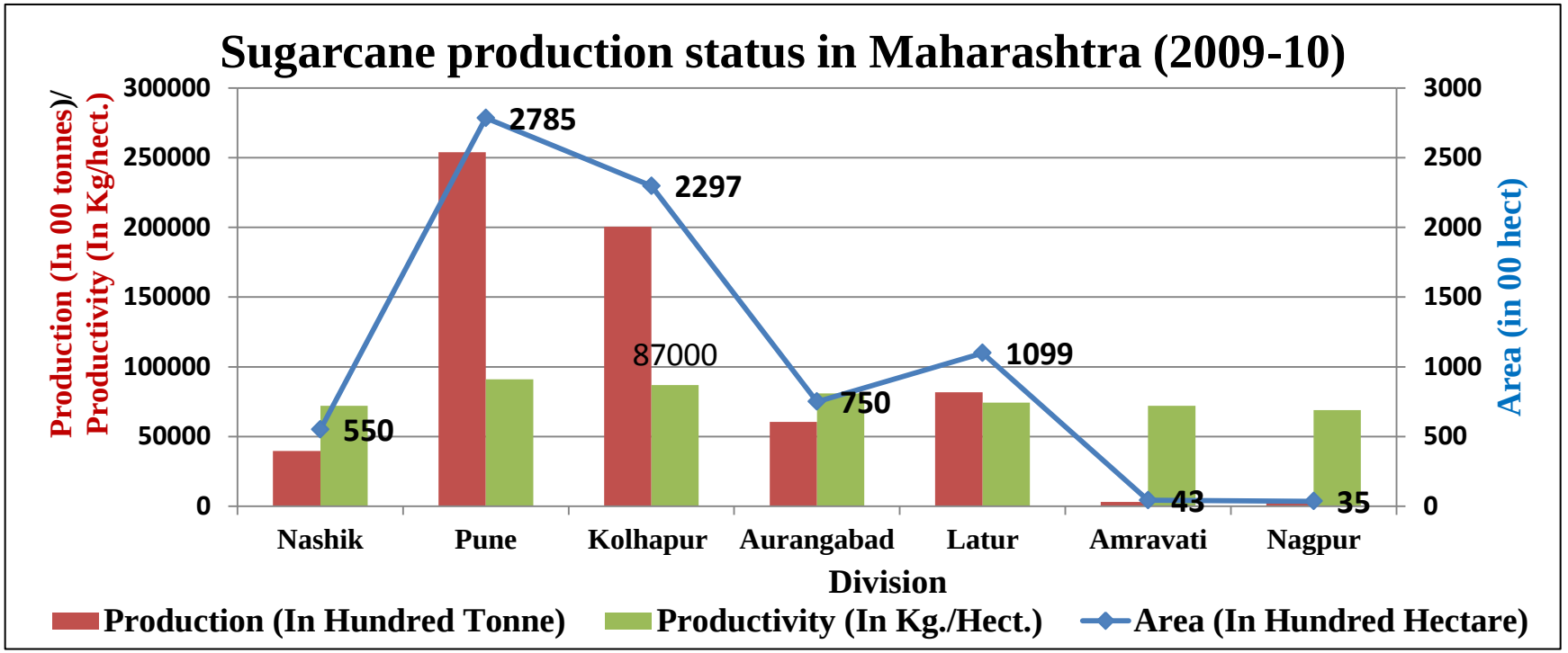
Observation: Between three consecutive years 2005-07 the rainfall has been consistently matching the average

The consistent rainfall may have resulted in higher production of most of the major kharif crops in the financial year 2007-08.

Approach 2: Assessment of vulnerable areas

- Set I: 6 Case Studies. Vulnerability analysis (Socioeconomic and Biophysical factors) of the state indicates that Nandurbar is the most vulnerable district.
- Set II: Six areas which might be impacted due to climatic variations (2030, 50, 70) as indicated by the climate model have been analysed.
  - **Nashik, Dhule, Aurangabad, Ahmednagar, Wardha and Gadchiroli.**
  - Important Kharif crops of the region include
    - **Cotton, Soybean, Maize and Rice**
  - Important Rabi crops of the region include
    - **Wheat and Jowar**
  - Important Summer crops of the region include
    - **Maize and ground nut**

Sugarcane- Perennial, most productive



Major sugarcane producing regions: Pune and Kolhapur

Concerns: water intensive crop. Thus if there is rise in temperature, water requirement for irrigation would increase

Recommendation**:** Technologies like drip fertigation/ irrigation, sprinkler have enhanced productivity by 133% while saving 49% of water. Thus huge potential exists to scale up area using such technologies.

Sugarcane: Highest production in Pune

- Ideal climatic conditions:
  - Rainfall between 1100 - 1500 mm
  - Optimum temperature is 32° to 38°C.

- Mean /Projected Increase:
  - Min Temperature = 0.9 - 1.9°C = 17.76/ 19.66
  - Max Temp = 0.5 – 1.3 °C = 31.59/ 32.89
  - Rainfall = ~30 % = 741/ 963

- Possible Impact:
  The water requirement for the crop are higher than the rainfall of the region which will result in demand for irrigation.

Rice: Highest Production in Konkan

- Ideal climatic conditions:
  - Rainfall between 1200-1400 mm
  - Optimum temperature is 20° to 38°C.

- Mean /Projected Increase:
  - Min Temperature = 1.01 - 1.6°C = 21.6/ 23.2
  - Max Temp = 0.6 – 1.8 °C = 32.8/ 33.6
  - Rainfall (mm)= ~12 % = 3164/ 3543

- Possible Impact:
  Temperature rise in the konkan region lies in the range of the conditions optimum for rice cultivation, however flash floods may impact the yield of rice.

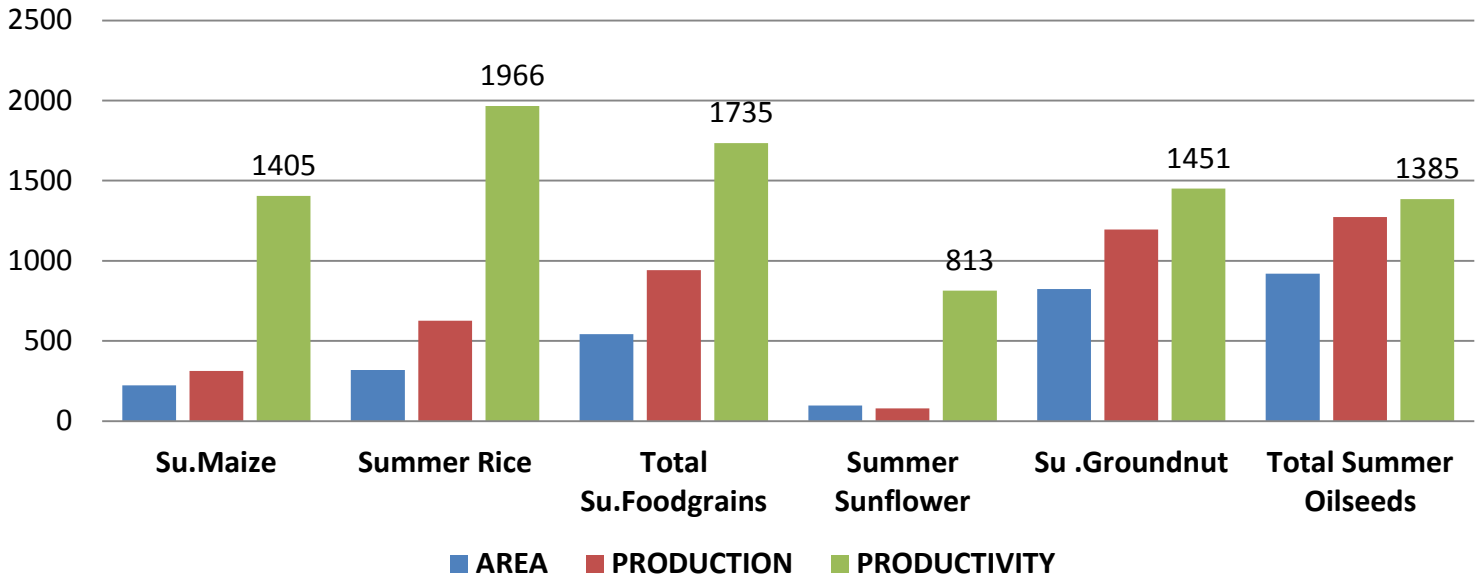
Rice: Highest Summer Rice Production in Bhandara

- Ideal climatic conditions:
  - Rainfall between 1200-1400 mm
  - Optimum temperature is 20° to 38°C.

- Mean /Projected Increase:
  - Min Temperature = 0.9-2.1°C = 20.9/ 22.1
  - Max (Summer) Temp = 1.12 – 1.6 °C = 32-38/ 33.31-39.6
  - Rainfall = ~20 % = 1388/ 1665

- Possible Impact:
  As summer temperature of Bhandara lies between 32-38 °C, projected increase in temperature of 1.6 °C summer rice may get affected as more than 37°C temperature affects the flowering and hence reduces the yield.

Summer crops are productive and significant for the state



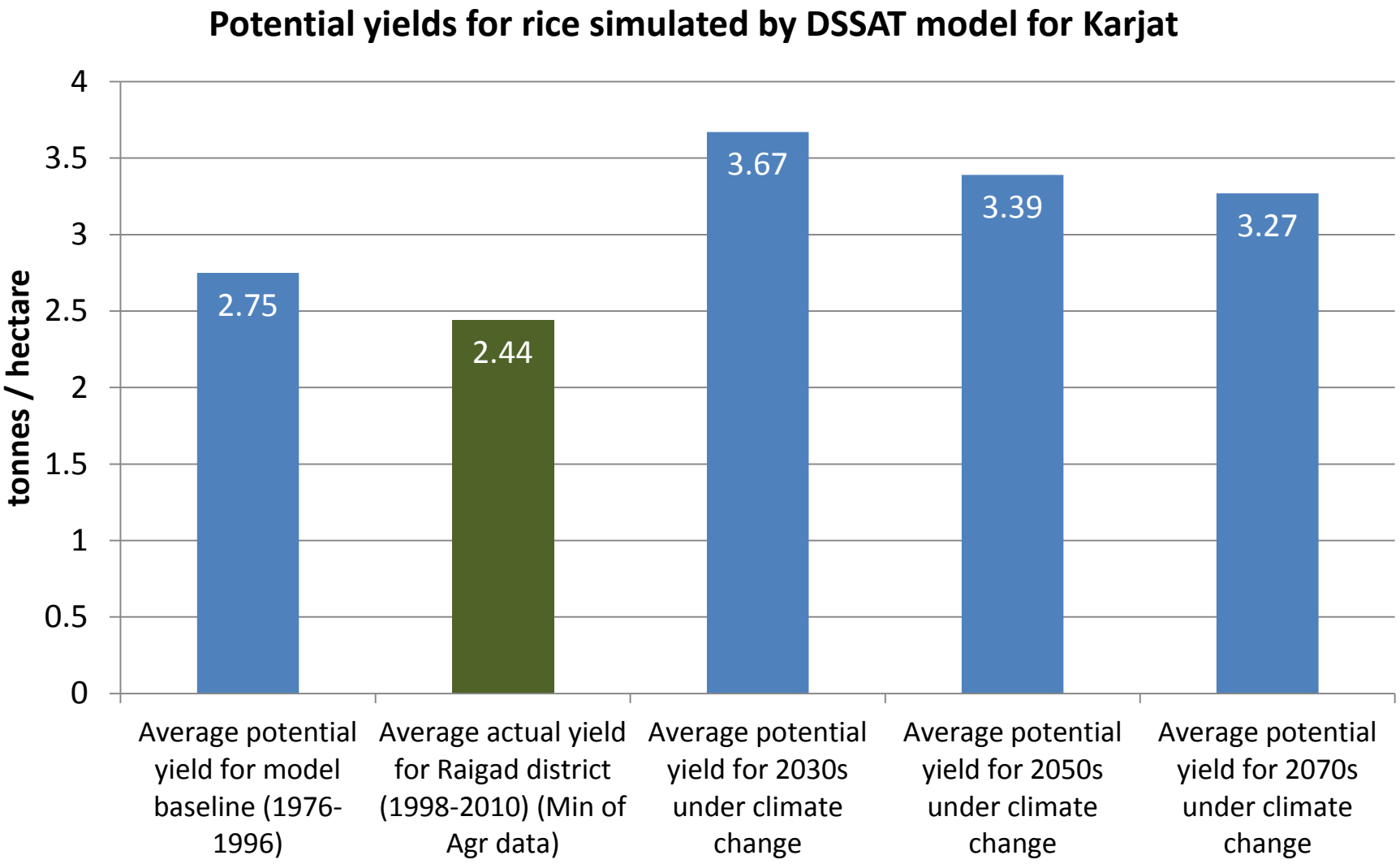
Significance: Highly productive and may provide as an excellent source for food and fodder

Concern: The area under cultivation is very low and hence its potential is not fully exploited

Recommendation:

- The area under cultivation to be increased using water efficient technologies like drip.
- Water storage could be looked at as an option to harness increase in rainfall being projected.
- Provide food and fodder during peak summer months through these highly productive summer crops

Approach 3: Crop Modelling – rice as an example



Critical gaps

- Field experiments to allow for simulations
- Data on crops grown, cultivars, genetic coefficients, crop management practices, soil conditions needed
- Region specific observed data on actual and potential yields of crops
- Our understanding about other factors and its influence for instance changes in disease dynamics and pest infestation of crops

Research: Scope for further improvement

Management Information System

- Maintain localized data regarding climatic factors, socioeconomic and Biochemical factors governing crop productivity.
- Practices followed across the world could be analysed and suitably adopted.
- Research stations should be equipped to demonstrate these practices at field levels for uptake and maintenance of records by communities.

Approach 4: Community consultations- Six case study sites

Discussion with the Govt. officials at Gondia Collector Office

Discussion with the farmers at Lonar Taluka, Buldhana

Key Highlights

- Perceptions about changes in climate and sensitivity of crops reported
- While % access to irrigation is reported to be high in case study areas, poor water supply are noted to affect rabi and summer yields
- Large percentage of households report weather forecasts to be reliable and useful. Varied sources reported from where information is picked up.

Recommendations 1 - for Agriculture, Livelihoods, Risk Management

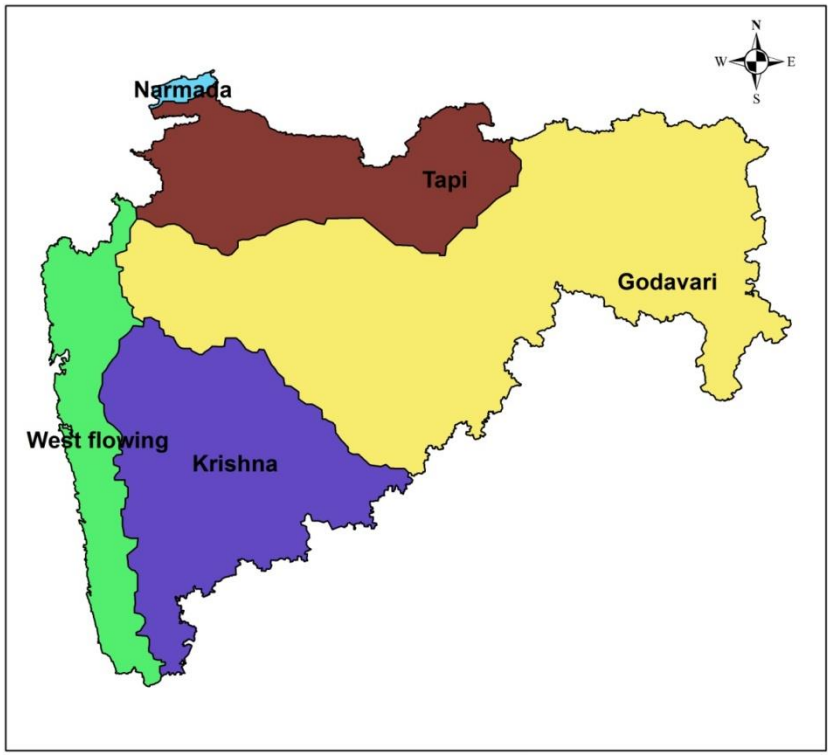
- Potential for scaling up water efficient technologies – may enhance area under irrigation and assure water supplies for irrigation in peak months
- Water storage could be enhanced to capitalise on increase in rainfall
- Considerable scope for agricultural processing and value addition of various crops

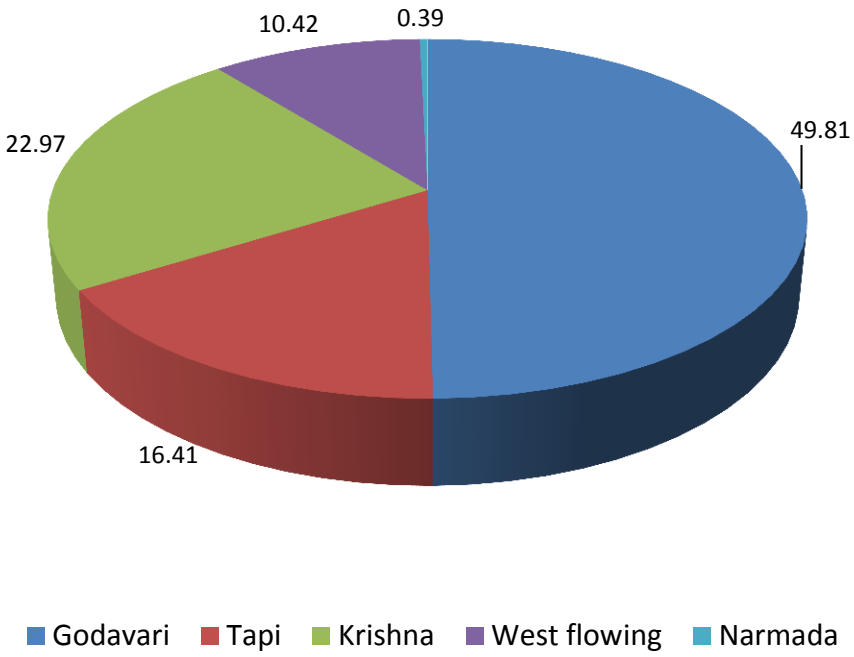
Recommendations 2 - for Agriculture, Livelihoods, Risk Management

- Introduce modes that can help non-loanee farmers also to draw on risk covering mechanisms (small-marginal, medium categories)
- Farmers' access to farm management information and technologies needs to be strengthened
- Participatory exercises could be used to develop village specific information that may help for planning and better utilisation of in-situ resources (align with RKVY and Eco-villages)

Water Resources

Basins in Study Area





% area under each river basin

Legend

Maharashtra Basins

- Godavari
- Krishna
- Narmada
- Tapi
- West flowing

0 50 100 200 Kilometers

Summary of regional rainfall patterns and key climate vulnerabilities

Region	Divisions	Districts	Normal annual rainfall (mm)	Key vulnerabilities
Vidarbha	Amravati	Amravati, Akola, Buldhana, Washim, Yavatmal	1104.6	Long dry spells, Recent increase in rainfall variability and decrease in amount, Salinity problem in Amravati, Akola, and Buldhana districts
	Nagpur	Nagpur, Bhandara, Chandrapur, Gadchiroli, Gondia, Wardha		
Marathwada	Aurangabad	Aurangabad, Beed, Hingoli, Jalna, Latur, Naded, Parbhani, Usmanabad	840.4	Drought-prone, Low forest cover, Low irrigation availability
Western Maharashtra	Nashik	Nashik, Ahmedanagar, Dhule, Jagaon, Nandurbar	850.5	Drought-prone, Water-intensive cultivation, Soil erosion,
	Pune	Pune, Kolhapur, Sangli, Satara, Solapur		
Konkan	Konkan	Mumbai City, Mumbai Suburban, Raigadh, Ratnagiri, Sindhudurg, Thane	2978.6	High intensity rainfall, Coastal salinity, Severe soil erosion

Source of rainfall data: India Meteorological Department

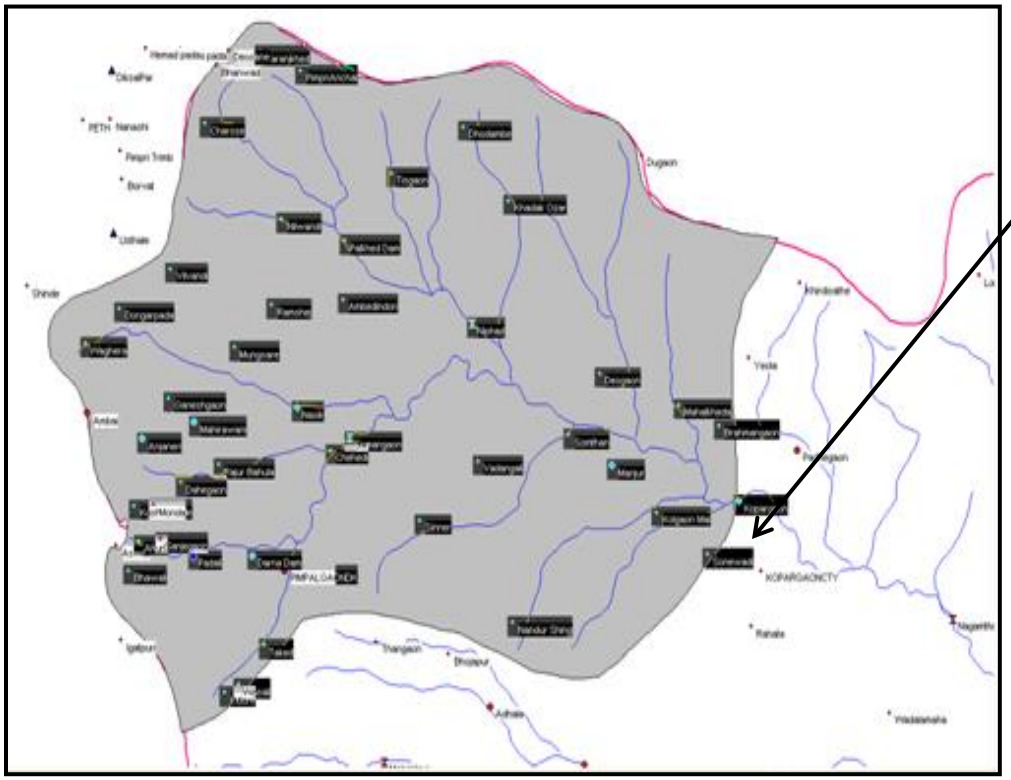
Consultations with Water Resources Department

- Meeting with Irrigation department on 18 September 2013 requesting to share data on surface runoff
- Meeting with Chief Engineer, Water Resources Department, Nashik on 5 October 2013.
  - Agreed to share processed runoff data with TERI. But need to follow the procedures and require time to process the data.

Validation of model results with the observed data from Water Resources department

Date	Runoff depth (in mm)
7/22/2011	0.2646903
7/23/2011	0.1353855
8/3/2011	0.56476
8/4/2011	0.3497046
8/5/2011	0.3071975
8/6/2011	0.3497046
8/7/2011	0.6305498
8/8/2011	0.56476
8/9/2011	0.4494696
8/10/2011	0.35708
8/11/2011	0.9822664
8/12/2011	1.40963
8/13/2011	0.88036
8/14/2011	0.9461499
8/15/2011	1.909008
8/16/2011	1.297866
8/17/2011	0.2924275
8/18/2011	0.2646903
8/19/2011	0.3071975
8/20/2011	0.3995871
8/21/2011	0.2291134
8/22/2011	0.2646903
8/23/2011	0.2291134
8/24/2011	0.1935364
8/29/2011	6.546689
8/30/2011	6.546689
8/31/2011	1.09403
Total Runoff	27.3662703

Partial catchment area of Godavari River



Discharge Gauge stations at Kopargaon. Runoff calculated at Kopargaon station for this catchment area.

Total 253 stations in Maharashtra located in each sub-basin for each of the rivers

Constraint: High data cost (INR 600 per station per year)

(Data for 30 years, 253 stations= ~40 lakhs)

Action Plan

- MMR
  - Adaptation Strategy
    - Preservation of mangroves, salt pans, and other wetlands
    - Introduce integrated flood management system for the city and suburbs
  - Action Plan
    - Strict compliance of CRZ norms in the coastal parts of Shivadi, Navi Mumbai and Thane.
    - Protection of mangroves along the coast- Shivadi, Airoli, Borivali and Western suburbs, preservation of salt pans in the entire MMR region.
    - Wetlands protection plan for urban areas. Holding ponds at Navi Mumbai need to be specially protected.
    - Compounded impacts of developmental and environmental pressures on the urban ecosystems need to assessed and subsequent changes in the policy need to be brought out
- Agriculture
  - Adaptation Strategy
    - Safeguard farmers against climate risks
    - Enhance resilience of farming systems
    - Secure food supply chains
  - Action Plan
    - Agri universities and research stations to help disseminate climate services to communities.
    - To assess best management practices for significant crops like Sugarcane, Maize and Ground nut.
    - To compare potential of new varieties developed at other states/ research institutions and to assess potential for introduction into the state.
    - Water efficient technologies to be promoted in general, but specifically for water intensive crops.

Action Plan

- Ecosystems
  - Adaptation Strategy
    - Promote Biodiversity conservation.
    - Research including simulation/ modeling exercise for selected locations and species.
  - Action Plan
    - Launch a Green Maharashtra Mission that aims to promote conservation of species, address data gaps and improve research in related areas.
    - Revival of existing forest monitoring plots at places such as Bhimashankar, Mahabaleshwar, several protected areas, etc. (SFD could undertake this activity collaboratively).
    - To diversify fisheries related livelihood especially in districts like Sindhudurg.
- Health
  - Adaptation Strategy
    - Improvement in health infrastructure.
    - Invest in health research.
    - Develop systems to adapt to conditions of extreme heat
  - Action Plan
    - Enhanced monitoring & surveillance for different climate-sensitive diseases
    - Promote research on mutations and its impacts due to changes in temperatures and humidity patterns for emergence of new diseases
    - To fix certain work hours preventing direct exposure to heat, construct shelters near farm areas especially in the districts where temperature increase is projected to be high. For Examples- Wardha, Nagpur, Gondia and Solapur.

Way forward

- Template to be developed for detailing key recommendations drawn from the adaptation strategies
- Institutional framework for implementation
- Financial needs on key recommendations to be taken forward

Thank you