Indo-UK Collaborative Research Programme on the Impacts of Climate Change on India

Vulnerability and Adaptation Assessment for Madhya Pradesh

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Development Alternatives
B-32, TARA Crescent, Qutub Institutional Area, New Delhi - 110016, India

Team Leader
Dr.K.Vijayalakshmi

Team Members
Anand Kumar
Mustafa Ali Khan
Kavita Syal
Neelam Rana
Lokendra Thakkar
Manohar Patil
Rajita

Innovation Systems Branch, Development Alternatives, New Delhi, India
Phone: +91 11 2656-4444, 2654-4212 Fax: +91 11 2685-1158
Email: kvijayalakshmi@devalt.org

Executive Summary

Introduction

The findings of the recent fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) has clearly brought out the seriousness of the climate change issues and the need for taking urgent measures for dealing with them. India is among the countries that are most vulnerable to adverse impacts of climate change with economic losses potentially as high as 5-9 per cent of GDP (Stern Review). To study these issues in detail, the Ministry of Environment and Forests (MoEF), Government of India, and the Department for Energy and Climate Change (DECC), Government of UK, undertook the Indo-UK collaborative research program on the impacts of climate change in India. Result of this study indicated that Madhya Pradesh would be a severely affected region in the event of climate change. Therefore, under this program Development Alternatives (DA), Environment Planning and Coordination Organization (EPCO) and Stockholm Environment Institute (SEI) have undertaken a study on "Vulnerability and Adaptation Assessment for Madhya Pradesh". Given the higher vulnerability of the agricultural sector and the dependence of a large proportion of the population of the state on agricultural activities the focus of the study was on the agricultural and water system of the state.

Objectives

The overall goal of the research project is to prepare a climate change adaptation plan for the two agro-climatic regions of Madhya Pradesh and to integrate the adaptation plan with the existing programs and schemes in the state. The specific objectives of this study being:

- To conduct vulnerability assessments for understanding climate induced vulnerabilities at different levels.
- To analyze existing/new adaptation practices and assess their feasibility for policy based replication in Madhya Pradesh.
- To link various research outputs to existing development activities

Approach and Methodology

Overall Approach

Overall approach followed for this project sought to proactively engage stakeholders/stakeholder institutions in a process of dialogue through the course of the assignment via workshops, brainstorming sessions, in-depth interviews, observing on-site conditions together with client, et al. This research project was divided into four key components and under each component major activities were as follows (Figure 1):

a) Set up and mechanisms for effective delivery: In order to run the project successfully a short scoping phase had been designed with the following key activities: Situation Analysis for climate change adaptation in Madhya Pradesh and Partnership Development.

b) Impact and Vulnerability Assessment

c) Adaptation Planning and option assessment

d) Scale-up Planning and Capacity Development Assessment

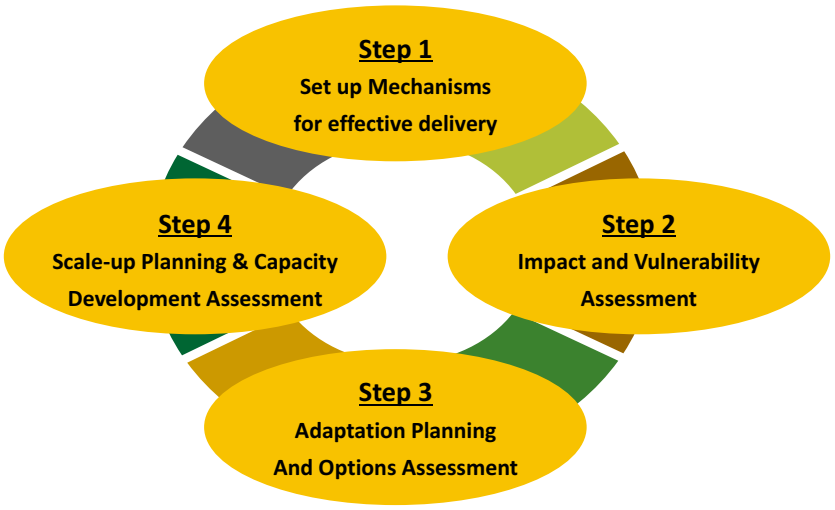

Figure 1: Overall approach to conduct the vulnerability assessment

Data sets used

In order to conduct the impact and vulnerability assessment and plot the same onto maps and in order to aid in the planning process a number of data sets and specialized spatial and non-spatial software packages were used. For the purpose of impact assessment study the literature was reviewed along with the assessment of different types of models used for study the impact of climate change. The different types of software used to study the impact of climate change in the present study are CERES-Wheat model and CROPGRO-soybean model. The data used to carry out the impact assessment simulations consists of the meteorological data, agronomic data and edaphic data. This data has been procured from the following centres:

a) Indian Institute of Tropical Meteorology, Pune, Daily Climate Data for 1960-2100

b) Indian Meteorological Department (IMD), Pune

c) National Institute of Disaster Management (NIDM), Impact of Climate Change on Agri Yields, CROPGRO-soybean and CERES-wheat models

d) National Remote Sensing Centre (NRSC), Hyderabad

e) Spatial Information System (SIS)

The data collected corresponds to the precipitation, minimum temperature, maximum temperature and solar radiation parameters on a daily basis for the years 1969 to 2005. This data was used to analyze the future impact scenarios of climate change on wheat and soyabean in the two agro climatic zones of Bundelkhand and Malwa. For the purpose of climate impact assessment on crops the A1B scenario was used. A1B describes a future world of very rapid economic growth with global population that peaks in mid-century and declines thereafter. Impact of climate change on grain yield of crops was studied using A1B 2030 scenarios derived from the PRECIS RCM. The PRECIS is a Regional Climate Model with HadCM3 as its GCM. The climate model's outputs on temperature (minimum and maximum) and rainfall for A1B-2030 scenarios were coupled to the baseline weather data.

Satellite imageries have been procured from National Remote Sensing Agency for the 4 districts and land use maps have been prepared. The GIS based maps is being utilized for communicating to policy/decision makers.

For assessment of vulnerability climate data was used along with the household data and information generated from crop simulation modeling exercises. The crop simulation exercises depend on the climate data to predict future yields of wheat and soy bean crops. The climate data was also used to understand the variability of criteria and the long term trend of parameters.

For the purpose of conducting vulnerability assessment indices were computed for all four districts under study. The following equations were derived to calculate vulnerability of the districts:

Indicators Index (Ix)	Profile (P)	Component (C)	Vulnerability Index
= [Ib - I (min)] / [I(max) - I (min)]	= (ni=1 Ixi) / n	=[(ni=1 WPiPi) / (ni=1 W Pi)]	= (E-A) X Sensitivity

Block level assessments were carried out for each of the four districts. Various indicators were selected for developing the profile. These indicators include average no of drought events in past 10 years, average rainfall (mm) (over the period of (2002-2007), average temperature (oC), rural BPL families, per capita forest cover, ground water table (m), wasteland (ha), work force in agriculture, yield per hectare, net irrigated area, no of pump sets per ha agri land per capita loan, average land holding, livestock population, number of pukka houses. The vulnerability profile is in the range of -1 to +1 showing low to high vulnerability.

Key Findings

Climatic Assessments

Data and analysis shared by IITM Pune indicates a declining trend for rainfall over the state of MP from 1901 to 2000. The trend is even worse if the data if the last 5 decades alone is analyzed. This shows water availability in Madhya Pradesh has been declining. Also the extraction of groundwater has been increasing. Put together this indicates that level of ground water has also gone down. If similar trends continue it will result in even lesser amount of ground water availability thus enhancing the risk of crop failure in times of low rainfall as life saving irrigation will not be present.

Studies carried out by EPCO have also shown that winter precipitation in Bundelkhand region may drop by upto 50% by 2100. This reduction in precipitation if and when it happens is bound to have serious impacts on the food security in the region in particular and in the state in general. It is the winter season in which the wheat crop is grown in the state. However, it needs to be remembered that these are results of modeled projections and therefore are probabilistic outcomes. Also, inter annual variability in the projected precipitation is very high and therefore adaptation measures which are decided upon need to be robust enough to factor in these uncertainties. Wheat is the major food crop of Madhya Pradesh. In absence of rainfall farming community will have to depend on irrigation from groundwater. Carrying out irrigation for agricultural activities is a fuel intensive process in absence of quality electricity supply. Many households are not able to support irrigation costs. Carrying out irrigation also reduces the returns on sale of produce as the inputs costs become higher.

Agricultural Assessments

In the case of wheat crop it was found that the productivity of potential yield of wheat is likely to change -14 to -20% in A1B 2030 scenarios depending upon the locations. As average of 4 locations the yield (potential, irrigated and rainfed) is going to decline by -18 to -23%, total above ground biomass by -8% to -13% and maturity duration decreased by -3 to -8%. The A1B 2030 scenarios projected somewhat higher surface air temperature than observed weather records for the present day atmosphere and as a consequence the simulated grain yields show a decline in crop yields. The yields in wheat are found to decline almost identically for the all 4 locations, but rain fed environment will be more suffer than other. The total above ground biomass will also be affected and going to decline during 2030s. The maturity duration of the crop will be reduced by 4-10 days all locations depending on production environments.

For soybean the simulation analysis indicates that the productivity of potential yield of soybean in MP region is likely to change -14 to -17% in A1B 2030 scenarios depending upon the locations. As average of 4 locations the yield (potential, irrigated and rainfed) is going to decline by -16% to -24%, total above ground biomass by -6% to -13% and maturity duration increased by 3% in potential and irrigated condition but decline by 2% in rain fed condition. The yields in soybean are found to decline almost identically for the all 4 locations. The total above ground biomass will also be affected and going to decline during 2030s. The maturity duration of the crop is extended by 3 - 4 days all locations.

Vulnerability assessment

A comparison of various blocks in the Bundelkhand and Malwa region indicated that across the districts the block with the highest vulnerability is Tikamgarh in Bundelkhand region of MP.

The household surveys carried out in Bundelkhand and Malwa validate the findings of the indices based results obtained from secondary research. The key results obtained from the household surveys which were carried out using a structured questionnaire are being presented below for Bundelkhand and Malwa region. A total of 600 household surveys were undertaken across the two regions. In order to make the surveys representative the widest geographical coverage in the state was taken up. For representing different socio economic strata in the data collection process staggered, learnings based approach was followed.

Important findings of the survey in Bundelkhand were as follows:

- Average landholding of the farmers is 2 hectares
- 55 % of the surveyed population had undertaken migration in the last 5 years. Out of these in 67% cases only the bread winners had migrated while in the other 33% cases entire family had migrated
- 72% of the migration took place for fulfillment of basic needs
- Average credit per family in a year is Rs. 9,000/-
- Money had been borrowed by 70% of the respondents. 52% of the money is being lent out by informal institutions such as villagers and money lenders
- 96% of the respondents perceived agricultural activities to be highly sensitive to weather phenomenon

- The primary reason of shifting away from agriculture has been poor returns
- Migration of farmers was absorbed by the construction labour sector in high infrastructure growth centres such as Gurgaon, Delhi, Faridbad, Jhansi etc.
- The level of trust among villagers has got worse in the past 5 years (67% of respondents)
- 80% of the respondents are not satisfied with the operations of the government departments
- 15% of farmers have changed their rabi crop from wheat to other crops such as sesame, lentils etc.

Some of the key findings of the household level survey carried out in Malwa region are as follows:

- The people of the region are economically very backward with almost 86% of the households holding a ration card of Below Poverty Line category
- 39% of the persons interviewed has expressed that the financial condition of their household is good, while 28% has reported to be either bad or very bad, whereas another 33% reported to be indifferent
- 32% of the people admitted to have taken loan from various sources. 8% of the respondents have mortgaged assets
- An overwhelming 80% of the persons questioned is of the opinion that his/her fellow villagers are always ready to help out others
- Only 2% of the respondents daily listen to radio
- Only 22.5% of the respondents are of the opinion that there is enough quantity of water for irrigation purposes

Conclusions

In this light it is evident that adaptation to climate change needs to be supported and catalyzed within the agricultural system of Madhya Pradesh.

The overall strategy for adaptation to climate change may consist of the following core action points:

- Enhancing water use efficiency to increase availability and accessibility to water. Fiscal instruments linked to water use efficiency may be put into place as means of facilitating behavior change.
- Establishment of knowledge platform contributing to policy formulation leading to community empowerment. The Bundelkhand Knowledge Platform is an example of such a platform. It was initiated for engaging with stakeholders for effective participation in drought mitigation actions in Bundelkhand, and engagement with state level and national partners for dialogue on climate change mitigation and adaptation.
- Blending formal and informal science for enhanced delivery on ground: Agricultural communities have been adapting to changing climate over the centuries. Thus the communities have knowledge which has been accumulated over the centuries and is appropriate for the local region. There is however a need to validate the traditional practices through modern scientific methods.
- Increasing access to appropriate technology for adaptation to climate change: Access to appropriate technology remains a big hurdle to adaptation in agriculture. Therefore, there is a need to establish Farmer/Agriculture Resource Centres which would serve as centres which facilitate the last mile

connect between the research outputs at the university/research institute level and agricultural practices of the farmer.

- Provision of Weather Based Crop Insurance: Weather based crop insurance has been hailed as a major breakthrough in adaptation to climate change sectors. However, weather based systems do not take into account the microclimatic variations which exist even within small regions. There are situations where in there is only a single weather monitoring station for one district.

Some of the short and medium term (2-3 years) measures which may be suggested are:

- Promotion of efficient irrigation, soil conservation methods and agro-forestry involving demonstration plots and exposure visits of farmers. Although single interventions have limited impacts; putting together different available technical options coupled with institutional strengthening demonstrate significant impacts. Farmers are ready to adopt 'demonstrated beneficial practices' even if these are not formally validated by research / Government institutions
- Extension of crop insurance to cover more farmers as the current penetration of the insurance scheme is not adequate
- Establishment of “Farmers Adaptation Clubs/Clusters” to bring farmers together to respond to the threats of climate change by connecting them to local markets
- Enhancing the access to information of the farmers by use of innovative platforms such as radio based Rural Reality Shows and mobile telephony. Access to knowledge and information and cooperative action will enable farmers to enhance productivity, reduce input costs and quick change in strategy when the monsoon variability threatened the kharif sowing
- As exchange of knowledge is critical to adaptation there is a need to set up or to strengthen existing knowledge platforms
- No cost options such as change in sowing dates have been shown to minimize losses or to actually increase the yields of agricultural crops. Such measures need to be tested at a pilot level for research purposes and then if found feasible, be scaled up

In the long run there will need to be a systematic approach to the problem and may consist of:

- Conducting research to identify the best approach to adapt agriculture to climate change by determining the crop mix which will be most resilient to the impacts of climate change in different regions of the state
- Establishment of a meteorological network in the state to provide customized local information and forecasting services to the farmers will help in reducing the impacts of climate variability
- Institutional capacity building will play a crucial in adapting to climate change by providing appropriate direction and channelization of funds and efforts. Therefore there is a need of a long term program for capacity building on key aspects of climate change adaptation
- The Government of MP needs to review its procurement policy to include/enhance quota for alternate crops such as sesame for preferential purchase in drought prone areas

For decision makers it has been observed that it is very important for them to understand the relevance of the suggested adaptation options in case the predictions made by the modeling exercises do not happen or happen at a magnitude which was lesser or more than that predicted.

Below is a robustness matrix which presents the various adaptation options and how relevant each one of them is in case climate change does not take place, the impacts of climate change are less than that predicted, impacts are as they were predicted and impacts are more than they were predicted to be. The robustness of each one of the adaptation options has been derived from a combination of expert view, consultations and direct on ground observations.

Measures	Adaptation options	Climate change impacts less than predicted	Climate change impacts as predicted	Climate change impacts more than predicted	Action required	Relevant department
Short term measures	Efficient irrigation	✓✓✓	✓✓✓	✓✓✓	Large scale application of technology in farmers' fields	Agriculture, Irrigation
		✓✓✓	✓✓✓	✓✓✓	Wider dissemination	Finance, Agriculture
	crop insurance Establishment of "Farmers Adaptation Clubs/Clusters"	✓✓✓	✓✓✓	✓✓✓	Mobilization of farming community	Agriculture
	access to information	✓✓✓	✓✓✓	✓✓✓	Conceptualize and plan for programs	Information Technology, Telecom, Information Broadcasting
	Knowledge exchange	✓✓✓	✓✓✓	✓✓✓	Set up/support platforms	Information Technology, Telecom
Long term measures	Change in Sowing dates	✓✓✓	✓✓✓	✓✓✓	Pilot level tests	Agriculture
	Research and development for determining crop mix	✓✓✓	✓✓✓	✓	Plan and initiate field level experiments	Agriculture, Irrigation, Power
	Establish meteorological network	✓	✓✓✓	✓✓✓	Plan and implement network	Meteorology
	Institutional capacity building	✓✓✓	✓✓✓	✓✓✓	Develop curriculum	Human Resources
	Procurement policies	✓✓✓	✓✓✓	✓✓✓	Review existing policy	Planning

✓✓✓ = robust; ✓✓ =less robust; ✓ =not robust

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1. INTRODUCTION

"Climate change affects us all, but it does not affect us all equally. The poorest and most vulnerable - those who have done the least to contribute to global warming - are bearing the brunt of the impact today"

- Ban Ki-Moon

The findings of the recent fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) has clearly brought out the seriousness of the climate change issues and the need to take urgent measures to deal with them. India is among the countries that are most vulnerable to adverse impacts of climate change with economic losses potentially as high as 5-9 per cent of GDP *(Stern Report)*. To study these issues in detail, the Ministry of Environment and Forests (MoEF), Government of India and the Department for Energy and Climate Change (DECC), Government of UK undertook the Indo-UK collaborative research program on the impacts of climate change in India. Result of this study indicated that Madhya Pradesh would be a severely affected region in the event of climate change. Therefore, under this program Development Alternatives (DA), Environment Planning and Coordination Organization (EPCO) and Stockholm Environment Institute (SEI) have undertaken the study on "Vulnerability Assessment and Adaptation Planning for Madhya Pradesh".

1.1 Objective

The overall goal of the research project was to prepare a climate change adaptation plan for Madhya Pradesh (Bundelkhand & Malwa agroclimatic regions) and to integrate this adaptation plan with the existing programs and schemes running in the state. The specific objectives of this study were:

(i) To conduct vulnerability assessments for understanding climate induced vulnerabilities at different levels.

(ii) To analyze existing/new adaptation practices and assess their feasibility for policy based replication in Madhya Pradesh.

(iii) To link various research outputs to existing development activities.

1.2 Background Context

India is one of the fastest emerging economies with nearly 700 million rural population directly dependent upon climate sensitive sectors (agriculture, forests and fisheries) and natural resources for their subsistence and livelihoods. Further, the adaptive capacity of dry land farmers, forest dwellers, fisher folk and nomadic shepherds is very low. Climate change is likely to impact all the natural ecosystems as well as socio-economic systems as per the National Communications Report of India to the UNFCCC[1].

Madhya Pradesh is the second largest state of India (with around 50 districts, spread over 11 agro climatic

1 National Communications Report of India, 2004, Government of India.

zones). The state is marked by a complex social structure, predominantly agrarian economy, difficult and inaccessible terrain, along with scattered settlements over a vast area that together pose several formidable problems to service delivery systems[2]. As per Census 2001, the total population of the state was 60.35 million out of which the rural population was 73.54 per cent. The state has a high proportion of tribal population (23 percent of total tribal population in the country) which has the lowest human development index (predominantly tribal districts like Jhabua, Barwani, Panna, Khargone, Betul etc. are at the lowest rank of HDI)[3]. This group is highly dependent on agriculture for their food security and income. Agriculture is predominant sector in the state (75 per cent of rural population dependent). The state is characterized by predominance of marginal and small farmers. The net area sown is about 150.74 lakh hectares which is half of the MP's geographical area. Total irrigation area of the state is 30.5 per cent and about 70 per cent of area is rainfed, cropping intensity of the state is 135 per cent. The most important crops are rice, wheat, soybean, sorghum (jowar), maize, pulses (peas, beans, lentils), and groundnuts[4]. Although studies on climate change assessment at state level are few some kind of conclusions may be drawn from regional projections and estimates.

(i) **Agriculture Sector:** Within India MP's significance as an agricultural state has recently increased. Agriculture in MP is mostly rain-fed;: the total irrigated area of the state is 43 per cent and 70 per cent is rain fed. Erratic and uneven distribution of rainfall is the major constraint for achieving targeted level of production[5]. MP is predominantly a kharif (monsoon) crop growing state (kharif 55 per cent and rabi (winter crop) approx 45 per cent). 41 per cent of crop production is in cereals, 21 per cent pulses and oilseed 27 per cent, the remainder being vegetables, fodder and horticulture. The area under irrigation is less than the national average. Fertiliser consumption was less than 40 per cent of the national average in 2001-02. On average 8 per cent of crops are lost to pests every year. In 2007-08 around half the land of the State was sown.

(a) Being an agrarian economy (with 43 per cent of the workers being classified as cultivators and 29 per cent agricultural labourers) climate change can pose serious threats to the state's economy at the same time affecting developmental goals of the state.

(b) Wheat yields in central India are likely to suffer a drop of up to 2 per cent in a pessimistic scenario, but there is also a possibility that yields may increase by 6 per cent if the global change is optimistic.

(c) The increased climatic variability may affect rain-fed crops, such as pulses, significantly.

(d) A temperature rise of 3°C might nullify the positive effect of doubled CO2 on soya bean yield at few places in Madhya Pradesh.

(e) In rain-fed areas groundnut yields would increase under doubled CO_2 and temperature increase up to 3°C if the rainfall did not decline. Reduction of rainfall by 10 per cent might reduce the yield by 12.4 per cent.

2 Meryln Hedger and Vaideeswaran S, March 2010, Scoping Study for Madhya Pradesh State Climate Change Action Plan. DFID (India),IDS
3 National Human Development Report, 2002, Planning commission, Government of India.
4 Indian State of Forest Report -2009
5 State Plan 2009-10

(f) It is expected that the response of crops to the added fertilizer would be lower, as climate becomes warmer. In future, therefore, much higher levels of fertilizer may need to be applied to meet the increasing demand for food.

(ii) **Forests:** MP has highest forest cover of all the states. Forest resources are rich in the central, eastern and southern parts, the western area (including Malwa) is susceptible to desertification. According to Forest Survey of India Report 2009, the state has 77,770 square Km forest cover (25.21 per cent of geographical area). Comparison of the current forest covers (Oct-Dec 2006) with the previous assessment (Oct-Dec 2004) shows loss of 39 square km of forest cover[6]. Around two-thirds is reserved forest and one third is protected forest comprising four forest types: tropical moist, tropical dry, tropical thorn, and subtropical broadleaved hill forest. These ecological resources are main source of livelihoods for rural and tribal populations living in and around the forests, with a large number of Non Timber Forest Products (fuel, fodder, fiber and timber) being collected for income generation. As many as ten million people live in the 22,000 villages located in the vicinity of the forests, majority belonging to the scheduled tribes who are largely dependent on the forests for subsistence and daily needs. Climate change is predicted to result in a large scale shifting and change of forest biomes throughout India. These shifts will impact livelihoods at a community level, as well as impact trade of forest products at the regional and national levels. These are:

(a) The biome type most seriously impacted is the Dry Savanna.

(b) Dry Savanna (33 per cent) is projected to change (year 2085) such that Tropical Dry Forest (37.2 per cent) becomes dominant.

(c) Projected shifts in area and boundary of different forest types especially Dry Savanna in semi arid regions. The shift will not only poses threat to biodiversity but will also have adverse implications on forest-dependent communities.

(iii) **Water Sector:** India's Initial NATCOM identified that there were serious potential impacts from climate change on water stress and reduction in the availability of rainfall. Historic climate variability with floods and droughts, and extreme events have caused widespread destruction and loss of life so there is a need to understand what might happen better by improving the reliability of climate change projections at the regional level, and to develop and implement adaptation strategies involving water conservation, changing land use and cropping patterns flood warning systems and crop insurance. NATCOM1 also identified the need for intensive development of ground water resources, exploiting both dynamic and in-storage potential.

(iv) **Health:** A study by National Physical Laboratory (NPL) predicts increase in Transmission Windows (TWs) for malaria under climate change for India. For Madhya Pradesh State number of months of open TW for malaria is projected to be increased from 4-6 months (base scenario) to 7-9 months (under climate change scenario)[7].

6 India State of Forest Report - 2009

7 Investigating Impacts of climate change in India, An Indo-UK Collaborative Study. GoI, MoEF, UK's Department for Environment, Food and Rural Affairs (DEFRA) Undertaken by IITM, IARI, TERI, IISc, NIO, NPL

Several previous research outputs have fairly clearly indicated that Madhya Pradesh is among the most vulnerable states in India. Using bio-physical indicators (soil degradation and cover, groundwater availability) along with others (social and technological) vulnerability and adaptation assessment was conducted by TERI for agriculture sector. Results clearly showed that Madhya Pradesh has comparatively low adaptive capacity making the state more vulnerable to climate change impacts. Natural calamities like droughts, floods and hailstorms are a common feature of the state, with at least one part of the state generally being hit by one of these natural calamities. The National Communications of India (2004) also predicts increased climate variability for the state. Such variability and change can cause havoc with the state's socioeconomic systems. Along with high physical vulnerability, the state is also extremely low on adaptive capacity. Some of the major findings which have indicated that Madhya Pradesh is high vulnerability (socio-economic) and possess low adaptive capacity are as follows:

(i) **High Physical Vulnerability to Climate Change:** Several previous research outputs have fairly clearly indicated that Madhya Pradesh is among the most vulnerable states in India. Natural calamities like droughts, floods and hailstorms are the common features of the state, with at least one part of the state generally being hit by one of these natural calamities. The National Communications of India (2004) also predicts increased climate variability for the state. Such variability and change can cause havoc with the state's socioeconomic systems and needs to be understood much better than at present. The results of the India State Hunger Index 2008 by International Food Policy Research Institute (IFPRI) highlights grim situation of hunger in Madhya Pradesh state. 12 of the 17 states fall into the “alarming” category, and one Madhya Pradesh-falls into the “extremely alarming” category.

(ii) **Lower Adaptive Capacity:** Along with high physical vulnerability, the state is also extremely low on adaptive capacity (Figure 3). Out of 15 states for which the Human Development Index (HDI) has been calculated, Madhya Pradesh ranks at 12. The state ranks very poorly on most of the social indicators forming the adaptive capacity such as the inflation and inequality adjuster per capita consumption expenditure (Rs. 92/month). a high percentage of people below the poverty line (37.43 per cent as against the national average of 26.10 per cent for India), few households with access to toilet facilities (7.87 per cent against national average of 49.32 per cent), only half the population with access to safe drinking water, just 58 per cent people having road connectivity at village level and a low literacy rate of 58 per cent against the national average of 59 per cent[8]. Although the proportion of population consuming less than 1890 kcal/cu/diem has in fact increased for Madhya Pradesh but even than the state has very high level of food insecurity. More than 90 per cent of rural households in Madhya Pradesh did not have access to toilets within their premises[9]. More than 35 per cent of the total population belongs to the marginalised scheduled castes and scheduled tribes compared to 25 per cent for India and these groups form nearly two thirds of the below poverty line population. Also, the growth rate of per capita income has not been able to keep pace with the national average (0.8 for MP compared to 4.85 for India between 2000 and 2008).Therefore, a study was conducted in the state of

8 Human Development Report - 2001

9 Athreya V B and Bhavani R V et al. (2008), Report on the State of Food Insecurity in Rural India, World food programme (WFP) and M. S. Swaminathan Research Foundation (MSSRF).

Madhya Pradesh to assess the extent of climate change vulnerability and how resilient its communities were to cope with the affect of climate change. Also, possibilities of how different adaptation measures can be effectively incorporated within the existing development processes and state policy for vulnerability were explored. Madhya Pradesh is divided into 11 agro-climatic zones, out of which two zones were selected to conduct this study further; these are Bundelkhand (representing eastern MP) and Malwa (representing western MP). Study region includes two districts (Dhar and Ujjain) from Malwa Region and two districts (Datia and Tikamgarh) from Bundelkhand region. The primary focus of the present study was to understand climate change implication on agriculture sector in the Madhya Pradesh state. The reason for selection of agriculture sector is that it accounts for a large part of total income generation in the state (about 70 per cent workforce depends directly or indirectly on agriculture[10]). Also, this sector is likely to be highly affected by climate change, thus impacting a large number of people and their livelihoods. To assess climate change impacts on agriculture yield and thus the vulnerability of the agricultural communities, two prime crops have been selected and these are wheat (food crop) and soybean (cash crop) (given in box 1 and 2). To provide a regional perspective and aid the planning processes a remote sensing and GIS study was also included.

10. Fifth State of the Environment Report, Madhya Pradesh 2006, Goverment of India.

2. METHODOLOGY AND DATA USED

2.1 Overall Approach

Overall approach followed for this project sought to proactively engage stakeholder(s) institutions in a process of dialogue through the course of the assignment via workshops, brainstorming sessions, in-depth interviews, observing on-site conditions together with client, et al. Experience says that such approach yields rich dividends in the form of commitment and ownership of frameworks, models and recommendations made under the assignment. This research project was divided into four key components and under each component major activities were as follows (Figure 1):

(i) **Set up mechanisms for effective delivery:** In order to run the project successfully a short scoping phase was designed with the following key activities:

(a) **Situation analysis for climate change adaptation in Madhya Pradesh:** The activity of situation analysis was running parallel to the partnership development. In this activity, the focus was on:

- ***Analysis of past and on-going initiatives on climate change adaptation in Madhya Pradesh:*** There are several organizations in Madhya Pradesh including government; research and non-government organizations which have implemented different type of research and policy based projects on climate change. The information collected through different resources were collated and analyzed to identify different types of stakeholders working at the state and national level and also the possible inter-linkages with the other on-going initiatives were identified.
- ***Review of Phase - I outputs:*** In order to minimize primary data generation and maximize use of available information, the outputs brought out in the Phase-I of the Indo-UK collaborative research project were thoroughly reviewed.

(b) **Partnership Development:** A Launch Workshop was organized for this project, primarily for the stakeholder's identification for pre-assessment. The purpose of this workshop was:

- to launch the project in the state,
- to establish the need for an interdisciplinary inter-departmental team,
- to holistically address the vulnerability and adaptation issues to get a commitment from the concerned departments to be a part of the research project,
- to identify a broad framework for the research project.

(ii) **Impact and Vulnerability Assessment:** After scoping phase of the project, impact and vulnerability assessments were carried out. Two agro-climatic zones of the state that is western M.P. (Malwa) and north-eastern M.P. (Bundelkhand) were selected to study the impacts on two main crops (wheat as a staple food crop and soybean as a prime cash crop). The assessments for the impact of climate change on the yield of soybean & wheat have already been made with the help of recalibration of the agro-climatic region specific impacts models. This gave us a clear understanding of the specific areas

in the state with high severity of impacts. These physical impacts were then extrapolated at district level. The process followed for impact assessment is given below:

(a) **Impact Assessments**

- ***Review of available literature to identify the 2 major crops of Bundelkhand and Malwa:*** Wheat and soybean crops were chosen as they represent the most important pillars for the food and economic security for the state of Madhya Pradesh. The two major crops selected were wheat which is a main staple food crop of Bundelkhand and soybean one of the major cash crop of Malwa which is also used as a raw material for soya based food processing industries.
- ***Impact assessments of climate change on Wheat and Soybean of Bundelkhand and Malwa:*** As the results generated through the available data were not accurate, therefore, recalibration of the agricultural models as per the data of the state was done along with the identification of impacts on particular crops in the specific regions. The two crop simulation models used in this study are **CERES-Wheat** and **CROPGRO-soybean** for impact assessment and developing adaptation plan. These models are process-based and management-oriented, simulates the growth and development of wheat and Soybean.
- ***Conversion to digital maps:*** It is fairly well recognized that pictorial representation makes it much easier for users to get the holistic picture accurately and faster. To enable easier and more effective communication of the above information to the stakeholders, this information was converted into digital maps using the Geographical Information System (GIS) techniques.

Box-1	Box-2
Soybean i. Main producers of soybean are the United States (32per cent), Brazil (28per cent), Argentina (21per cent), China (7per cent) and India (4per cent). ii. Area (all India): • 09.6 Mha in 2009 iii. Production (All India) • 0.014 million tons (mT) in 1970 • 9.700 mT in 2009 iv. Productivity (All India) • 380 kg/ha in 1970 • 1100 kg/ha in 2009 v. Madhya Pradesh called as a 'Soya State' • Largest share in production 70 per cent in India • 5.12 mha (54per cent of India) • 5.85 mT (60per cent of India)	**Wheat** i. Second largest producer of wheat (~70-80 mT); 12per cent of world's wheat production and second largest wheat consumer after China ii. Area (all India): • 28 mha in 2007-08 iii. Production (All India) • 6.5 mT in 1950-51 • 78.4 mT in 2007-08 iv. Productivity (All India) • 660 kg/ha in 1950-51 • 2,785 kg/ha in 2007-08 v. In Madhya Pradesh • Productivity 1600-1800 kg /ha • 3.5 mha. (14per cent of India) area, 7.0 mT (10per cent of India) production • Irrigated wheat 78per cent area

(b) **Vulnerability Assessments:** The vulnerability assessments are meant to understand precisely the potential impacts of climate change. Assessing vulnerabilities is a key step towards a clear recognition of climate risks and the need for adaptation within relevant policies and/or projects. Climate Change Pressures and its potential impacts on agriculture were identified by studying and analyzing the climate data/projections provided by IITM, Pune. The following steps were followed for carrying out the vulnerability assessments.

- Review of climate data/information and development of framework of vulnerability assessment
- Socio-economic baseline assessments
- Analysis of non-climate factors and barriers to resilience
- Analysis of thresholds of vulnerability
- Analysis of autonomous adaptation

Table 1: Framework Used for Vulnerability Assessments

Systems of Interest	Climate change signals (trends/ projections) of concern the system of interest is exposed to	Potential biophysical and socio-economic impacts (also considering sensitivity)	Overall Vulnerability
Agriculture	• Seasonal rain pattern becomes erratic • Increase in the frequency of drought period • Heavy rainfall in short periods of time • Increasing number of hot days per year	• Decreasing agricultural yield and production • Loss of income • Adverse effects on food security	variability is high

Socio-economic assessment helped in generation of vulnerability profiles in a sample locations of Bundelkhand & Malwa to contextualize the climate induced impacts on agriculture. To Conduct the socio-economic vulnerability assessment; structured questionnaires were prepared for households' survey. The questionnaires were prepared in order to obtain primary information from the households on the following areas:

- Basic information regarding the demography and coordinates of the family
- Economic status in terms of earnings, loans, capacity to pay back, lend money
- Livelihood profile to ascertain various sources of income and diversifications being explored by the community
- Human capital in relation to education, employability and need for capacity development, migration patterns
- Health expenditure to gauge finances spent on medical priorities and surplus estimation

- Social Capital to estimate the trust levels and the ability of the community to come together and contribute for social good
- Natural Capital pertaining various ecosystem services available and accessible to the community
- Agriculture to understand the land holding patterns and the managements practices, the kind of returns farmers are getting from farming activities, and coping mechanisms being adopted by them
- Irrigation includes the type of irrigation available, its sufficiency, variability and constraints in expanding the network to rainfed areas

Extensive series of consultations were held with the block, district and state level agencies. Various scientific institutions such as IARA, CRIDA, IGFRI, NRAA, NRCAF, ICRISAT, KVK were engaged to bring in scientific rigor. In order to develop vulnerability indices for various districts secondary research was carried out utilizing data sources from the District Statistical books. The secondary data (district statistical handbooks) after validating with the primary data (household survey) was compiled and feed in Livelihood vulnerability index methodology to generate vulnerability profile of Datia, Tikamgarh, Dhar and Ujjain districts of Bundelkhand & Malwa. The Livelihood Vulnerability Index (LVI) method estimates the differential impacts of climate change using multiple indicators to assess exposure to climate variability, social and economic characteristics of households that affect their adaptive capacity, and current health, food, and water resource characteristics that determine their sensitivity to climate change impacts. The choice of vulnerability indicators were guided by the dual considerations of availability of data and requirements for determining the vulnerability. The indicators selected to calculate the vulnerability indices are given in the Table 2.

The data collected from the secondary sources were cross checked against primary sources. Though the unit of reporting was sometimes not same it was found that the data were in line with each other. For example the secondary data and primary data collected both indicated for Tikamgarh that the average landholding was below 2 hectares per household.

Table 2: Major components and sub-components comprising the Livelihood Vulnerability Index (LVI) developed for two agro-climatic regions of Madhya Pradesh.

Component	Sub-components	Wightage	Indicators
Exposure (E)	Climate	3	Average no of drought events in past 10 years
			Average Rainfall (mm) (2002-2007)
			Average Temperature (degree Celcius)
	Demographics	1	Rural BPL families
Sensitivity (S)	Ecosystem	3	Per capita forest cover
			Ground water table (m)
			Wasteland (ha)
	Agriculture	3	Work force in agriculture
			Yield per hectare
			Net irrigated area
Adaptive Capacity (A)	Socio-economic	7	No of pump sets per hectare agriculture land
			Per capita loan
			Average Land holding
			Livestock population
			Number of pukka houses
			Number of health care centers
			Number of villages with drinking water access

The LVI uses a balanced weighted average approach *(Sullivan et al., 2002)* where each indicator contributes equally to the overall index. This formula uses the simple approach of applying equal weights to all sub-components. The 'n' number of indicators contributes towards the same number of weightage to each sub-component. For example, if the number of indicators selected for two sub-component of one major component are 3 and 1 respectively then this will adds to total weightage 4 of the major component (refer Table 2) . The following equations[11] were derived to calculate vulnerability of the districts (these studies were carried out at block level to generate the vulnerability index of the district):

Indicators Index (Ix)	**Profile (P)**	**Component (C)**	**Vulnerability Index**
= [Ib - I (min)] / [I(max) - I (min)]	= (ni=1 Ixi) / n	=[(ni=1 WPiPi) / (ni=1 W Pi)]	= (E-A) X Sensitivity

(iii) **Adaptation planning and option assessment:** Adaptation planning needs to respond not only to the long term vulnerability of the region but also to the short term ones. As a result adaptation options were divided into short to medium term options and long term options to aid in the process of adaptation planning. In order to generate adaptation options and assess them, a protracted process was followed. As a starting point adaptation/coping measures followed by the local communities were documented through different surveys in the 2 regions. Adaptation options were also collected

11 Hahn, M B and Riederer, A M et al. (2008), The Livelihood Vulnerability Index: A pragmatic approach to assessing risks from climate variability and change - A case study in Mozambique, Global Environmental Change Journal.

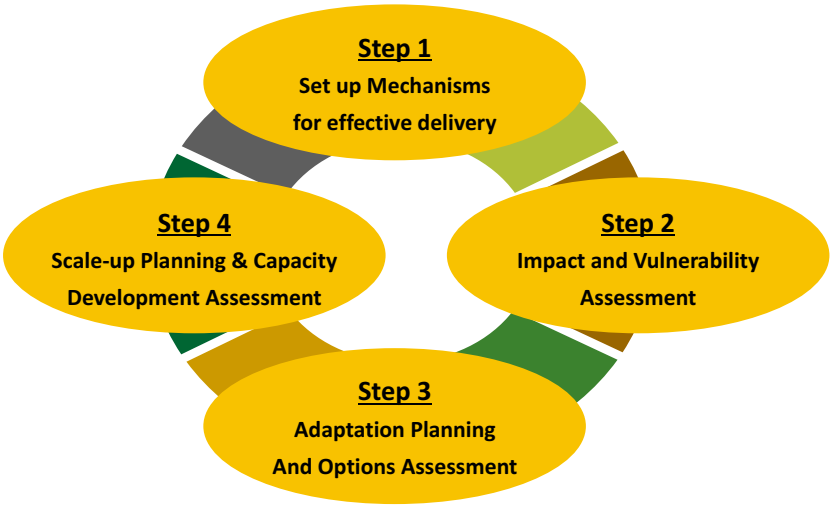
through means of workshops and online climate change centric platforms such as Solutions Exchange and CANSA. To further strengthen the process of consultation, an online platform was established in the backward region of Bundelkhand named as **Bundelkhand Knowledge Platform** in order to capture the voices from the ground. To provide scientific rigor to the process various premier institutions such as Central Research Institute for Dryland Agriculture (Hyderabad), International Crop Research Institute for Semi-Arid Tropics (Patancheru), Water Technology Center at Indian Agricultural Research Institute (IARI), National Disaster Management Institute (New Delhi), Indian Grassland and Fodder Research Institute (Jhansi), National Research Center for Agroforestry (Jhansi) besides State Departments of Madhya Pradesh and many others were consulted. The adaptation options thus collected and rationalized were prioritized based on the needs of the farming community at the ground.

(iv) **Scale-up planning and capacity development assessment:** A large part of the analysis focused on scaling up of identified good adaptation practices through policy measures and development programmes. At this stage, an extensive engagement with the specific stakeholders working on the identified sectoral policies was initiated along with the detailing of the steps actually required for scaling up various identified options and their incorporation within the policies. Scaling up of identified adaptation options is intricately linked to the capacity of the State administration to understand the underlying concepts and the intent of the suggested interventions. In order to identify the capacity development needs of these stakeholders, the following key activities were taken up:

(a) **Consultations with key stakeholders** directly through meetings and structured questionnaires.

(b) **Small orientation and consultation workshops** were held with the identified stakeholders oriented on the identified measures. These measures were then taken into consideration along with the barriers and constraints in potentially implementing these measures.

Figure 1: Overall approach to conduct the vulnerability assessment



2.2 Data Sets Used

A number of data sets has been used for conducting the impact & vulnerability assessment. For the purpose of impact assessment, literature was reviewed along with the assessment of different types of models to study the impact of climate change. Different type of softwares were used to study the impact of climate change in the present study are CERES-Wheat model and CROPGRO-Soybean model. The data used to carry out the impact assessment simulations consists of the meteorological data, agronomic data and edaphic data. This data has been procured from the following centres:

- Indian Institute of Tropical Meteorology, (IIMT) Pune, Daily Climate Data for 1960-2100
- Indian Meteorological Department (IMD), Pune
- National Institute of Disaster Management (NIDM), Impact of Climate Change on Agri Yields, CROPGRO-soybean and CERES-wheat models
- National Remote Sensing Centre (NRSC), Hyderabad
- Spatial Information System (SIS)

The data collected corresponds to the precipitation, solar radiation parameters, minimum and maximum temperature on a daily basis for the years 1969 to 2005. This data was used to analyze the future impact scenarios of climate change on wheat and soybean in the two agro climatic zones of Bundelkhand and Malwa. For the purpose of climate impact assessment on crops the A1B scenario was used. A1B describes a future world of very rapid economic growth with global population that peaks in mid-century and declines thereafter.

Impact of climate change on grain yield of crops was studied using A1B 2030 scenarios derived from the PRECIS RCM. The climate model outputs on temperature (minimum and maximum) and rainfall for A1B-2030 scenarios were coupled to the baseline weather data. The model operates on a daily time-step and calculates biomass production, which is then partitioned to the leaves, stems, roots and grain, depending on the phenological stage of the plant. The model uses empirical functions to compute daily canopy gross photosynthesis in response to CO_2 concentration, air temperature and daily canopy evapotranspiration. The model calculates net photosynthesis based on a constant radiation use efficiency, leaf area index, extinction coefficient and light absorption by the canopy.

3. RESULTS

As mentioned the research study was conducted in the two districts of Bundelkhand (Datia and Tikamgarh) and Malwa (Dhar and Ujjain) agro-climatic zones.

3.1 Vulnerability Assessment

For assessing the vulnerability, climate projections were used along with the household data and information generated through crop simulation modeling exercises. The crop simulation exercises depend on the climate data to predict future yields of wheat and soy bean crops. The climate data was also used to understand the variability of criteria and the long term trend of parameters.

For the purpose of conducting vulnerability assessment indices were computed for all four districts under study. The **vulnerability profile** is in the range of **-1 to +1 showing low to high vulnerability**. Therefore, vulnerability profile for each of the districts is given below:

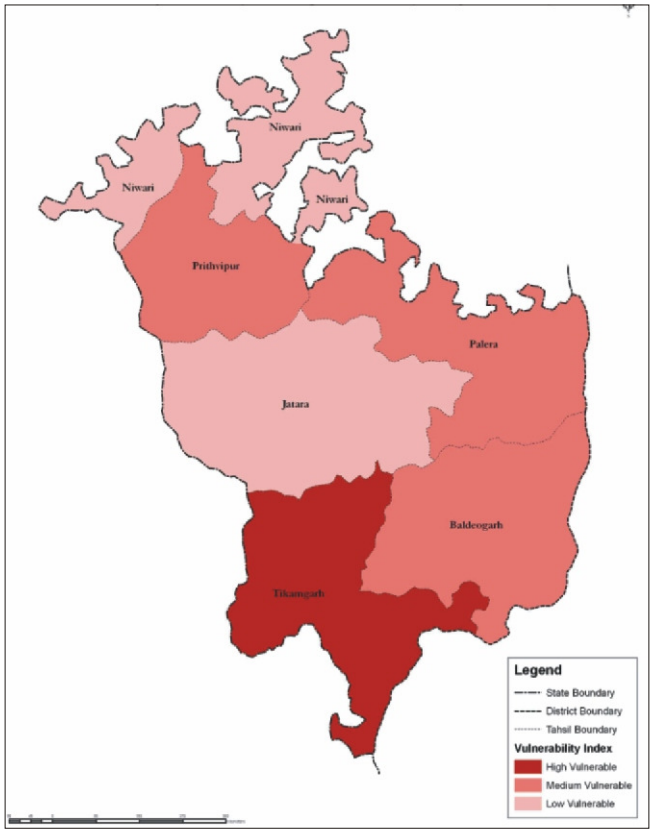
3.1.1 Vulnerability profiles

(i) Bundelkhand region

(a) Tikamgarh district

The vulnerability indices for the six blocks in Tikamgarh are as follows: Tikamgarh (0.050), Baldevgarh (0.033), Jataara (-0.068), Palera (0.012), Niwari (-0.024) and Prithvipur (0.004).

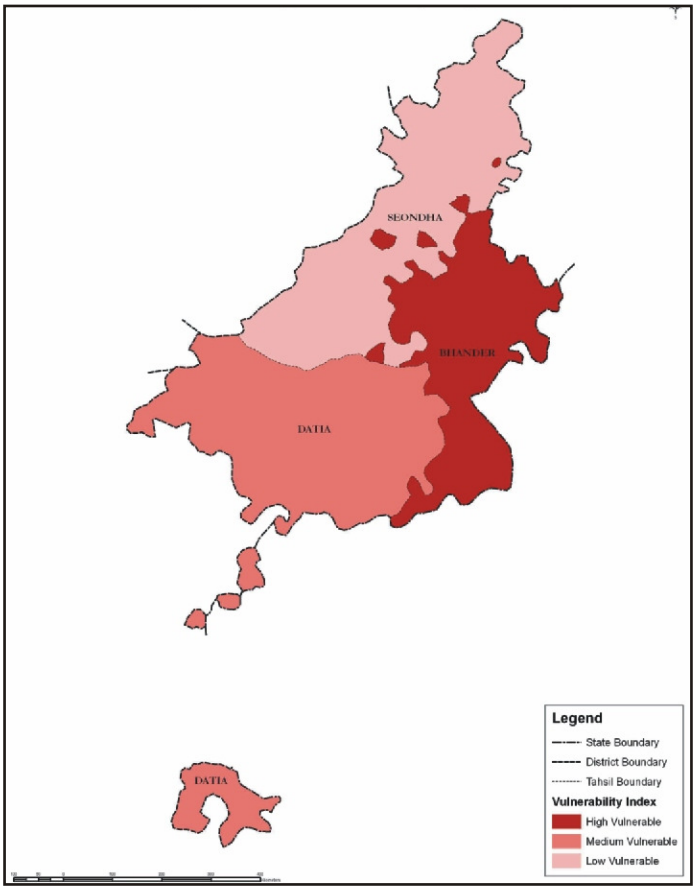
Figure 2: Vulnerability Index Map of Tikamgarh District, Madhya Pradesh



(b) Datia district

The vulnerability indices for the various blocks in Datia are: Datia (-0.2078), Seondha (-0.016) and Bhander (0.005).

Figure 3: Vulnerability Index Map of Datia District, Madhya Pradesh

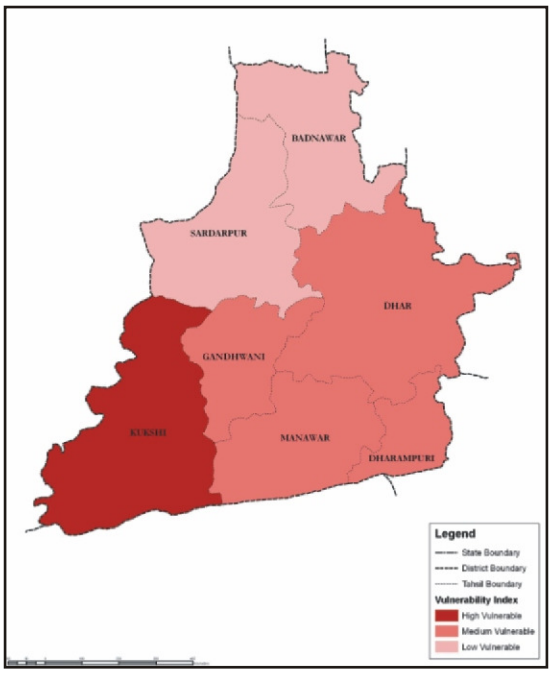


(ii) Malwa region

(a) Dhar district

The vulnerability indices for the various blocks in Dhar are: Tirla (-0.023), Nalchha (-0.181), Badnawar (-0.330), Kukshi (-0.007), Bagh (-0.022), Dahi (-0.008), Nisarpur (0.015), Manawar (-0.071), Umarban (-0.016), Sardarpur (-0.473), Gandhwani (-0.089), Dharampuri (-0.001).

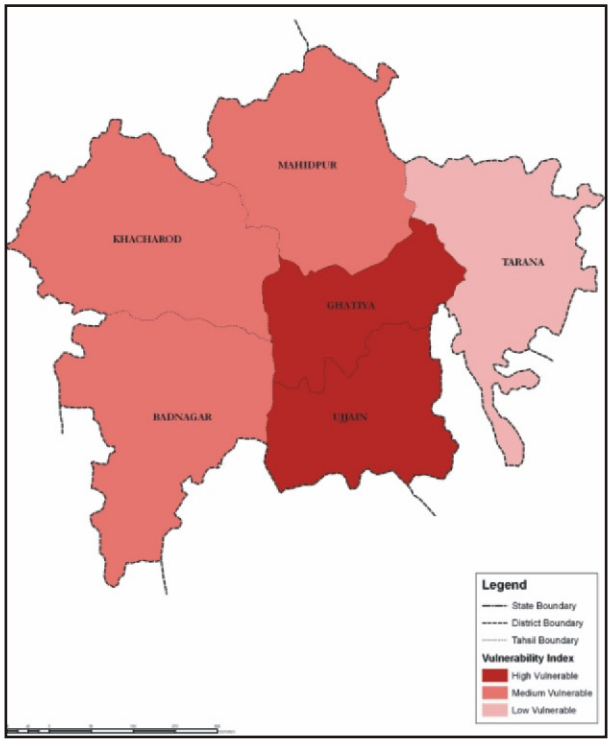
Figure 4: Vulnerability Index Map of Dhar District, Madhya Pradesh



(b) Ujjain district

The vulnerability indices for the various blocks in Datia are: Datia (-0.2078), Seondha (-0.016) and Bhander (0.005). Thus the block with highest vulnerability is Bhander.

Figure 5: Vulnerability Index Map of Ujjain District, Madhya Pradesh



3.1.2 Interpretation of households surveys

The household surveys carried out in Bundelkhand and Malwa validate the findings of the indices based results obtained from secondary research. The key results obtained from the household surveys which were carried out using a structured questionnaire are being presented below for Bundelkhand and Malwa region. A total of 600 household surveys were undertaken across the two regions. In order to make the surveys representative the widest geographical coverage in the state was taken up. For representing different socio economic strata in the data collection process staggered, learning's based approach was followed. This enabled the communities to express their opinions in an unbiased manner.

2 agro-climatic regions = Bundelkhand + Malwa

2 agro-climatic regions = 4 districts (Tikamgarh, Datia, Dhar and Ujjain)

4 districts * 150 households = Total 600 households

Key findings observed in **Bundelkhand region** are as follows:

Average landholding of the farmers is around 2 hectares

55 % of the surveyed population has migrated in the last 5 years. Out of these in 67% cases only the bread winners migrated while in the other 33% cases entire family migrated

72% of the migration took place for fulfillment of basic needs

Average credit per family in a year is Rs. 9,000.

Money had been borrowed by 70% of the respondents. 52% of the money is being lent out by informal institutions such as villagers and money lenders

96% of the respondents perceived agricultural activities to be highly sensitive to weather phenomenon

The primary reason of shifting away from agriculture was the poor returns from it.

Migration of farmers was absorbed by the construction labour sector in high infrastructure growth centres such as Delhi-NCR, Jhansi etc.

The level of trust among villagers has got worse in the past 5 years (67% of respondents)

80% of the respondents are not satisfied with the operations of the government departments

15% of farmers have changed their rabi crop from wheat to other crops such as sesame, lentils etc.

Key findings observed in **Malwa region** are as follows:

The people of the region are economically very backward with almost 86% of the households holding a ration card of Below Poverty Line category (BPL).

39% of the persons interviewed, expressed that the financial condition of their household is good, while 28% reported to be either bad or very bad, whereas rest 33% reported to be indifferent.

32% of the people admitted to have taken loan from various sources. 8% of the respondents have

mortgaged assets

An overwhelming 80% of the persons questioned is of the opinion that his/her fellow villagers are always ready to help out others

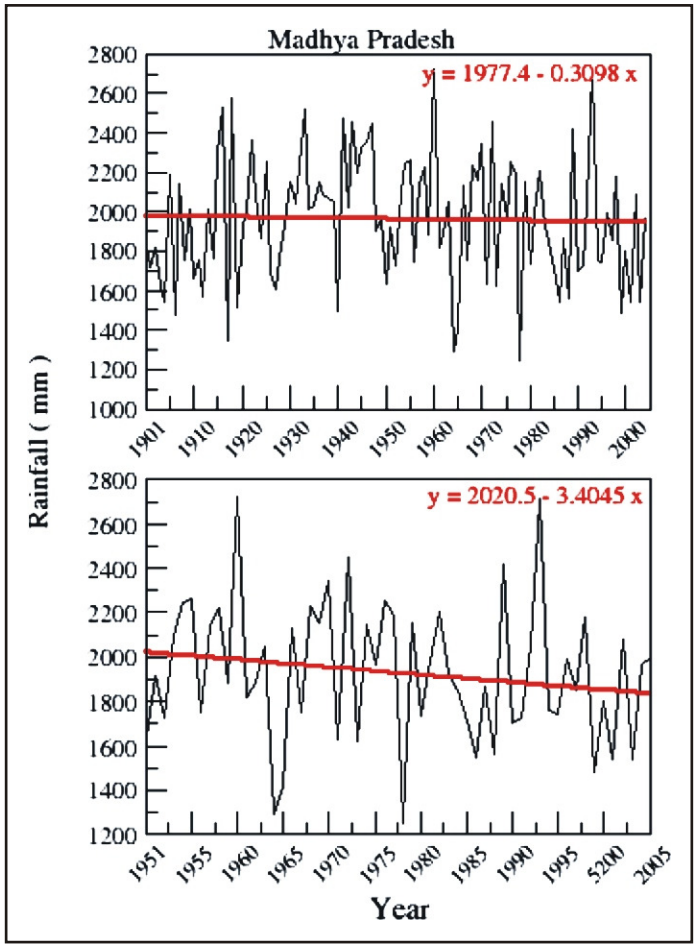
Only 2% of the respondents daily listen to radio

Only 22.5% of the respondents are of the opinion that there is enough quantity of water for irrigation purposes

3.1.3 Climate data and projections

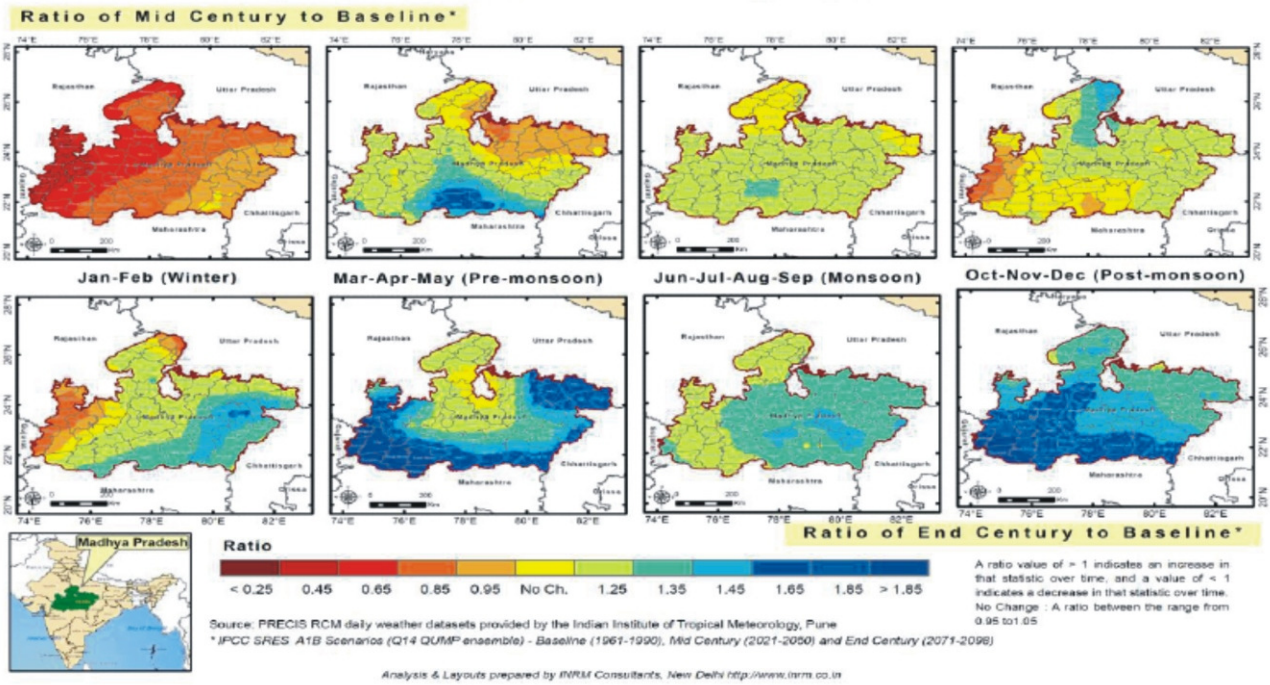
Data and analysis shared by *IITM Pune* indicates a declining trend for rainfall over the state of MP from 1901 to 2000. The trend is even worse if the data of the last 5 decades alone is analyzed. This shows water availability in Madhya Pradesh has been declining. Also the extraction of groundwater has been increasing. Put together, this indicates that level of ground water has also gone down. If similar trends continue it will result in even lesser amount of ground water availability thus enhancing the risk of crop failure in times of low rainfall as life saving irrigation will not be present.

Figure 6: Inter-annual variability of seasonal rainfall over MP 1901-2000 (top) and 1951-2005(bottom)



Source: IITM, Pune

Figure 7: Change in average seasonal precipitation in Madhya Pradesh in 2021-2050 and 2071-2100 with respect to base line (1961-1990)



Source: IITM, Pune

Wheat is major food crop of Bundelkhand grown in the season of November and December (winter). Studies carried out by IITM have also shown that winter precipitation in Bundelkhand region may drop by upto 50% by 2100. This reduction, if happens will consequently impact on the wheat productivity leading towards the serious impacts on the food security of Bundelkhand region. However, it needs to be remembered that these are results of modeled projections and therefore are probabilistic outcomes. Also, inter annual variability in the projected precipitation is very high and therefore adaptation measures which are decided upon need to be robust enough to factor in these uncertainties. In absence of rainfall, farming community will have to depend on irrigation from groundwater. Carrying out irrigation for agricultural activities is a fuel intensive process in absence of quality electricity supply. Many households are not able to support irrigation costs. Carrying out irrigation also reduces the returns on sale of produce as the inputs costs become higher.

The mean rainfall over West MP is 85.5 cm while East MP receives on an average 110 cm rainfall during monsoon. When the two seasonal rainfall series over West and East MP are considered individually, they also do not exhibit any trend as shown in Figure 8. Considered individually east MP has been showing a declining trend as compared to west MP where precipitation has been increasing. However, earlier reports from Phase I have indicated that the number of days in which precipitation will take place will decline resulting in higher intensity rainfall. High intensity rainfall results in lower rates of recharging of groundwater and soil erosion. Both of these factors do not bode well for agriculture in the state. Reduced water table leads to reduced availability for agricultural activities and soil erosion results in reduced nutrients which are essential for optimum crop yield and nutritive quality.

Figure 8: Time series of seasonal (June through September) rainfall (mm) for West (top) East (bottom) Madhya Pradesh for the period 1901-2004

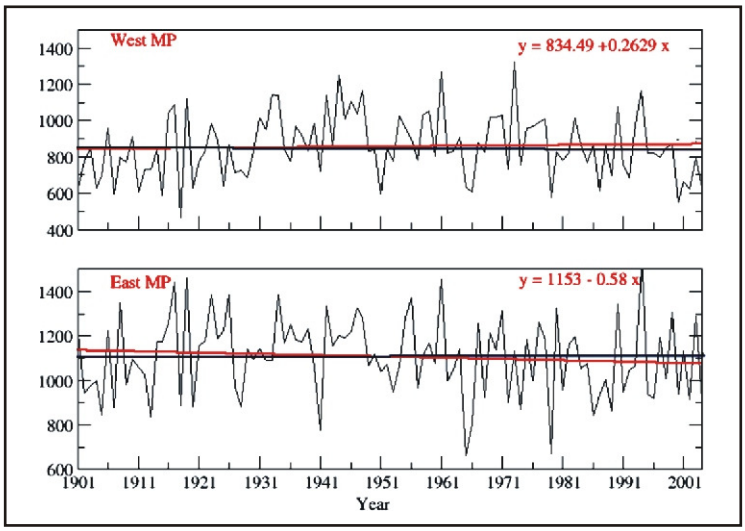
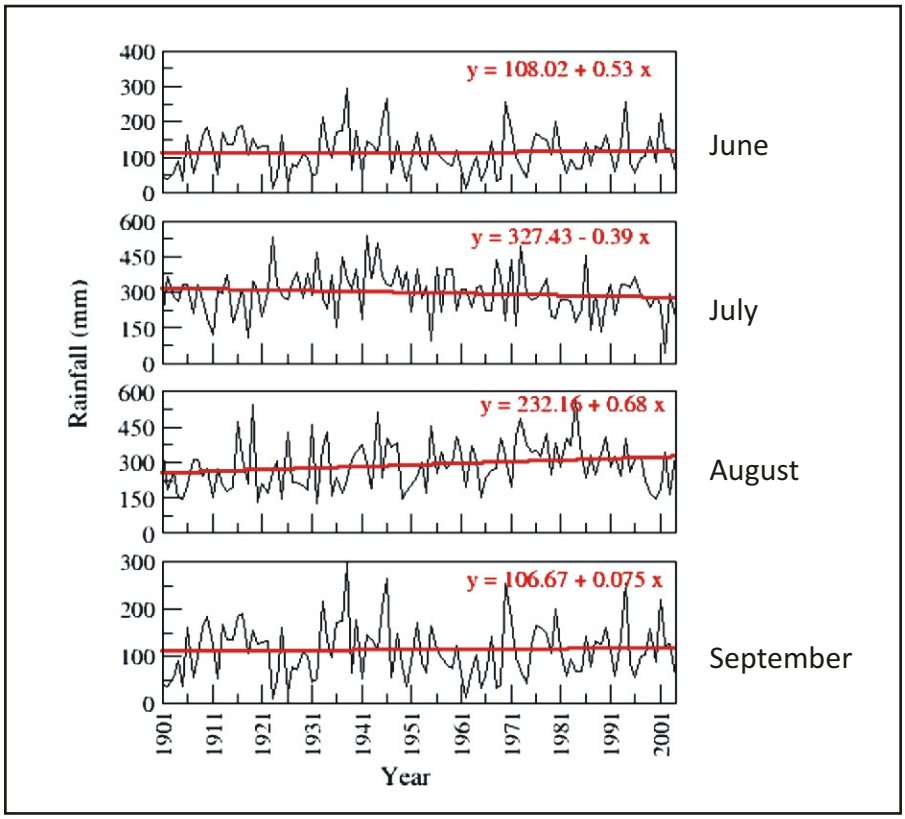


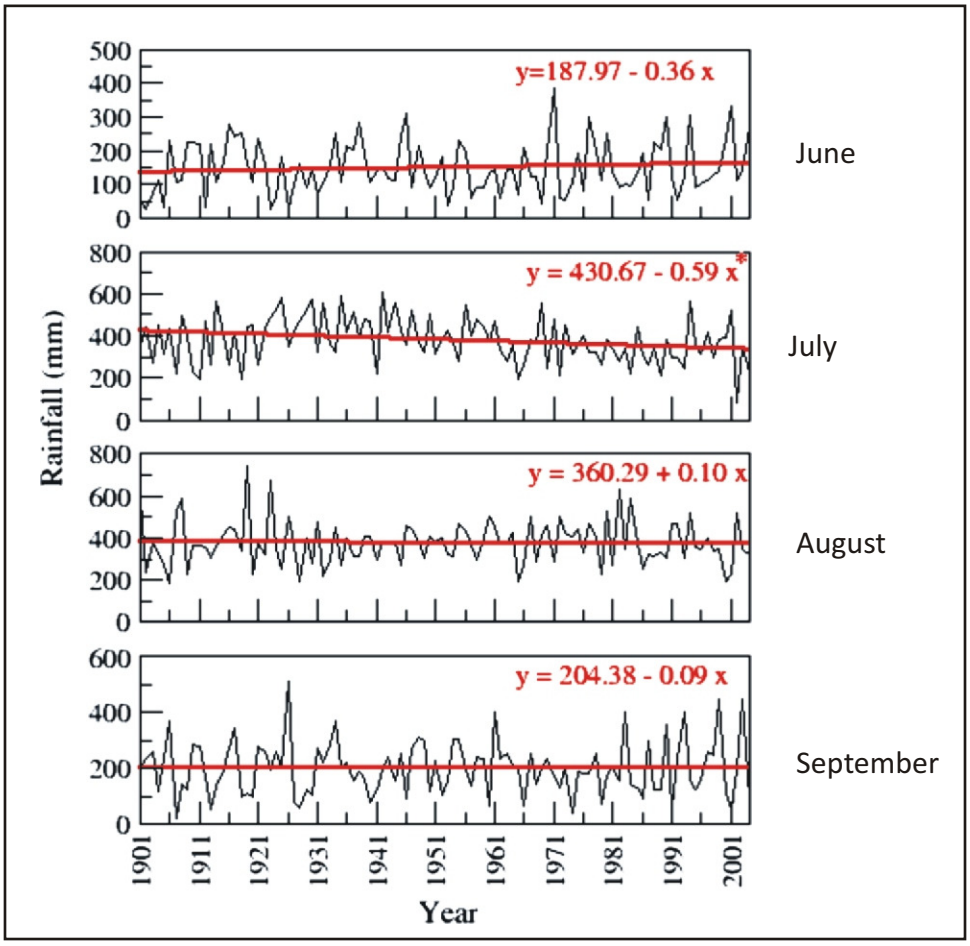
Figure 9 provides precipitation for the months June, July, August and September (monsoon) individually for both West MP and East MP. In West MP rainfall is showing a decline in July while it shows an increasing trend in August and September. The decline in July in Western MP (a region covering Malwa, which is important for soya bean) is significant as this is an important time for the sowing of soya bean

Figure 9: Time series of seasonal rainfall (mm) for West Madhya Pradesh from top to bottom (June, July, Aug. & Sept.) for the period 1901-2004



In eastern MP as well, July precipitation has been declining over the time period of 1901 to 2004. This time is important for the plating of rice crop in eastern MP when the young seedlings are traditionally submerged in water in fields. Any decline in rainfall will result in enhanced risks of crop yield reduction and in absence of irrigation result in risk of crop failure. There are clear trends for months of June, August and September.

Figure 10: Time series of seasonal rainfall (mm) for West Madhya Pradesh from top to bottom (June, July, Aug. & Sept.) for the period 1901-2004



The overall analysis of the indices based, and household survey based results indicate that the regions are precariously poised in their own ways. Even as Bundelkhand is grappling with drought, Malwa region has a high proportion of population which is tribal and the land masses suffer from erosion and the predictions of lowered rainfall do not bode well. Results shared by IITM also show that rainfall has been declining. In the next section we will compare the potential impact of future climate change on crop production

3.1.4 Agriculture impact assessment

For the purpose of conducting the simulation studies on crops, one needs to choose a futuristic scenario under which predictions of crop impacts are to be made. A climate scenario[12] is based on different socio-

12 Scenario: projections of a potential future, based on a clear logic and a quantified storyline

economic and environmental assumptions which result into different levels of future emissions of greenhouse gases and causes a change in the climate system. Each scenario family[13] describes one possible demographic, politico-economic, societal and technological future. Four types of emission scenarios can be used to predict the future impact of climate change on crops. These are:

(i) **A1 scenario:** It is developed into three groups that describe alternative directions of technological change in the energy system. It describes a future world of very rapid economic growth with global population that peaks in mid-century and declines thereafter.

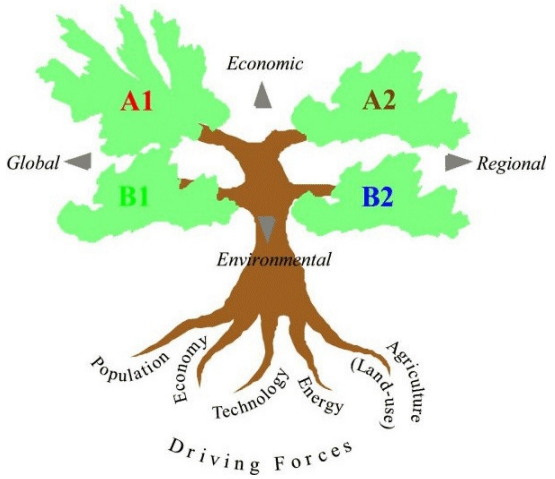
- **A1B:** Balance across all sources, it does not rely too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies.
- fossil intensive (**A1FI**).
- non-fossil energy sources **(A1T).**

(ii) **A2 scenario:** It describes very heterogeneous world, of self-reliance, continuously increasing population, regionally oriented economic development, with slower growth of per capita economic growth and technological change than other storylines[14].

(iii) **B1 scenario:** It describes a convergent world with a rapid economic growth, a low population growth, rapid change in economic structures toward a service and information economy with the introduction of clean and resource efficient technologies.

(iv) **B2 scenario:** It describes a world with the emphasis on local solutions to economic, social, and environmental sustainability.

Figure 11: The SRES Scenarios, IPCC



Estimates of impact of climate change on crop production could be biased depending upon the uncertainties in climate change scenarios, region of study, crop models used for impact assessment and the level of management. So it is very important to give these uncertainties due importance while assessing the impacts of possible climate change on crop productivity for formulating response strategies. The current chose A1B scenario for describing impacts of climate change on crop production as it is the most likely one in business as usual scenario given the 8-9 percent per annum economic growth in developing countries even in recessions. The world population is nearing 7 billion and will most probably not stabilize before mid-century. Use of other scenarios would probably lead to predictions of lesser loss of productivity. Thus care needs to be taken in future in order to assess crop loss due to climate change by

13 Scenario family: one or more scenarios that have the same demographic, politico-societal, economic and technological storyline

14 Storyline: a narrative description of a scenario (or a family of scenarios), highlighting the main scenario characteristics and dynamics, and relationships among key driving forces.

choosing the appropriate scenario based on changes in global and regional economic and environmental circumstances. The certainty of the results should therefore be taken in the context of these limitations.

Impact of future climate change (2030) was adjudged using models under the A1B (2030) scenario for wheat and soybean in all the four districts (Datia, Tikamgarh, Dhar and Ujjain). The district level results of the crop simulations for wheat and soybean are given below:

(i) Wheat:

(a) The productivity of potential yield of wheat will decline from 14% to 20%

(b) The potential, irrigated and rainfed yield will decline by 18% to 23%

(c) Decline in ground biomass by 8% to 13%

(d) Maturity duration will decrease by 3% to 8%

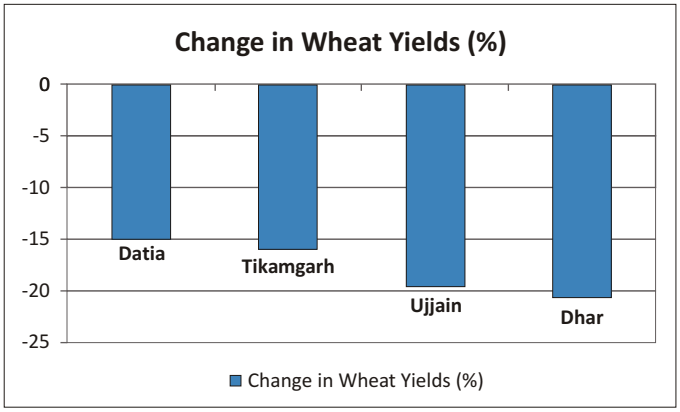
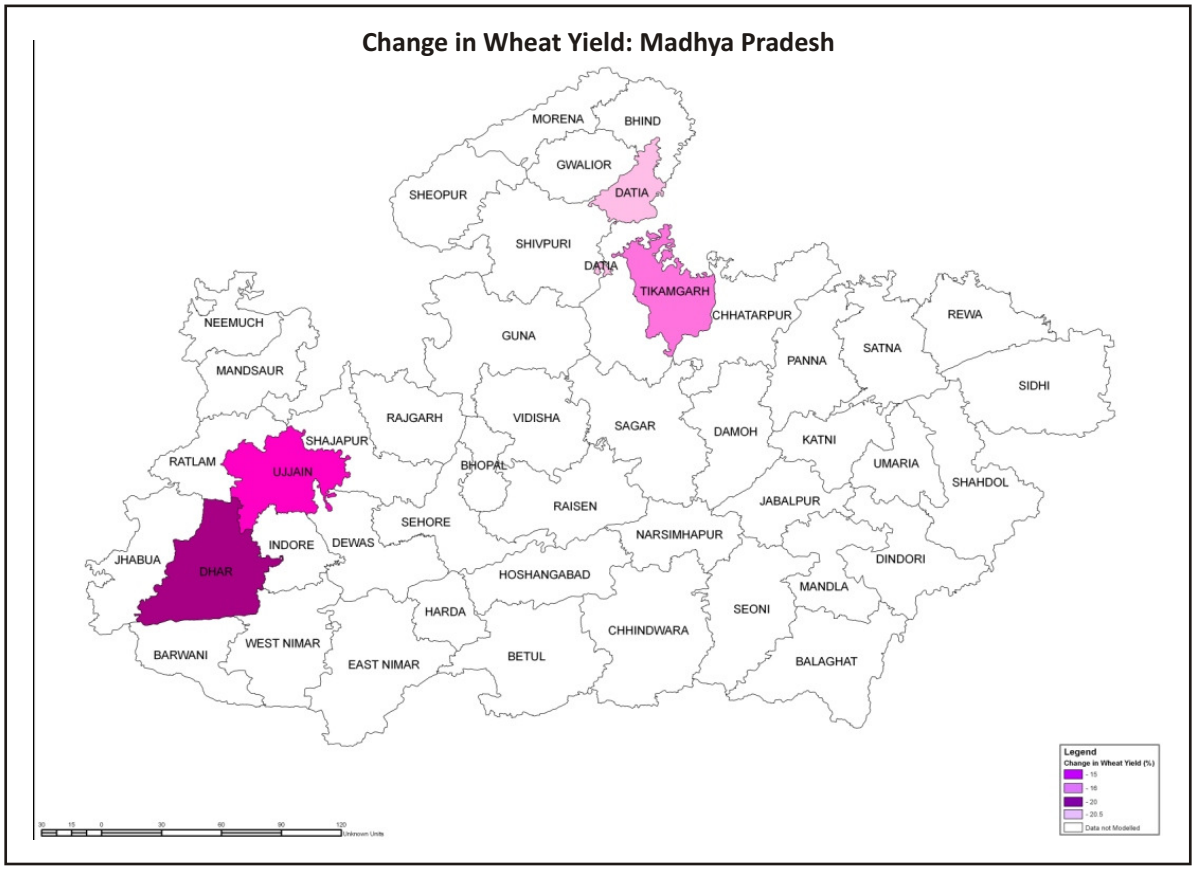


Figure 12: Percentage change in the yield of Wheat, Madhya Pradesh



(ii) Soybean:

(a) The productivity of potential yield of wheat will decline from 14% to 17%

(b) The potential, irrigated and rainfed yield will decline by 16% to 24%

(c) Decline in ground biomass by 6% to 13%

(d) Maturity duration increased by 3% in potential & irrigated condition but decline by 2% in rain fed condition

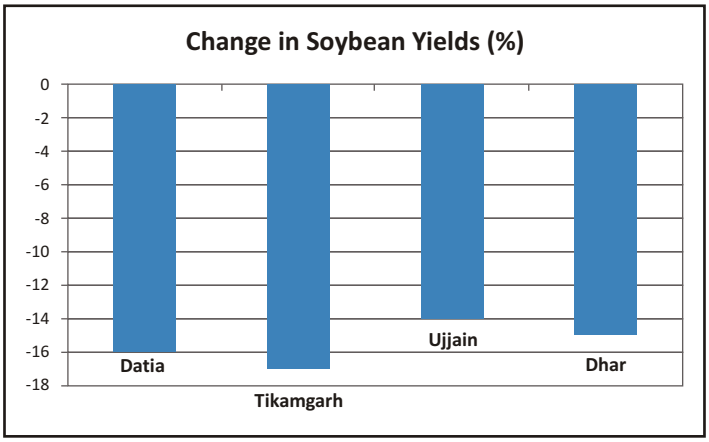
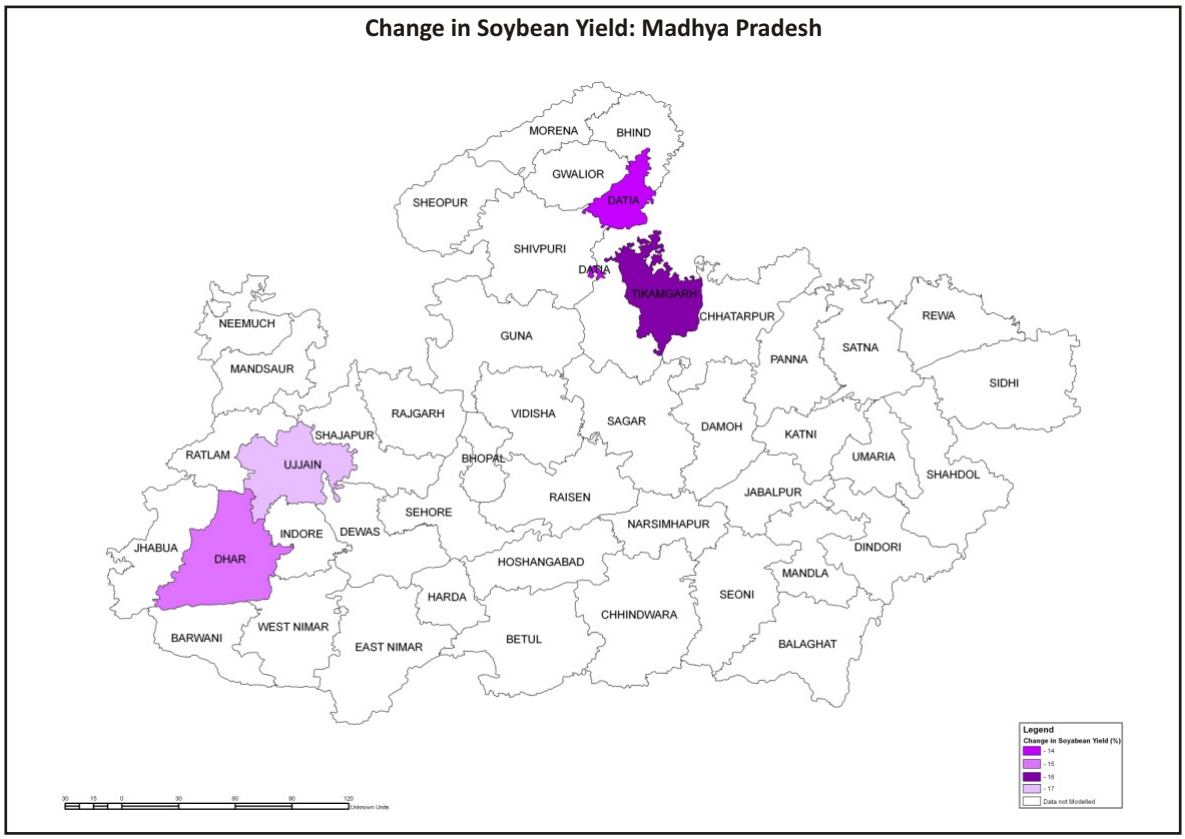


Figure 13: Percentage change in the yield of Soybean, Madhya Pradesh



The A1B 2030 scenarios projected somewhat higher surface air temperature than observed weather records for the present day atmosphere and as a consequence the simulated grain yields show a decline in crop yields. The yields in wheat are found to decline almost identically for the all 4 locations, but rain fed environment will be more suffer than other. The total above ground biomass will also be affected and going to decline during 2030s. The maturity duration of the crop will be reduced by 4-10 days all locations depending on production environments. The yields in soybean are found to decline almost identically for the all 4 locations. The total above ground biomass will also be affected and going to decline during 2030s. The maturity duration of the crop is extended by 3 - 4 days all locations.

3.2 Overall adaptation options for Bundelkhand and Malwa

Based on vulnerability assessment the field surveys, interaction with the district and state administrations, crop simulations result and consultation workshops, a number of adaptation/coping option were identified. These are being summarized hereunder region wise.

Bundelkhand

(i) Agriculture

(a) Efficient farming practices: The farmers should adapt efficient farming practices such as:

Drip or sprinkler based irrigation, line sowing, raised bed technique, seed treatment, shade net, improved seeds, breeder seeds, agro-forestry, agri-horti models.

Focus on Horticulture

Organic farming, Vermi-composting

Promotion of vegetable farming

Afforestation/ Plantation of income generation trees (Bamboo, Amla)

(b) Information dissemination to farmers related to the changed Weather conditions to save their crops failure. Also, linking climate change risk schemes such as crop insurance to give more benefits to farmers.

(c) Alternative options for livelihood security and enhanced income especially for tribal families.

(d) Capacity building and awareness programmes should be run for farmers with respect to climate change.

(e) Increased accountability for government and administrative units, along with the scalable solutions that are affordable for livelihood, food and water security.

(f) Markets should be interlinked directly with farmers to optimize farm income for farmers.

(ii) Energy

(a) Different option for renewable energy should be promoted so that proper utilization of cow dung can be done along with the crop residues.

(b) The energy conservation technologies should be promoted.

(iii) Water

(a) Enhancing water use efficiency to increase availability and accessibility to water

(b) Economically viable solutions for water filtration

(c) Streamlining and sequencing water management structures

(d) Rain water harvesting structure, recharging of abandoned wells/ ponds

(e) Watershed management in hilly areas by developing trenches and converging them to a pond

(iv) Livestock

(a) Need to improve varieties and breeds of milking animals

(b) Research on Fodder varieties

(v) General

(a) Climate change impacts and vulnerabilities should be studied at local level (community)

(b) Mainstreaming climate change into developmental planning

(c) Need to have diversified solutions for energy, water, nutrition, livelihood to reduce risk

(d) Need to establish 'Knowledge Dialogue' with local communities to capture their traditional wisdom/knowledge and make them aware of different adaptation options

(e) Need to establish Village Committees and revive existing committees Jal Samvaad, Janpad Sadsay, Jaati Panchayat, Paani Panchayat

(f) Need to involve local research, academic institutions, KVK

(g) Need to bridge the gap between research and farmers

(h) Need for more efficient monitoring and evaluation system to track efforts of the community, Government, and private players.

(vi) Other issues

(a) Establishment of knowledge platform contributing to policy formulation leading to community empowerment

(b) Blending formal and informal science for enhanced delivery on ground

(c) Increasing access to appropriate technology for adaptation to climate change

(d) Provision of Weather Based Crop Insurance

(e) Promoting and reviving traditional drought coping mechanisms such as traditional water harvesting structures, drought resistant crop verities that have under gone transformations due to technological changes with higher risks.

(f) Establishment of knowledge platform contributing to policy formulation leading to community empowerment

(g) Blending formal and informal science for enhanced delivery on ground

(h) Increasing access to appropriate technology for adaptation to climate change

(i) Provision of Weather Based Crop Insurance

Malwa

(i) Agriculture

(a) The biggest problem in agriculture is that the farmers are not technically trained, so farmers need to be trained to adapt to climate change.

(b) Improved quality of seeds: improved quality of seeds need to be provided to the farmers by government or the private sector, particularly for varieties which can grow in less water. The farmers of Dhar District have done experiment in soybean and wheat in which they have been successful.

(c) Focus on horticulture will enable the farmers to secure incomes throughout the year.

(d) Information dissemination to farmers related to Weather conditions

(e) Linking farmers to climate change risk mitigation schemes such as crop insurance with weather forecasts is necessary

(f) Markets should be linked directly with farmers to optimize income for farmers

(ii) Energy

(a) Treadle pump for irrigation purpose will help replace diesel pumps

(b) Setting up of biogas plants will help in proper utilization of resources and reduce dependence on grid based electricity

(c) Farmers in many regions have successfully adopted CFLs

(d) Farmers use diesel engines for work related to farming. Diesel engines should be of that type which will consume least fuel and reduce environmental

(e) Use of agricultural residues for energy generation

(iii) Water

(a) Drip irrigation system will help reduce dependence on water and help farmers take good yields even in low rainfall years

(b) Rain water harvesting by making farm - pond and other structures.

(c) Farmers of Dhar district have managed to save water even while growing water intensive crops such as melon and cotton.

(iv) Livestock

(a) Conservation of local breeds of livestock is important because they are adapted to local conditions and thus are a more secure source of livelihood.

(b) Ensuring availability of green fodder using low water demanding crops and techniques.

(v) Geneal

(a) Alternative options for livelihood security and enhanced income especially for tribal families, raise awareness programmes with respect to climate change

(b) Increased accountability for government and administrative units

(c) Economically viable solutions for water filtration

(d) Climate change impacts and vulnerabilities should be studied at local level

(e) Mainstreaming climate change into developmental planning

(f) Need to have diversified solutions for energy, water, nutrition, livelihood to reduce risk

(g) Need to establish 'Knowledge Dialogue' with local communities to capture their traditional wisdom/knowledge and make them aware of different adaptation options

(h) Need to establish Village Committees and revive existing committees such as Jal Samvaad, Janpad Sadsay, Jaati Panchayat, Paani Panchayat

(i) Need to involve local research, academic institutions, KVK, bridge the gap between research and farmers

(j) Need for more efficient monitoring and evaluation system to track efforts of the community, Government, and private players.

3.3 Adaptation Options for Wheat and Soybean

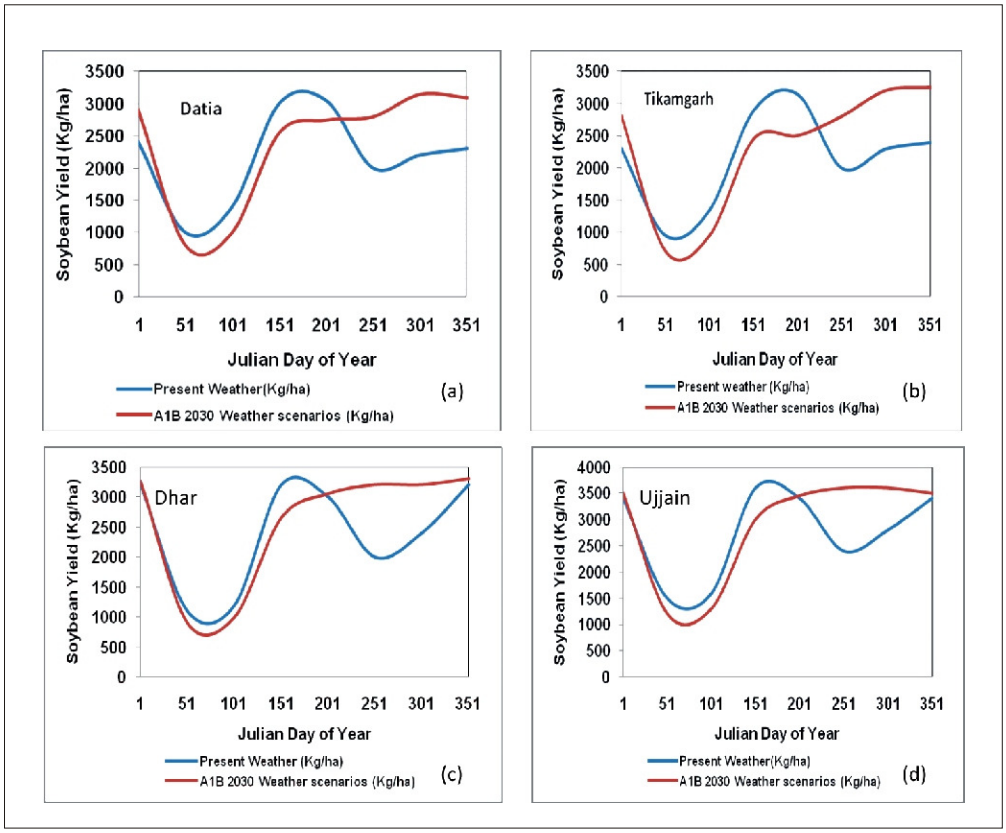
Wheat crop

The general practice in MP and all four locations, sowing dates for wheat crop falls in October and November moths. Adaptation measures to mitigate the potential impact of climate change included possible changes in sowing dates and genotype selection. Preponing dates of sowing by 10 days in late-sown cultivar (01 December) and delaying of sowing by 10 days in normally sown cultivars resulted in better yield in 2030s. From simulation it is found that 15 November or 20th November will be best option for 2030. The 15th November will be best option for Datia and Tikamgarh otherwise better crop management (variety selection, water management) will be a positive options.

Soybean crop

It is clearly evident that the present choices of sowing dates (Julian days 152183 corresponding to JuneJuly months) of soybean are most appropriate in terms of maximum crop yield in different parts of MP. Proper sowing date adjustments will, however, be necessary for efficient utilization of natural resources under the climate change scenarios. The simulation results suggest that for the four stations (Datia, Tikamgarh, Ujjain and Dhar), the sowing of soybean crop may have to be delayed from June and first week of July to first fortnight of August, such that the adverse impacts of thermal stress due to projected climate change could be avoided during reproductive growth of the crop. Results also suggest that seasonal shift in sowing of soybean crop to December will be beneficial in terms of higher yields particularly in Datia and Tikamgarh district.

Figure 14: Showing effect of varying planting dates on soybean yields under present-day thermal conditions (blue line) and under A1B 2030 weather scenarios (red line), (a) and (b) of Bundelkhand and Figure (c) and (d) for Malwa region



3.4 Overall Strategy for Adaptation

(a) **Enhancing water use efficiency to increase availability and accessibility to water:** In face of drought and minimal availability even during years of normal rainfall it is of paramount importance that water be used in a more efficient manner. Production techniques which consume lesser amount of water need to be promoted at the policy level. Fiscal instruments linked to water usage may put into place. State Electricity Boards need to be provided with fixed targets for water usage beyond which they would need to purchase water reductions from other boards which have performed beyond their targets.

(b) **Establishment of knowledge platform contributing to policy formulation leading to community empowerment:** A number of policies plans and scheme are being announced by the central and state governments for the development of the semi-arid regions. However, many a times it has been observed that these plans, programmes and schemes do not take into consideration climate change and its impacts. As a result the development activities are not climate sensitive or resilient. Therefore, there is a need to apply the "climate change lens" to the government plans, programmes and schemes. Such a lens would help in identifying lacunae in the current implementation and planning and would thus support practice and policy. Bundelkhand is a typical example of a semi-arid region. It is a socio-economically backward region in central India and straddles the states of Uttar Pradesh and Madhya Pradesh. It is a semi-arid region and the last four out of five years have been drought hit. The people in the region are extremely vulnerable to climate change impacts, with their

dependence on subsistence agriculture and livestock in climate unfriendly ways. The **Bundelkhand Knowledge Platform (BKP)** is an example of such a platform. It was initiated for engaging with stakeholders for effective participation in drought mitigation actions in Bundelkhand, and engagement with state level and national partners for dialogue on climate change mitigation and adaptation. The formative meetings with with CSOs from the region reveal the need for a sharing knowledge and collaborative action towards improved agriculture and livestock to reduce livelihood vulnerability in the region. Collaborative planning for action has been initiated facilitated by the Platform.

(c) **Blending formal and informal science for enhanced delivery on ground:** Agricultural communities have been adapting to changing climate over the centuries. Thus the communities have knowledge which has been accumulated over the centuries and is appropriate for the local region. There is however a need to validate the traditional practices through modern scientific methods. This is necessary since agriculture has been a way of life and a number of practices are more of cultural importance than that of technological. Once validated and improvised the traditional knowledge will be more effective and also more acceptable to the community since it has its origins amongst them.

(d) **Increasing access to appropriate technology for adaptation to climate change:** Access to appropriate technology remains a big hurdle to adaptation in agriculture. Though the Krishi Vigyan Kendras along with the Agricultural University system has been making efforts for dissemination of technology among farmers they have not been able to reach the unreachable. Therefore, there is a need to establish Farmer/Agriculture Resource Centres which would serve as centres which facilitate the last mile connect between the research outputs at the university/research institute level and agricultural practices of the farmer. The resource centres will not only serve for technology dissemination but will also provide information and advisory services to the farmers.

(e) **Provision of weather based crop insurance:** Weather based crop insurance has been hailed as a major breakthrough in adaptation to climate change sectors. However, weather based systems do not take into account the microclimatic variations which exist even within small regions. There are situations where in there is only a single weather monitoring station for one district. There have been instances where districts are declared drought hit even though it is quiet visible that the district is drought hit. This has been attributed to poor availability of meteorological networks in many parts of the country.

Figure 15: Agricultural practices followed in Madhya Pradesh

3.5 Institutional Capacity Assessment

Interactions with the block, district and state level functionaries took place during district and state workshops and also during one to one meetings. These interactions provided ample opportunities to gauge the current capacity of the state institutions. In general, the state institutional set up is well geared. The district administration for example is well versed in drought prone areas to reach out to the community for aid purposes.

However, interaction between various departments has potential for improvement. For example in order to adapt to climate change in the agriculture a number of departments will need to act in unison. Some of these are Department of Agriculture, Irrigation Department, Planning Department, Finance Department, Department of Power, etc. In order to bring coherence in the actions of these various departments a core group on climate change adaptation needs to be set up at the state level with members from key departments. Membership of the core group should also be open to civil society and private sector as well. Agriculture extension services in the various districts are highly understaffed. For the new methods and resources to reach out to the maximum number of farmers it is essential that the numbers of extension cadre be enhanced substantially. As of now the Krishi Vigyan Kendras (Agriculture Science Centers or KVKs for short) have limited staff which is sufficient only for demonstration purposes but not for roll out. In case further recruitment is against policy of the state then in this condition partnership with private sector needs to be established.

Another area where capacity needs further strengthening, is outreach to the community in terms of participatory planning methods. Most of the planning processes do not involve the communities directly. This leads to disconnect with the ground reality as a result of which the intended benefits of schemes are not seen. The formulation of the Madhya Pradesh Action Plan for Climate Change was consultative in manner but direct communication and deliberation with the communities was not taken up. Given the very large of the state of MP (more than 300,000 sq km) it might had not been possible to do so. However, at the time of district level planning for adaptation the district administration needs to be advised to include the rural communities directly in the consultations.

4. DISCUSSION OF RESULTS

This research study not only helped to assess the extent of vulnerability and sensitivity of climate change to the local communities but also to check that how resilient and well adapting the communities with the changing climatic conditions.

4.1 Key Lessons Learnt

(a) **Impact, vulnerability and adaptation assessment**

(i) ***Impact assessment:*** Both wheat and soybean crops are susceptible to future climate change in MP. However, the vulnerability of the wheat crop is much more than that of soybean. Also, though decrease in yields of soy crop may be balanced by adjust date of sowing the same option is available to a lesser extent in wheat crop. Therefore there is greater need to focus research and development by both formal and informal institutions on the wheat crop. The current chose A1B scenario for describing impacts of climate change on crop production as it is the most likely one in business as usual scenario given the 8-9% per annum economic growth in developing countries even in recessions. The world population is nearing 7 billion and will most probably not stabilize before mid century. Use of other scenarios would probably lead to predictions of lesser loss of productivity. Thus care needs to be taken in future in order to assess crop loss due to climate change by choosing the appropriate scenario based on changes in global and regional economic and environmental circumstances. The certainty of the results should therefore be taken in the context of these limitations.

(ii) ***Vulnerability and adaptation assessment:*** A number of farmers have migrated to urban centers in the recent past, many with their families. However, this migration is not likely to have an adverse impact on the food security of the region as the per capita land holding is about 2 hectares. Therefore consolidation of land holdings as a result of migration might not reduce the availability of human resources to carry out agricultural operations. It has also been observed that due to lower availability of water farmers have shifted away from water intensive crops such as wheat to sesame. However, adoption of sesame has the downside the market is not as readily available as it is for wheat. The next step is to link the farmers with enterprise development support and market linkages for ensuring that new enterprises take-off. Many farmers have already started trade in vegetables and milk specially in regions near to urban centers. Adaptation and reduction of vulnerability will necessitate their moving up the value chain in these activities. This, as the project has found, requires intensive orientation, exposure and training efforts for enterprise development and management, local marketing of products and capacities to interact with facilitating agencies

(b) **Capacity building assessment**

(i) Although the officials of the district administration are keen to work on the issues of climate change many of them lack a clear understanding of how climate change adaptation project differs from a development project with a natural resource management one. Another area of capacity building relates to prioritization of

adaptation measures. Most of the officials are exposed to the concepts of post disaster management. However, the differentiating factor of foresight and planning needs further strengthening.

(c) **Multi-stakeholder knowledge and policy networks**

(i) A number of policies programs and schemes exist catering to the agriculture sector but the real lacuna lies on visioning the integration of all policies and schemes in a common framework.

(ii) The decision makers understand that the climate is changing but there is a lack of availability of material which communicates the key issues and potential solutions to the problems at hand.

4.2 What Worked Well/Not so Well

(a) **What worked well:**

(i) ***Direct contact with the community*** helped the project team to understand the situation on ground, identify coping mechanisms and aspiration of community. This led to value addition in the prioritization of adaptation options.

(ii) ***Simulation models for crop impacts*** have been successful in bringing out the differential impact on the crops. The simulation study has therefore been helpful in providing pointers for further research. Simulation study also provided insights into potential no cost adaptation options.

(iii) ***Stakeholder engagement*** was ensured by the formation of a core committee comprising of various relevant line departments of State Government of Madhya Pradesh. Regular meetings were held to keep the committee updated about the methodology and the findings of the study. Feedback provided by the committee served as a sounding board for the work carried out and provided direction for the way forward. EPCO was a partner in the implementation of the project which ensured buy in of the State Government. Several of the findings and the suggested adaptation options were incorporated into the draft State Action Plan on Climate Change which was prepared by EPCO, DA's partner in the current study. The Project Steering Committee which was formulated for the State Action Plan overlaps with that of the Core Committee which was established for the current study preceding it by more than 6 months. Some of the adaptation strategies identified under the current study are being integrated into the Madhya Pradesh State Action Plan on Climate Change (MP SAPCC). These are promoting use of soil and water conservation technologies, planning cropping systems suitable for each agro-climatic conditions, capacity building, strengthen weather based crop insurance, enhancing dissemination of new and appropriate technologies developed by researchers and strengthening research further, additional impetus for accessibility of markets, building institutional mechanism for Climate Change Action Plan. The Methodology, key results, outcomes and recommendations of the research study is highlighted as a case study into the MP SAPCC.

(b) **What did not worked so well**

(i) ***Consistent engagement with the top administration*** in the state was affected due to frequent transfers of the officials. The incumbent official had to be explained the project afresh each time. However, the officials were always cooperative and keen to respond to the needs of the hour.

4.3 Comparison of Key Findings with Other Studies

The adaptation options which have come up as a result of the current study compare well with those suggested by Hedger and Vaideeswaran, 2010. The said study identifies that crop insurance and awareness generation as critical for adaptation in the agriculture sector. However, Hedger and Vaideeswaran did not undertake simulation studies on crops and therefore they have no suggestions as regards to altering the sowing dates as a no cost adaptation option. The study is also limited by the fact that it did not undertake any primary research and thus the voice of the community is not represented.

The Draft State Action Plan on Climate Change of Madhya Pradesh was released for public comments on the 15th September 2011 has a section on adaptation in the agriculture sector and some of the key strategies suggested include agroforestry, water and soil conservation practices and institutional capacity building. The State Action Plan was prepared through an elaborate process of public consultations in various districts of MP supported by review of literature. Again, this study too differed in not conducting any primary research.

The results of the simulation studies provided the likely impact of future climate change on yield of wheat and soybean in Bundelkhand and Malwa region of MP. Increasing number of recent studies have also recommended the effectiveness of agronomic adaptation strategies including adjustments in planting dates in coping with climate-induced yield losses in different regions of India (Lal et al., 1999; Mall et al., 2004, 2006; Aggarwal et al., 2008). Similar results were also found by Mall et al (2004) and they studied the climate change impact on soybean crop in India. They also suggested that in MP state delay in sowing that and seasonal shift in sowing of soybean crop to December will be beneficial in terms of higher yields particularly in Jabalpur, Gwalior, and Jabalpur district. As per review reports by Mall et al. (2006) and Aggarwal et al (2008) there have been not another study till date taken out in India on impact of climate change on soybean crop in MP state.

4.4 Interpretation of the Results

The approach of the study is a major factor which needs to be considered while interpreting the results. The study's approach is to synthesize the findings of primary survey, simulation study, and consultations. This has resulted in a set of adaptation options and strategy which would have been difficult to arrive at had these components of the study been taken up alone.

The study focused on two agro climatic zones within MP viz. Bundelkhand and Malwa and therefore the extrapolation of the results to the entire state needs further calibration. The capacity building assessment which was conducted was done so in vivo. Had the same assessments been done via e mails or through telephone the results may differ accordingly.

5. CONCLUSIONS

5.1 Integration with the National Level Work

At the national level three work packages were carried out as a part of the broader Indo UK Collaborative Project. These included work on hydrology by IIT Delhi, climatology by IITM Pune and study on use of energy for irrigation from canal systems by IIM Ahmedabad.

The IIT Delhi study highlighted that in future particularly in the Bundelkhand region the duration over which rainfall would occur will decrease leading to rapid erosion of soils and lower recharge rates of aquifers. This was useful information which further enhanced the confidence levels in recommending soil and water conservation efforts as one of the short/medium term adaptation options.

IITM Pune's data sets also highlighted that in the future temperature rise will take place along with reduced precipitation, particularly in the winter season, which is the time for growing the wheat crop, which the staple food crop in the region. Their study lends further support to the fact that A1B scenario would be a likely one moving ahead. This guided us in taking A1B as the scenario of choice to conduct simulation studies.

5.2 Key Highlights of Results

The wheat crop is more vulnerable to climatic change as compared to soy bean. The finding is significant as wheat is the staple food crop of the region. Madhya Pradesh already has a lower yield as compared to the other states of the country, this being particularly true for Bundelkhand. With any further negative impact the results might be mass scale migration to urban centers. Long term rainfall data analysis has indicated that during the period 1901-2005 rainfall over MP shows decreasing trend though not very significant. However, in the recent five decades (bottom panels) the seasonal rainfall over MP is showing further steepening of the decreasing tendency. Based on 105 years (1901-2005) the trend for temperature rise in MP was 0.005o C/yr while in recent 5 decades it increases to 0.0065o C/yr.

Soybean has been a major transformative factor for prosperity in many parts of Madhya Pradesh. However, climate change may have negative impact on this crop too. However, modification of the sowing dates may result in enhancement of yields.

The past five years have been particularly harsh on the farming community and as a result there has been a lack of trust within the society. Combined with this the rural regions in both Malwa and Bundelkhand have witnessed mass scale migration. Within this disruption there have been a number of innovations particularly related to diversification of livelihoods most notably vegetable trading.

Though Malwa region has in the past had abundance of water resources it is predicted that the region will become drier. Therefore, the need is to adopt water conservation methods to avoid over exploitation. Soil erosion is particularly high in the tribal dominated regions of highland Malwa and this coupled with reduced rainfall will result in reduced moisture availability leading to reduction in agricultural and milk yields.

5.3 Key Implications of the Results

Whereas decline in productivity of wheat is critical from food security point of view the decline in productivity of soybean is likely to have impacts on agro based industries in the state. Wheat being the staple food crop in MP is grown by farmers in the winter season (rabi). The winter season is also the one which has been indicated by Indian Institute of Tropical Meteorology to face declines in precipitation. Thus, it is clear that the state of MP faces the dual challenges of ensuring food security and economic growth in a scenario of climate change.

Faced with climatic variability the farming communities in the state of Madhya Pradesh have taken up a number of coping measures which varies from crop switch to diversification of livelihoods. Many of these coping mechanisms may or may not be climate adaptations. Rigorous research is required in participation mode with the farmers to identify the adaptation options from among the coping mechanisms of the community.

The farming communities are already at the brink of collapse and agriculture is a nonprofit making proposition to most farmers. In such a scenario any additional impact of climate change will be unbearable by the agricultural community. Keeping this in mind the government of Madhya Pradesh needs to take immediate measures to relieve stress on agriculture. The measures may be divided into short term and long term goals depending on the priority.

Extensive consultations were held with various stakeholders including district and state level officials, civil society organizations and research institutions. Surveys were conducted at the household levels for developing the list of adaptation options. While the household surveys provided an insight into the coping mechanisms of the agricultural community, wider consultations helped them to be put into a wider context of what is replicable at a wider scale. Thus the adaptation options represent a match between what is practical on ground and what are the options for which the state machinery is most ready.

Some of the short and medium term (2-3 years) measures which may be suggested are:

(a) Promotion of **efficient irrigation, soil conservation methods and agro-forestry** involving demonstration plots and exposure visits of farmers. Demonstration is the key for adoption of appropriate practices by the target groups. Exposure visits will result into the behavior change of farmers towards new ideas. Although single interventions have limited impacts; putting together different available technical options coupled with institutional strengthening demonstrate significant impacts. Farmers are ready to adopt 'demonstrated beneficial practices' even if these are not formally validated by any research / Govt institutions.

(b) **Extension of crop insurance** to cover more farmers as the current penetration of the insurance scheme is not adequate

(c) Establishment of **"Farmers Adaptation Clubs/Clusters"** to bring farmers together to respond to the threats of climate change by connecting them to local markets

(d) Enhancing the access to information of the farmers by use of innovative platforms such as radio based **Rural Reality Shows and mobile telephony**. Access to knowledge and information and cooperative action will enable farmers to enhance productivity, reduce input costs and quick change in strategy when the monsoon variability threatened the kharif sowing.

(e) As exchange of knowledge is critical to adaptation there is a need to set up or to **strengthen existing knowledge platform**s

(f) No cost options such as **change in sowing dates** have been shown to minimize losses or to actually increase the yields of agricultural crops. Such measures need to be tested at a pilot level for research purposes and then if found feasible, be scaled up.

In the long run there will need to be a systematic approach to the problem and may consist of:

(a) Conducting research to identify the best approach to adapt agriculture to climate change by determining the crop mix which will be most resilient to the impacts of climate change in different regions of the state.

(b) Establishment of a meteorological network in the state to provide customized local information and forecasting services to the farmers will help in reducing the impacts of climate variability.

(c) Institutional capacity building will play a crucial in adapting to climate change by providing appropriate direction and channelization of funds and efforts. Therefore there is a need of a long term program for capacity building on key aspects of climate change adaptation.

(d) The Government of MP needs to review its procurement policy to include/enhance quota for alternate crops such as sesame for preferential purchase in drought prone areas.

For decision makers it has been observed that it is very important for them to understand the relevance of the suggested adaptation options in case the predictions made by the modeling exercises do not happen or happen at a magnitude which was lesser or more than that predicted. Below is a robustness matrix which presents the various adaptation options and how relevant each one of them is in case climate change does not take place, the impacts of climate change are less than that predicted, impacts are as they were predicted and impacts are more than they were predicted to be. The robustness of each one of the adaptation options has been derived from a combination of expert view, consultations and direct observations on ground.

Table 3: Robustness matrix for adaptation options in different scenarios

Measures	Adaptation options	Climate change impacts less than predicted	Climate change impacts as predicted	Climate change impacts more than predicted	Action required	Relevant department
Short term measures	Efficient irrigation	✓✓✓	✓✓✓	✓✓✓	Large scale application of technology in farmers' fields	Agriculture, Irrigation
		✓✓✓	✓✓✓	✓✓✓	Wider dissemination	Finance, Agriculture
	crop insurance Establishment of "Farmers Adaptation Clubs/Clusters"	✓✓✓	✓✓✓	✓✓✓	Mobilization of farming community	Agriculture
	access to information	✓✓✓	✓✓✓	✓✓✓	Conceptualize and plan for programs	Information Technology, Telecom, Information Broadcasting

Measures	Adaptation options	Climate change impacts less than predicted	Climate change impacts as predicted	Climate change impacts more than predicted	Action required	Relevant department
	Knowledge exchange	✓✓✓	✓✓✓	✓✓✓	Set up/support platforms	Information Technology, Telecom
Long term measures	Change in Sowing dates	✓✓✓	✓✓✓	✓✓✓	Pilot level tests	Agriculture
	Research and development for determining crop mix	✓✓✓	✓✓✓	✓	Plan and initiate field level experiments	Agriculture, Irrigation, Power
	Establish meteorological network	✓	✓✓✓	✓✓✓	Plan and implement network	Meteorology
	Institutional capacity building	✓✓✓	✓✓✓	✓✓✓	Develop curriculum	Human Resources
	Procurement policies	✓✓✓	✓✓✓	✓✓✓	Review existing policy	Planning

✓✓✓ = robust; ✓✓ =less robust; ✓ =not robust

It is clear that the options are such that they do not result in allocation of resources into assets which become immobilized in event of climate change impacts not happening. That is these are options which in any case will be useful for the farming community.

Though, the departments have been identified it needs to be mentioned that the support of Civil Society Organizations, Research Institutions and Private Sector will be vital for large scale application of adaptation options.

5.4 Institutional Mechanisms and Partnerships

Bundelkhand Package

Bundelkhand Package has made budgetary allocations for credit, watershed management, water resources, agriculture, animal husbandry, horticulture and enhancing forest regeneration. The activities identified have potential for both adaptation and mitigation. However, the benefits can be maximized and the negative impacts reduced to a minimum if proper planning is in place. These and other such plans and packages provide a window of opportunity whereby climate change may be integrated into the planning processes village, district and state levels in Uttar Pradesh and Madhya Pradesh.

Bundelkhand Knowledge Platform

A number of players are involved in the development planning and implementation spheres. Each one of these partners has a unique role and lessons which have the potential to contribute to policy formulation and its implementation. Hence, it is necessary for the different partners to come together and participate in a meaningful dialogue using the Bundelkhand Knowledge Platform. Thus the Bundelkhand Knowledge Platform will serve also as a forum where ideas and experiences are exchanged leading to sustainable practices for agriculture, livestock, energy and water security and advocating appropriate development strategies and policies for Bundelkhand in the climate change context.

Objectives of the Bundelkhand Knowledge Platform

- Inform practice towards low carbon climate resilient growth
- Influence policy of the state and central government for mainstreaming climate change in planning and policy
- Developing substantive arguments in favour of appropriately directing the Bundelkhand Package towards energy and water and resource resilient practices in agriculture, livestock and livelihood creation and supporting monitoring systems for the effective implementation of the Package

The various potential stakeholders and their likely roles are as given under:

Stakeholders	Function
CSOs	Ground level learnings
PRIs	Community expectation and learnings
Institutions (Academic)	Validation and innovation
Institutions (Research)	
District Officials	Information on government initiatives

A dedicated website (www.bundelkhandvikasmanch.net) has also been launched for this purpose. Dr. B. Venkateswarlu (Director, Central Research Institute for Dryland Agriculture, Hyderabad) has agreed to be the advisor for the Knowledge Platform.

Madhya Pradesh Rural Livelihood Program (MPRLP)

MPRLP is particularly focused on delivering socio-economic empowerment to women and the selection of villages participating has been based on low female literacy rates (around 21%). Activities are undertaken in five themes: strengthening the Gram Sabah (supporting the state initiated decentralization processes); improving livelihoods; social protection; gender and equity and informing policy.

MPRLP has provided training on financial management, employment, local markets; non timber based forest produce trading and marketing, increase in organic farming, paddy grower's biogas plants, self-help groups. The focus has been on agriculture and livestock management - tree planting on field bunds 2900 villages- for windbreaks, soil carbon, and income sources.

Key Research Finding

The research project used a combination of consultations, modeling exercises and on ground studies involving direct contact with the vulnerable communities. There are sections within the agricultural communities which are more vulnerable than others and their situation is as such quite precarious. Climate change, if and when it happens, will make the situation worse. Adaptation options are known and in many cases have been tried by the state/disticts agencies. Of all the adaptation options, **efficient irrigation methods** need to be promoted at the earliest. It is also an option which will be useful whether climate change takes place or not. In the entire state water table has been falling, even in regions with adequate rainfall. Not only will it reduce the use of water and therefore conserve it for drought time, it will also help in reducing the input cost of agriculture and contribute to energy security of the State.

Besides this few key options can be:

Adoption of resource efficient farming practices such as sprinkler, drip irrigation.

Formation of Farmer Adaptation Clusters (FAC) needs to encouraged which will integrate the farmers traditional knowledge with government outreach efforts.

Promoting and reviving traditional drought coping mechanisms such as traditional water harvesting structures, promote small farm mechanization, development of heat tolerant and drought resistant crop varieties and change the cropping pattern of farming.

Bring effective crop insurance policies, irrigation practices and agriculture land use development to adapt to the changing impact of climate change.

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7. ANNEXURE

Annex 1

CLIMATE CHANGE IMPACT ON WHEAT AND SOYBEAN FOR THE STATE OF MADHYA PRADESH (BUNDELKHAND AND MALWA)

1. INTRODUCTION

In recent years, with the growing recognition of the possibility of global climate change, an increasing emphasis on world food security in general and its regional impacts in particular have come to forefront of the scientific community. Crop growth, development, water use and yield under normal conditions are largely determined by weather during the growing season. Even with minor deviations from the normal weather, the efficiency of extremely applied inputs and food production is seriously impaired. The carbon dioxide (CO_2) concentration was in the steady state at 280 ppm till the pre industrial period (1850). It is rising since then at the rate of 1.5 to 1.8 ppm per year. The concentration of CO_2 is likely to be doubled by the end of 21st century (Keeling et al., 1995). The increasing CO_2 concentration in the atmosphere and the anticipated climate change due to global warming are likely to affect future global agricultural production through changes in rate of plant growth (Lemon, 1983; Cure and Acock, 1986; Rotter and Van de Geijn, 1999), transpiration rate (Morison, 1987; McNaughton and Jarvis, 1991; Jacobs and DeBruin, 1992; Koti et al., 2007).

Worldwide agricultural production is governed by the combination of climate, soil tilth, technology, genetic resources, and farm management decisions such as tillage, manure and fertilizer applications, and crop variety selection (Aggarwal et al., 2009; Douglas, 2009; Nafziger et al., 2009; Huang and Khanna, 2010; Aggarwal & Singh, 2010; Wani et al., 2010; Chandrashekar, 2010; Reidsmaa et al., 2010). In general, advances in technology and changing agronomic practices are responsible for signi cant increases in wheat and soybean yields across the country [Deosthali et al., 2005; Ahirwar et al., 2006, Jat et al.; 2008; Paroda, 2009].

The soybean (U.S.) or soya bean (UK) (Glycine max) is a species of legume native to East Asia. The plant is classed as an oilseed rather than a pulse. It is an annual plant that has been used in China for 5,000 years to primarily add nitrogen into the soil as part of crop rotation. The main producers of soy are the United States (32%), Brazil (28%), Argentina (21%), China (7%) and India (4%). Soybean ranks first among the oilseeds in the world and has now found a prominent place in India. In recent years, soybean has established itself as a major rainy season crop (June-September; 'Kharif' season) in the rainfed agro-ecosystem of central and peninsular India. The region spread in latitudinal belt of about 15o to 25oN contributes to 98% of the total area under soybean in the country. Starting from just 0.30 million ha (Mha) in 1970, the area under soybean in India has increased to 9.6 Mha in 2009. The growth in production and productivity has been increased from 0.014 million tonnes in 1970 to 9.70 million tonnes in 2009 and 380 kg/ha in 1970 to 1100 kg/ha in 2009, respectively (SOPA, 2009). This increasing trend of fast adaptation of the crop by the

farmers in India points out that soybean is going to be the future leading commercial venture in the country.

The State of Madhya Pradesh has distinguished itself as a 'Soya State' on account of its largest share in (61%) and production (70 %) in India. Its cultivation has also brought about positive socio-economic changes in the life of farmers in some parts of India (Tiwari et al., 1999). There is still substantial scope to increase both area and productivity of soybean in India. Soybean has a good potential to get involved in the intercropping (Jat et al., 1998; Neog et al., 2008; Meeraiah et al., 2008) as well as crop sequences, as it is a short duration (85–120 days) leguminous crop. The crop is predominantly grown on Vertisols and associated soils with an average crop season rainfall of about 900mm which varies greatly across locations and years. Introduction of soybean in these areas has led to a shift in the cropping system from rainy season fallow followed by post-rainy season wheat system to soybean followed by wheat system (Singh et al., 2002; Bhatia et al., 2008, Srivastava et al., 2010.

India is one of the greatest success stories of Green Revolution, and Wheat (Triticum aestivum) is the most important winter cereal of India and is grown during "rabi season" November to mid-April. India is now second largest producer of wheat in the world with production hovering around 70–78 million tons in the past few years and produced a record 78.40 million tons during crop year 2007-08 (Nagarajan, 2005; DES, 2008). It accounts for approximately 12% of world's wheat production and is the second largest wheat consumer after China (FAO 2004). Wheat production of 6.5 million tons in 1950-51, was dwarfed by the 78.4 million tons produced in 2007-08, a more than tenfold increase. This national production increase is re ected in increased yields per hectare that went from around 660 kg/ha in 1950-51 to 2,785 kg/ha in 2007-08. Alongside increased yields came an increase in area planted from nearly 9.8 million hectares in 1950 to 24 million hectares in 1990, to about 28 million hectares in 2007-08 (DES, 2008).

Wheat is the important cereal crop in the state of Madhya Pradesh, India, occupying nearly 3.5 million ha. (~14%) area, 7 million tons (~10%) production, but productivity (~1600-1800 kg/ha) is low compared to national average of 2700 kg/ha. Wheat is grown under irrigated condition (78%) and high inputs in the winter season in the state, while in India 74.6% of the crop area is irrigated (DES, 2008). It is clear that over time more nutrients have been removed than added through the fertilizers, and the farmers have to apply more fertilizers to get the same yield, they were getting with less fertilizers 20-30 years ago. Climate change will further affect soil conditions. Changes in temperature and in precipitation patterns and amount will influence soil water content, run-off and erosion, salinisation, biodiversity, and organic carbon and nitrogen content. The increase in temperature would also leads to increased evapotranspiration. There is need to quantify the specific regional soil-related problems and that affect the global environmental change will have on soil fertility and its functioning for crop growth and production.

2. OBJECTIVE OF THE STUDY

The objective of the study is:

(i) To examine the present status of the knowledge of climate change impact on wheat and soybean in Madhya Pradesh.

(ii) To evaluate the performance of CROPGRO-soybean and CERES-wheat models under different seasons, weather, locations, management, and sowing dates;

(iii) to know the yield potential of wheat and soybean;

(iv) to assess the impact of climate change on wheat and soyabean crop in Bundelkhand and Malwa region and identifying adaptation options and future research needs.

3. MATERIALS AND METHOD

3.1 Study Site and Data Used

Table 4: Period of weather data used and soil depth at selected locations in MP.

Study Site	Latitude (N)	Longitude (E)	Present Period (weather)	Soil depth (cm)
Datia	25.50	78.30	1973-2005	140
Tikamgarh	24.45	78.53	1973-2005	140
Ujjain	23.42	75.50	1973-2005	160
Dhar	22.60	75.30	1973-2005	160

3.2 Simulation Models Used

The two crop simulation models have been used to study the impact of climate change on wheat and soybean. These are:

The CERES-Wheat model: The CERES-Wheat (Ritchie et al. 1998; Gijsman et al. 2002) model embedded in the Crop growth simulation models which share a common input and output data format have been developed and embedded in a software package called the Decision Support System for Agrotechnology Transfer (DSSAT) (Tsuji et al., 1994; Jones et al., 1994; Hoogenboom et al., 1994). Decision Support System for Agrotechnology Transfer (DSSAT v.4) module was used for simulation of wheat yield. The model is a process-based, management-oriented model simulating the growth and development of wheat. The model operates on a daily time-step and calculates biomass production, which is then partitioned to the leaves, stems, roots and grain, depending on the phenological stages of the plant. The model calculates net photosynthesis based on a constant radiation use efficiency, leaf area index, extinction coefficient and light absorption by the canopy (Mall and Aggarwal 2002).

The CROPGRO-soybean model: The models under DSSAT umbrella include CROPGRO for soybean. Its major components are vegetative and reproductive development, carbon balance, water balance and nitrogen balance. A detailed description of the modi ed version of CROPGRO-soybean model is provided in Boote et al. (1996). The model uses empirical functions to compute daily canopy gross photosynthesis in response to CO2 concentration, air temperature and daily canopy evapotranspiration. Canopy photosynthesis is computed at hourly time steps using leaf-level photosynthesis parameters and hedgerow light interception calculations (Boote and Pickering, 1994). Photosynthesis and evapotranspiration algorithms also take into account the changes in daily canopy photosynthesis under

elevated CO2 concentration and temperature conditions (Curry et al., 1990a,b). The model simulates the potential, water and nutrient limited yields of soybean.

3.3 Input Data

The models (CERES-Wheat and CROPGRO for soybean) require input data on soil, crop and weather for its calibration and validation in different environments. Weather (solar radiation, maximum and minimum temperatures and rainfall) and soil (albedo, first stage evaporation, drainage, USDA Soil Conservation Service Curve Number for runoff and layer-wise information and saturation, field capacity, wilting point, texture and hydraulic conductivity) and crop management data (dates of sowing, plant and row spacing, irrigation, fertilizer, etc.) were collected for each of the locations under study.

3.4 Evaluation of the Crop Models

***Genetic coefficients*:** To simulate a crop variety, the crop model requires genetic coefficients. The CERES-wheat model was calibrated and validated for the region using data from field experiment with the dwarf variety C-306 and Sujata grown under nonlimiting water and nitrogen conditions. A total of 8 sowing dates (October end November) were used covering five years (sowing years 1998-99 to 2002-03) of yield from 1.5 to 3.2 t/ha for the different treatment. In this field experiment, the wheat crop was sown at row spacing of 30 cm and the seed depth was maintained as 5 cm. A net 30-40 kg of nitrogen was applied as basal dose at the time of sowing. Seed rate was 100 kg/ha. The genetic coefficients obtained in this study were used here. The genetic coefficients derived here was in close match with Singh et al (2010).

The genetic coefficients of the 'JS 335' variety of soybean for the model were estimated by repeated iterations in the model calculations until a close match between simulated and observed phenology, growth and yield was obtained. All calibration data required to derive genetic coefficients were obtained from field experiment conducted at Indore during 1996 2001 and 2002 using random block design. In this field experiment, the soybean crop was sown at row spacing of 45 cm and the seed depth was maintained as 5 cm. A net 20 kg of urea was applied as basal dose at the time of sowing. Plant population was kept as 45 plants/m2. These coefficients were used in the subsequent validation and application. The genetic coefficient derived was in close match with Bhatia et al.. (2008)

The model validation: A large number of field experiments have been conducted in Madhya Pradesh where the effect of different agro-ecological factors such as season, weather, sowing dates and variety has been studied on growth and yield of soybean crop in different locations. This database included all relevant information (including the different management practices adapted and the location specific weather conditions) obtained from field experiments conducted between 1996 and 2003 in major soybean producing districts.

3.5 Climate Change Scenarios

Climate change is no longer a distant scientific prognosis but is becoming a reality. The anthropogenic increases in emissions of greenhouse gases and aerosols in the atmosphere result in a change in the radiative forcing and a rise in the Earth's temperature. The importance and significance of the vulnerability

of natural and human systems to climatic changes and adaptation to such changes is increasingly being realized. Consequently, there is now a growing recognition of the vulnerability and impacts of climate change on the key sectors of economic development. The Intergovernmental Panel on Climate Change (IPCC) has clearly concluded that the impact of human activities on climate is unequivocal (IPCC, 2007). The calibrated and validated crop models were used for simulating the yields during baseline period (1969-1990) and also for assessment of impacts. Climate change scenarios of PRECIS A1B for 2030 periods used in the model in four districts.

3.6 Crop Simulation

Impact of climate change on grain yield of crops was studied using A1B 2030 scenarios derived from the PRECIS RCM. The PRECIS is a Regional Climate Model with HadCM3 as its GCM. The climate model's outputs on temperature (minimum and maximum) and rainfall for A1B-2030 scenarios were coupled to the baseline weather data. The projected carbon dioxide levels as per Bern CC model for respective scenarios were also included in the model for simulations. All other simulation conditions were maintained as explained earlier. Based on the simulated yields in changed scenarios, production was calculated as in case of baseline production assuming that the area under wheat in each district would remain same in future as well. To express the impacts on production, the net change in production in climate change scenarios was calculated and expressed as the percentage change from baseline mean production. The effect of climate change on productivity was simulated for normaly sown crops at three levels of production:

(i) Potential productivity assuming no effect of water and nutrition stress on crop growth.

(ii) Irrigated productivity assuming application of 120 kg N /ha (wheat) and 40 kg N/ha (soybean); and five irrigations during the cropping season.

(iii) Rainfed productivity, assuming no irrigation and 50 kg/ha (wheat) and 20 kg/ ha (soybean) basel N application.

4. RESULTS AND DISCUSSION

4.1 Impact on Wheat Crop

Table 5: The simulated potential, irrigated and rain fed wheat yields for the selected 4 sites under current condition along with their coefficients of variation (CV %) are shown in table.

Study Site	Simulated Potential Yield (kg /ha)	CV %	Simulated Irrigated Yield (kg /ha)	CV %	Simulated Rainfed Yield (kg /ha)	CV %
Datia	5.70	10.8	4.2	11.2	1.3	16
Tikamgarh	5.60	11.3	4.1	10.7	1.2	14
Ujjain	5.10	8.2	3.5	9.8	0.8	13
Dhar	4.60	7.8	3.2	7.9	0.7	11

We performed a set of simulation to examine the sensitivity of wheat productivity with the A1B 2030 scenarios weather data derived from the PRECIS RCM for India. The result of the simulation is presented in table 2. The simulation analysis indicates that the productivity of potential yield of wheat in MP region (selected 4 stations) is likely to change -14 to -20% in PRECIS A1B 2030 scenarios depending upon the locations (Fig. 1). As average of 4 locations the yield (potential, irrigated and rainfed) is going to decline by -18 to -23%, total above ground biomass by -8% to -13%and maturity duration decreased by -3 to -8%. The PRECIS A1B 2030 scenarios projected somewhat higher surface air temperature than observed weather records for the present day atmosphere and as a consequence the simulated grain yields show a decline in crop yields. The yields in wheat are found to decline almost identically for the all 4 locations, but rain fed environment will be more suffer than other. The total above ground biomass will also be affected and going to decline during 2030s. The maturity duration of the crop will be reduced by 4-10 days all locations depending on production environments.

Figure 16: Change in potential wheat yields under PRECIS A1B 2030 climate scenarios in comparison to observed present weather

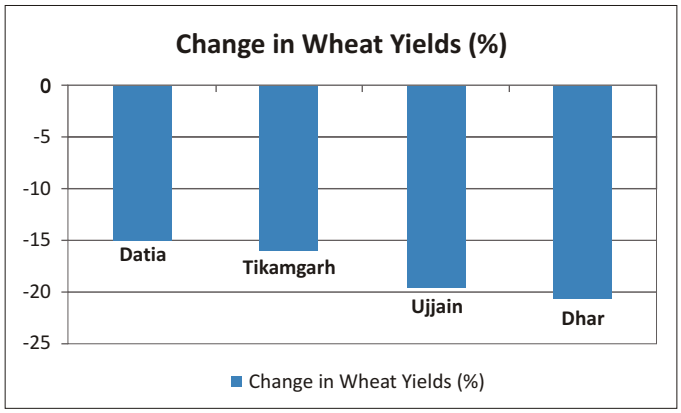


Table 6: Some crop growth parameters of the wheat variety as simulated by CROPGRO-soybean for A1B 2030 scenarios (2040-2060) (values represented average of 4 locations in MP).

Crop growth parameters	Potential		Irrigated		Rainfed	
	Present Weather	A1B 2030 Weather scenarios	Present Weather	A1B 2030 Weather scenarios	Present Weather	A1B 2030 Weather scenarios
Change in yield	0%	-18%	0%	-19%	0%	-23
Change in above ground biomass	0%	-8%	0%	-9%	0%	-13
Change in maturity duration	0%	-3%	0%	-4%	0%	-8

4.2 Impact on Soybean Crop

The CROPGRO-Soybean model simulates the potential yield of soybean, mainly driven by solar radiation and temperature and on varietal characteristics. In predicting the potential yields, it is assumed that the crop has no water and nitrogen stress and is free from any insect, pest and disease effects. Dates of sowing for each location were chosen based on the local practice. The potential soybean yields for the selected 4 sites under current condition along with their coefficients of variation (CV%) are shown in table 3. The

seasonal average daily temperature during the soybean growing period is also included in this table. Simulated potential yields ranged from 3050 to 3650 kg/ha and actual yield ranged from 900 to 1345 kg/ha.

Table 7: Mean simulated potential yields of soybean and their coefficients of variation (CV%), district wise area, production and yield (2009), average seasonal temperature for current climatic conditions at selected locations in MP

Study Site	Simulated Potential Yield (kg /ha)	CV %	Area (Lakh ha)	Production (Lakh Mt) -	Present average district actual Productivity (Kg/ha)	Seasonal average temp. (max/Min C)	Soil depth (cm)
Datia	3050	11.2	0.005	0.005	900	33.5/23.6	140
Tikamgarh	3150	10.4	0.344	0.313	910	32.8/23.1	140
Ujjain	3200	9.2	4419	5634	1275	32.1/23.5	160
Dhar	3650	8.9	2530	3403	1345	31.7/22.9	160

We performed a set of simulation to examine the sensitivity of soybean productivity with the A1B 2030 scenarios weather data derived from the PRECIS RCM for India. The result of the simulation is presented in table 4. The simulation analysis indicates that the productivity of potential yield of soybean in MP region (selected 4 stations) is likely to change -14 to -17% in PRECIS A1B 2030 scenarios depending upon the locations (Fig. 2). As average of 4 locations the yield (potential, irrigated and rainfed) is going to decline by -16% to -24%, total above ground biomass by -6% to -13% and maturity duration increased by 3% in potential and irrigated condition but decline by 2% in rain fed condition. The PRECIS A1B 2030 scenarios projected somewhat higher surface air temperature than observed weather records for the present day atmosphere and as a consequence the simulated grain yields show a decline in crop yields. The yields in soybean are found to decline almost identically for the all 4 locations. The total above ground biomass will also be affected and going to decline during 2030s. The maturity duration of the crop is extended by 3-4 days all locations.

The mean yield is found to be significantly affected under PRECIS A1B 2030 model-generated climate scenarios. In view of this, the assessment of the options to mitigate the negative impact of the climatic change will be dealt in the next section with reference to the model-generated climate change scenarios.

Figure 17: Change in potential soybean yields under PRECIS A1B 2030 climate scenarios in comparison to observed present weather.

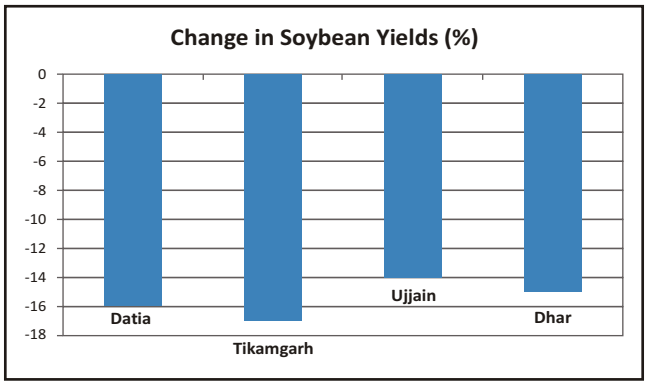


Table 8: Some crop growth parameters of the soybean variety as simulated by CROPGRO-soybean for A1B 2030 scenarios (2040-2060) (values represented average of 4 locations in MP).

Crop growth parameters	Potential		Irrigated		Rainfed	
	Present Weather	A1B 2030 Weather scenarios	Present Weather	A1B 2030 Weather scenarios	Present Weather	A1B 2030 Weather scenarios
Change in yield	0%	-16%	0%	-18%	0%	-24%
Change in above ground biomass	0%	-6%	0%	-8%	0%	-13%
Change in maturity duration	0%	3%	0%	3%	0%	-2%

4.3 Adaptation Strategies for Agriculture Production

Any perturbation in agriculture can considerably affect the food systems and thus increase the vulnerability of large fraction of the resource-poor population. We need to understand the possible coping strategies by different sections and different categories of producers to global climatic change. Farmers and society have always attempted to adapt to climatic stresses by resorting to mixed cropping, changing varieties and planting times, and by diversifying their sources of income. Policy of maintaining buffer stocks of food helps in managing periods of scarcity. In future, such adaptation strategies would need to simultaneously consider the background of changing demand due to globalization and population increase and income growth, as well as the socio-economic and environmental consequences of possible adaptation options (Aggarwal et al. 2010, Easterling et al. 2007).

While agriculture may benefit from carbon dioxide fertilisation and an increased water efficiency of some plants at higher atmospheric CO2 concentrations, these positive effects are likely to be negated due to thermal and water stress conditions associated with climate change. Thermal stress significantly affects the agricultural productivity when it occurs in critical life stages of the crop (Mall et al., 2006; Aggarwal et al., 2008). Increase the temperature reduces the total duration of crop by inducing early flowering and shortening grain fill period. The shorter the crop duration, the lower is the yield per unit area; a rise in temperature should therefore lead to a fall in agricultural production in a warmer atmosphere. Reports of heat-stressed crops have become common in the recent years in India. Even irrigated crops suffer from high evaporation losses and heat stress. Under these conditions, photosynthesis declines and the plant switches from a growth path to a survival mode thus reducing yields. A clear understanding of the relationship between climatic variability, crop management and agricultural productivity is critical in assessing the impacts of climatic variability and change on crop production, the identification of adaptation strategies and appropriate management practices, and the formulation of mitigating measures to minimize the negative effects of climatic variability including extreme events on agricultural productivity (Aggarwal, 2010).

Developing adaptation strategies exclusively for minimizing the negative impact of climatic changes may be risky in view of large uncertainties associated with its spatial and temporal magnitude. We need to identify 'no-regrets' adaptation strategies that may anyway be needed for sustainable development of

agriculture. These adaptations can be at the level of individual farmer, society, farm, village, watershed, or at National level. Some of the possible adaptation options include:

(i) ***Weather based Agro-Advisories Services:*** Due to increasing uncertainties in weather, it is necessary to provided agro-advisories to farmers for real-time decision making. This requires a state-of-the-art infrastructure to measure and record weather variables; standardized data protocols; systems for data storage, assimilation and dissemination; and access to short-, medium- and extended-range weather forecasts and seasonal climate forecasts at desired spatial and temporal scales.

(ii) ***Early warning system and crop insurance policies:*** Improved risk management though the encouraging crop insurance and can provide protection to the farmers if their farm production is reduced due to natural calamities. In view of these climatic changes and the uncertainties in future agricultural technologies and trade scenarios, it will be very useful to have an early warning system of environmental changes and their spatial and temporal magnitude. Such a system could help in determining the potential food insecure areas and communities given the type of risk. Modern tools of information technology could greatly facilitate this.

(iii) ***Augmenting production:*** There are large yield gaps in all crops and across all ecosystems and bridging them could ensure meeting increased food demands of the future. Even if a fraction of these yield gaps could be bridged, food security of the region will get strengthened and its vulnerability to climate change reduced. Fragile seed sector, poor technology dissemination mechanisms, lack of adequate capital for inputs, and poor markets and infrastructure are the key reasons for yield gaps.

(iv) ***Alternative Crops/New Varieties:*** Studies have shown that responses to climate change are strongly variety specific and the hypothetical new varieties would respond to climate change. The present simulation analysis, however, considers the variety characteristics to be almost the same in the future as at present. In reality, it is likely that the plant breeding research will develop newer high yielding varieties under the projected climatic conditions, thus alleviating the climate change impact to some extent. Changes in land-use and management including cultivating alternate crops or cultivars more adapted to changed environment; watershed management, resource conservation technologies can provide multiple benefits in future climatic stress conditions.

Few other are:

- Intensify search for genes for stress tolerance across plant and animal kingdom.
- Intensify research efforts on marker aided selection and transgenic development for biotic and abiotic stress management.
- Develop heat and drought tolerant genotypes.
- Attempt transforming C3 plants to C4 plants.
- Change of sowing dates and seasonal changes.

(v) ***Mainstreaming adaptation in current policy considerations:*** Climate change impacts and adaptations should be considered in all major development planning activities.

(vi) Develop new infrastructure, policies and institutions to support the new land use arrangements identified by science and technology.

(vii) Enhance investment in water harvesting and conservation options; and promote small farm mechanization and efficient water use technologies.

(viii) Explore international partnerships for collaborative research on adaptation of climate change research.

(ix) Establish 'Green Research Fund' for strengthening research on adaptation, mitigation and impact assessment.

(x) Intensify efforts for increasing climate literacy among all stakeholders of agriculture, including students, researchers, policy planners, science administrators, industry as well as farmers.

4.3.1 Adaptation Practices for Wheat

The general practice in MP and all four locations, sowing dates for wheat crop falls in October and November moths. Adaptation measures to mitigate the potential impact of climate change included possible changes in sowing dates and genotype selection. Enhancement of sowing by 10 days in late-sown cultivar (01 December) and delaying of sowing by 10 days in normally sown cultivars resulted in better yield in 2030s. From simulation it is found that 15 November or 20th November will be best option for 2030. The 15th November will be best option for Datia and Tikamgarh otherwise better crop management (variety selection, water management) will be a positive options.

4.3.2 Adaptation Practices for Soybean

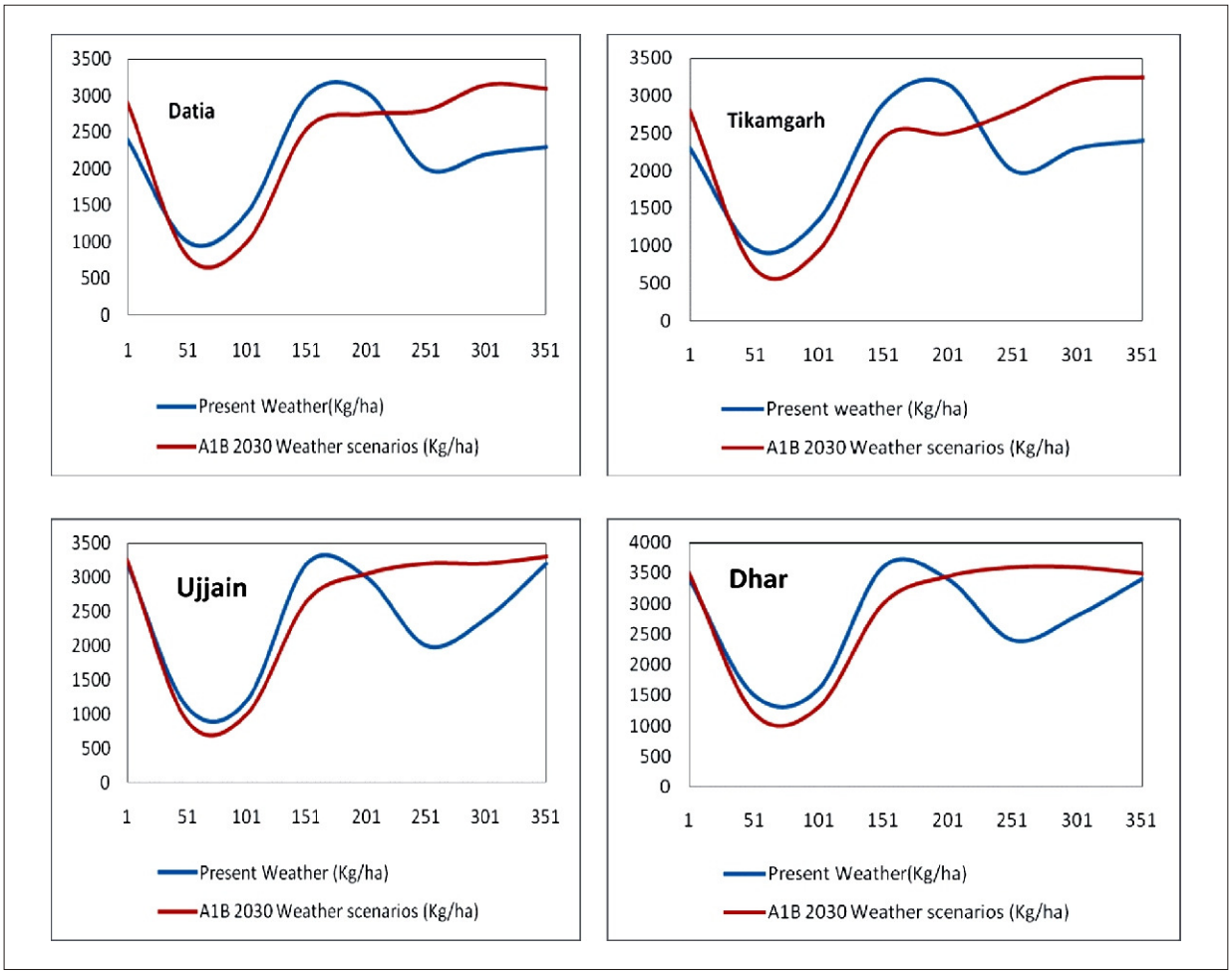
Considering the importance of soybean as a major cash crop in soya state of India, the key focus in this study is to identify measures in order to reduce the potential negative effects of climate change on soybean productivity. Planting date is one of the important management practices influencing soybean yield.

It is clearly evident that the present choices of sowing dates (Julian days 152–183 corresponding to June–July months) of soybean are most appropriate in terms of maximum crop yield in different parts of MP. Proper sowing date adjustments will, however, be necessary for efficient utilisation of natural resources under the climate change scenarios. The simulation results (Fig. 2) suggest that for the four stations (Datia, Tikamgarh, Ujjain and Dhar), the sowing of soybean crop may have to be delayed from June and first week of July to first fortnight of August, such that the adverse impacts of thermal stress due to projected climate change could be avoided during reproductive growth of the crop. Results also suggest that seasonal shift in sowing of soybean crop to December will be beneficial in terms of higher yields particularly in Datia and Tikamgarh district.

In view of findings reported above, potential adaptation options for sustained soybean productivity in India include adjustment in cropping calendar and crop rotation, development and promotion of use of high yielding varieties and sustainable technological applications. Delayed sowing date for soybean crop at all locations in India should be most effective in mitigating the thermal effects of climate change. Since soybean is a short duration leguminous crop, it has a good potential to get involved in the intercropping as well as crop sequences. However, under the circumstances, it might not be feasible to grow second crop in the subsequent season at some locations, thus resulting in overall reduction in the food productivity at these locations. Therefore, delay in the planting dates for soybean crop must be decided on the basis of the

temporal rainfall distribution pattern at any particular region. It may be noted here that increasing number of recent studies have also recommended the effectiveness of agronomic adaptation adaptation strategies including adjustments in planting dates in coping with climate-induced yield losses in different regions of India (Lal et al., 1999; Mall et al., 2006; Aggarwal et al., 2008).

Figure 18 Effect of varying planting dates on soybean yields [under present-day thermal conditions (blue line), under (dashed line) and under A1B 2030 Weather scenarios (changed thermal conditions) (red line).



5. CONCLUSION

The effect of climate change will be pronounced in MP state where wheat yield potential is already low as a result of relatively higher temperature than northern India. The soybean crop also suffers but delay in sowing and shifting in season will provide higher yield than present weather condition in MP. The study indicates that the productivity of wheat in MP region (selected 4 stations) is likely to change -14 to -20% in PRECIS A1B 2030 scenarios depending upon the locations. As average in MP the yield (potential, irrigated and rain fed) is going to decline by -18 to -23%, total above ground biomass by -8% to -13%and maturity duration decreased by -3 to -8%.

It is also found that the productivity of soybean in MP region (selected 4 stations) is likely to change -14 to -17% in PRECIS A1B 2030 scenarios depending upon the locations. As average of 4 locations the yield

(potential, irrigated and rain fed) is going to decline by -16% to -24%, total above ground biomass by -6% to -13% and maturity duration increased by 3% in potential and irrigated condition but decline by 2% in rain fed condition. The impact of modified climate in 2030s was observed to be higher under rain fed conditions than under other conditions (potential or irrigated).

The adaptation assessment suggests that the possible changes in sowing dates and hybrid selection can reduce the negative impact of projected climate in 2030s. It should be noted that shifting of sowing dates is a no cost decision that can be taken at the farm level; a large shift in sowing dates probably would interfere with agro technological; management of other crops, grown during the remaining part of the year. Changes in cropping mixtures, better forecasting of weather conditions, irrigation and agriculture land use can be additional alternative options for adaptation in agriculture in MP.

METHODOLOGY FOR VULNERABILITY ASSESSMENT

1. INTRODUCTION

The findings of the recent fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) has clearly brought out the seriousness of the climate change issues and the need for taking urgent measures for dealing with them. India is among the countries that are most vulnerable to adverse impacts of climate change with economic losses potentially as high as 5-9% of GDP (Stern Report).

To study these issues in detail, the Indian Ministry of Environment and Forests (MoEF) and the UK Department for Environment, Food and Rural Affairs (Defra) undertook the Indo-UK collaborative research programme on the impacts of climate change in India; the programme being managed on their behalf by Environmental Resource Management Limited.

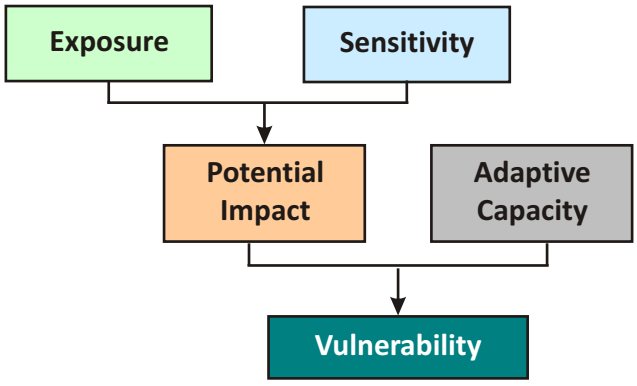
The Phase I of this research programme addressed uncertainties in climate scenarios with application of regional climate models in India and formulated some socio-economic scenarios for India, in line with IPCC guidelines.

The Phase II of this programme will build on the findings and the needs identified in Phase I. The programme will consist of national and state level projects.

With this background Development Alternatives has been assigned to undertake the vulnerability assessment and adaptation to climate change for agriculture sector in the state of Madhya Pradesh with a view to the potential scale-up of implementation of resulting adaptation processes and practices within the state and elsewhere in India.

Defining Vulnerability and Adaptation

Vulnerability is best defined as an aggregate measure of human and/or natural welfare that integrated environment, social, economic and political exposure to a range of potential harmful perturbations. Vulnerability is a multilayered and multidimensional space defined by the determinate, political, economic and institutional capabilities of people in specific places at specific times (Bohle, 1994).



Adaptation is the adjustment in human and/or natural systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (UNFCCC Resource Guide, 2008).

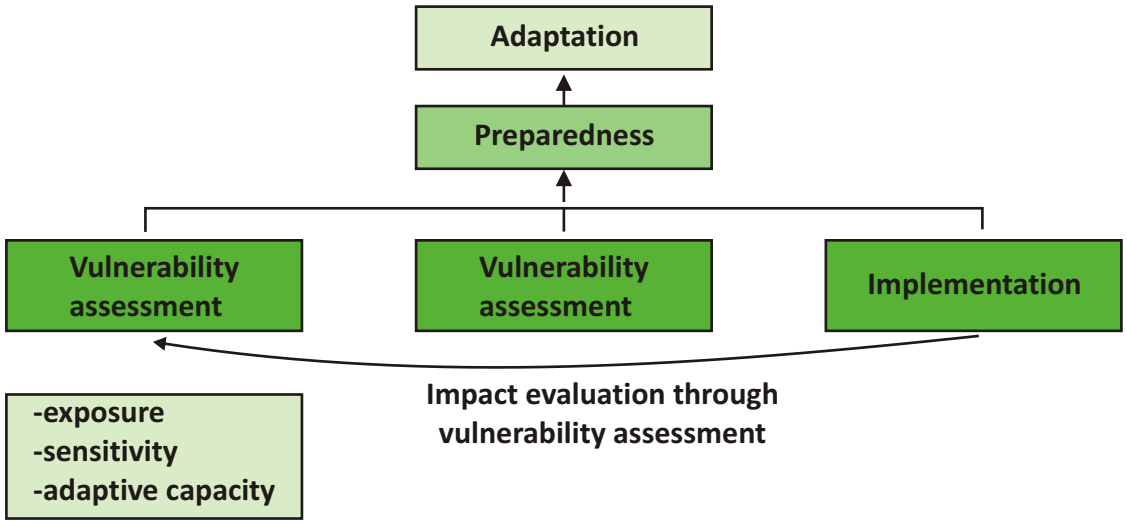
Two main types of adaptation are:

(i) **Autonomous adaptation:** It is the one which a society or an individual undergoes in response to changing conditions without the intervention of external agencies. As such there are no distinct technical, economic or social adaptation measures and any adaptation measure will include all these three aspects to it. Its is the reaction of, for example, a farmer or a group of farmers to changing precipitation patterns, in that s/he/they change crops or use different harvest and planting/sowing dates. Change of crop includes technical, social as well economic aspects to it and all are interrelated.

(ii) **Planned adaptation:** Planned adaptation measures are conscious policy options or response strategies, often multi-sectoral in nature, aimed at altering the adaptive capacity of the system or facilitating specific adaptations. It is the one which a society undergoes in response to changing conditions with the intervention of external agencies, usually state or national governments. For example, deliberate crops selection and distribution strategies across different agroclimatic zones, substitution of new crops for old ones and resource substitution induced by scarcity (Easterling 1996).

To adapt to climate change induced impacts, one should know the vulnerability of target group. In order to reduce vulnerability preparation of knowledge products and action plan is required. Implementation of the adaptation action plan will result in preparedness. Whereas implementation of the adaptation action plan will be done by developmental or state agencies preparedness is the output among the target community. However, since human knowledge as well as ground realities change with time there is a need of monitoring and evaluation of adaptation plan. A diagram showing interlinkages between vulnerability and adaptation is given below in the figure 19.

Figure 19: Vulnerability and Adaptation Interlink



Source: Development Alternatives

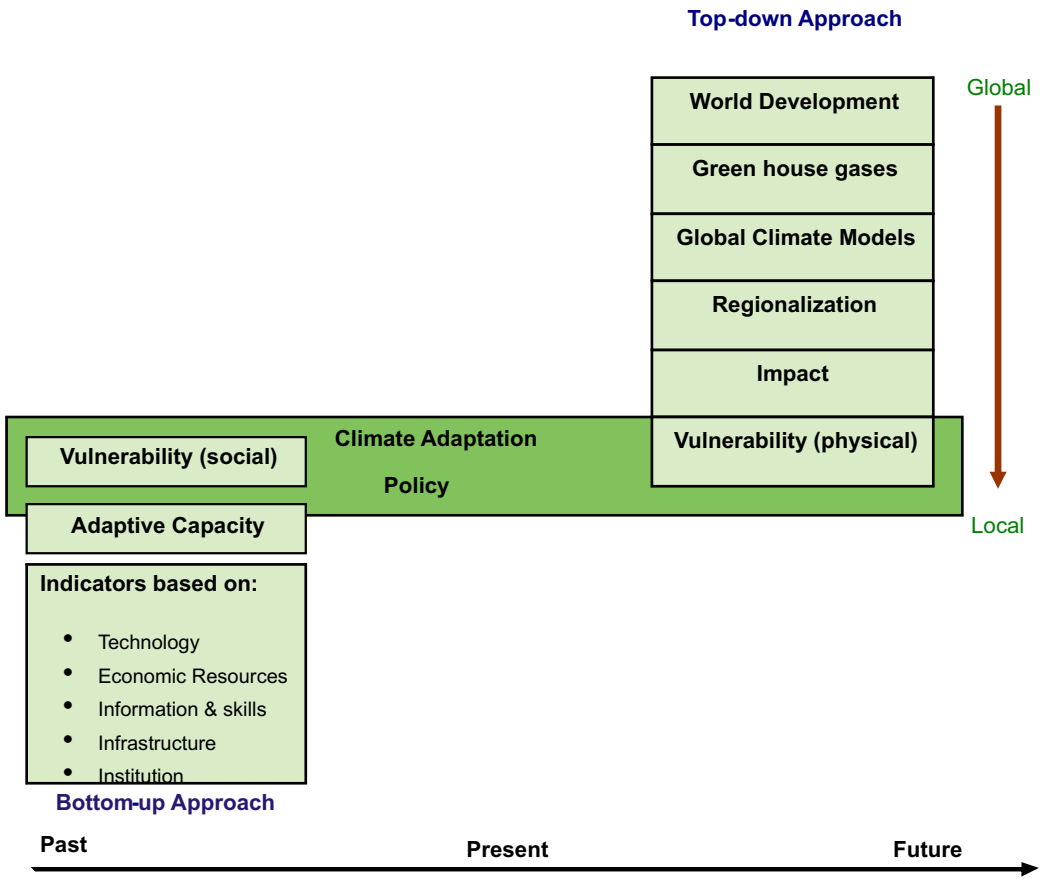
Vulnerability Assessment Framework

A diverse set of vulnerability assessment frameworks exist. Broadly these vulnerability assessment frameworks may be classified as first generation, second generation, top-down and bottom-up, depending on the criteria used.

- **First generation** frameworks focus more on understanding how significant the impacts of climate change will be in order to direct mitigation efforts.
- **Second generation** frameworks focus on more holistic impact assessments within adaptation decision-making contexts.
- **Top-down** frameworks were designed to mainly to help understand the potential long-term impacts of climate change (using global, national or regional models).

Bottom-up frameworks, were designed to focus on adaptation and involve stakeholders primarily at the local level. Since uncertainties will always be present in climate change predications it is important to help build the resilience of the community also local initiatives have higher potential to succeed as compared to regional or national because local initiatives originated keeping in mind the locally prevailing conditions.

Figure 20: Features of top-down and bottom-up approaches to assessing vulnerability and adaptation



Source: UNFCCC Resource Guide, 2008

The ultimate aim of both approaches is to find out the vulnerability of the target group. The top-down approach relates more to the climatic aspects such as precipitation, temperature etc. whereas the bottom-up approach deals with social resilience to face the climatic impacts. The climatic impacts themselves are related to a degree of uncertainty and even though improvements are taking place the uncertainty can never be avoided. Therefore there is a need to identify the adaptive capacity and vulnerability of the target group.

However, it is important to note that approaches to vulnerability assessment are evolving rapidly, with more recent work focused on blending merits of both first- and second-generation approaches, and bottom-up and top-down approaches. For example, greater emphasis is being placed on socio-economic scenarios, stakeholder participation and strengthening adaptive capacity.

2. PROJECT METHODOLOGY

The project methodology is as follows:

(i) **Set up and mechanisms for effective delivery**

- Situation Analysis
- Partnership Development
- Establishing the Project Management System

(ii) **Impact and Vulnerability Assessment**

(iii) **Adaptation Planning and Options Assessment**

- Identification of Traditional Coping measures
- Commissioning of Rapid Studies to Experts for identifying existing and potential adaptation measures
- Stakeholder Workshop for Assessment of Adaptation Options
- Economic Assessments of the Identified Adaptation Options
- Synthesis of information to arrive at the recommended menu of adaptation options

(iv) **Scale-up Planning and Capacity Development Assessment**

METHODOLOGY - VULNERABILITY ASSESSMENT

Our overall aim and approach to vulnerability assessment is to link socioeconomic and biophysical vulnerability with processes of adaptation.

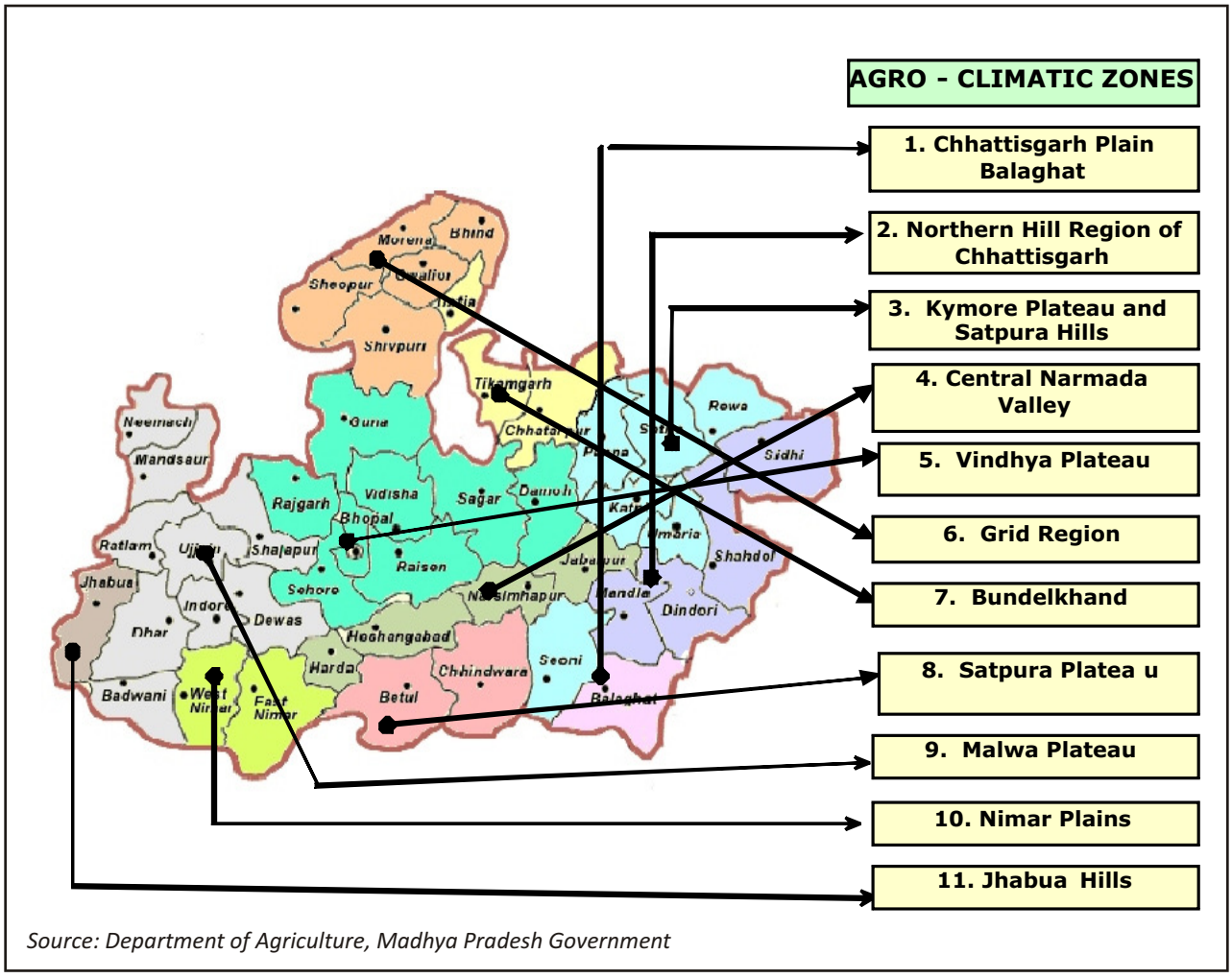
Madhya Pradesh is divided into 11 agro-climatic zones. These are:

Agro-climatic zones:

1. Chhattisgarh Plain Balaghat
2. Northern Hill Region of Chhattisgarh
3. Kymore Plateau and Satpura Hills

4. Central Narmada Valley
5. Vindhya Plateau
6. Grid Region
7. Bundelkhand
8. Satpura Plateau
9. Malwa Plateau
10. Nimar Plains
11. Jhabua Hills

Figure 21: Agro-climatic zones of Madhya Pradesh



Source: Department of Agriculture, Madhya Pradesh Government

For the purpose of conducting the vulnerability assessment 2 districts each have been finalized in Bundelkhand (north east of the state of Madhya Pradesh) and Malwa (south west of the state of Madhya Pradesh) agro-climatic zones. The assessment will be carried out in Datia and Tikamgarh districts in Bundelkhand and in Dhar and Ujjain districts in Malwa.

The first step is to define the actors vulnerable to climate change. Generally this is a hierarchical mapping of society, with livelihood security as a key level of analysis also reflecting class, gender and social networking. This will lead to development of causal chains of exposure for archetypes to climate change vulnerability.

The causal chains will also indicate types of interventions that affect the vulnerability. For instance, the progression from a crop failure to household food deprivation might be mediated by food aid, among many other adaptation measures.

Casual chains will be constructed as more formal profiles of vulnerability in a few representative locations to understand climate induced agricultural sector impacts on current and future livelihoods. A quantified and prioritized list of factors contributing to climate change vulnerability in the representative locations will be derived. This will provide the guidance in prioritizing the issues on which the adaptation measures should focus to achieve the maximum impact on reducing vulnerability in the state. It will also facilitate in identifying the factors that can be addressed through policy based adaptation measures in the short, medium and long terms.

In order to understand the broader vulnerability context, a systematic process will be followed. Our experience from a SoE process and other solutions focused research studies shows that a purely participatory or a purely analytical approach does not field very useful outputs. In fact, an integrated approach involving a clever combination of data collection and analysis with the participatory process is much more effective.

Analytical Framework

Previous studies done both in India and globally, and our own experience of doing so in the Bundelkhand area of Madhya Pradesh have brought out that it is both the climatic and non-climatic factors that combine to strongly amplify vulnerability; they should therefore be understood in tandem to arrive at the real picture. The link to adaptation planning requires approaches to vulnerability assessment that are oriented to the actors involved and the decision trees of possible exposure and responses. Since the desired outcome of the vulnerability assessments is to identify the crucial contributors to vulnerability in the state, we will undertake a mixed quantitative-qualitative data based study. We do not believe that vulnerability indices that are usually used in many vulnerability assessments would be very useful for this kind of an integrated participatory-analytical approach. We will explore a range of dynamic and participatory vulnerability frameworks, adapting their best features to address climate change, livelihood resilience and development planning.

Methods

Recognizing the fact that there are multiple determinants/causes of vulnerability, distributed across household, village and policy levels, we will follow a multi-level approach. The various levels are household, community and district.

Study Area Selection

Madhya Pradesh is divided in 11 zones based on agro-climatic characteristics and for the purpose of conducting the study two regions were selected namely:

- Bundelkhand (representing eastern MP) and
- Malwa region (representing western MP)

While Bundelkhand represents eastern Madhya Pradesh, Malwa represents western Madhya Pradesh. The selection procedure followed for this was participatory in nature with sound scientific basis. The selection criteria are as follows:

- Diversity in socio economic characteristics
- Diversity in cropping pattern and practices
- Ongoing projects in both the regions (EPCO has strong
- presence in Malwa while DA in Bundelkhand)
- Time and cost
- Awareness and cooperative attitude among Panchayat
- Institutions on climate change studies

Easy accessibility

Sl. No.	Regional Characteristics	
	Malwa	Bundelkhand
1	General prosperity in the region	Backward area (poor socio-economic conditions)
2	Good socio-economic conditions but scare natural resources	Number of families under BPL is considerable
3	Severe water problems	Severe water problems
4	Low rainfall	Poor rainfall
5	Drought prone	Drought prone
6	-	Presence of Tribal belt

Under each region 2 districts were selected namely:

- Bundelkhand region : Tikamgarh and Datia
- Malwa region : Dhar and Ujjain

Selection of Priority

Blocks 2 blocks will be selected in each district for conducting the detailed survey at the house hold and community level. To zero down to specific blocks, having vulnerability w.r.t. climate change, an initial vulnerability analysis will be done. For this a two way process will be adopted i.e. analytical and participatory so to have perfect blend of content with perception. Analytical part will consist of GIS weighted overlay analysis, which will help in identifying most vulnerable blocks in a district and then in a participatory mode the identified blocks will be zeroed down for conducting the survey. A range of weighted vulnerability indicators will provide necessary information to GIS to have prioritized list of vulnerable blocks.

15% of the household in each village, under each gram Panchayat within each block under each district, will be targeted for conducting questionnaire based survey. The number for this comes out to be approx 500 households in each district and thus total 2000 households.

As far as community level assessment is concerned total 40 FGDs and other related PRA techniques will be.

Survey Techniques

After selecting the blocks, detailed survey will be carried out both at household as well as community level and different kind of survey tools and techniques will be used for both levels. While for household survey will be conducted by the means of questionnaires community level survey will be done through Focus Group Discussions with PRIs and other key stakeholders. The kind of outputs expected from both the exercises at two different levels will be entirely different from each other. The purpose and activities under each will be:

- ***Household Level:*** At this level, the effort will be to collect data on various issues such as incomes, food security, access to resources, ownership of assets, migration patterns etc. Analysis of this information will help us in classifying the households into various degrees of vulnerability and derive factors contributing to vulnerability. For assessing household level vulnerability structured questionnaires will be administered in local language.
- ***Community level:*** At the community level, Participatory Learning and Action and other Participatory and Reflective Approaches will be deployed to understand the community level dynamics that contribute to vulnerability. These dynamics include local development issues, identification of needs, problems and solutions, major changes observed within and over the years, relationship between individuals, groups and institutions and linkages with policies. This data will be qualitative, quantitative and even visual and will provide us a way of relating learning to action, and incorporating programme and policy improvement as an integral part of the learning process. The levels of these exercises will be much more in the 2 case study locations where the intention will be to actually effect changes during the research. The techniques which will be used are as follows:
  - ❒ Natural Resource Mapping
    - ◆ To map available resources at community level as means of alternative livelihood options
  - ❒ Hazard Mapping

- To become familiar with the community, and to see how the place is perceived by different groups within the community
- To identify important livelihoods resources in the community, and who has access and control over them
- To identify areas and resources at risk from climate hazards
- To analyze changes in hazards and planning for risk reduction

❒ Seasonal Calendar

- To identify periods of stress, hazards, diseases, hunger, debt, vulnerability, etc.
- To understand livelihoods and coping strategies
- To analyze changes in seasonal activities
- To evaluate use of climate information for planning

❒ Historical Timeline

- To get an insight into past hazards, changes in their nature, intensity and behaviour
- To make people aware of trends and changes over time
- To evaluate extent of risk analysis, planning and investment for the future

❒ Vulnerability Matrix

- To determine the hazards that have the most serious impact on important livelihoods resources
- To determine which livelihoods resources are most vulnerable
- To identify coping strategies currently used to address the hazards identified

❒ Venn Diagram

- To understand which institutions are most important to communities
- To analyze engagement of different groups in local planning processes
- To evaluate access to services and availability of social safety nets

- ***District level:*** The key stakeholders in the entire process will be the district level officials, which is the lowest administrative unit and governs all the development processes in communities within the district. They will be engaged through in-depth interviews, documents review, study of their rules and regulations for functioning and involving them in some community level assessments. This will provide us with an insight on their perspectives of the vulnerability, inform us of their capacity to understand the issue, guide us to identifying the constraints they face in implementing various types of policy measures and suggestions from them on what should be done about it. Analysis of this data and information will provide us with holistic information on the various probable region specific causes of vulnerability, which a priori and from available literature have been found to depend on factors such as:

- Household access to resources
- Social capital

- Food security
- Livelihood options
- Effectiveness of local governance
- Dependence on the markets for incomes
- Participation in decision making
- State of natural resources in the region
- Physical impacts of climate change
- Access to information
- State and national level policies

Analysis

The analysis may be described as participatory-analytical in approach. Principal statistical tools such as regression, correlation will be used along with expert opinion. Apart from these network analysis tools, Strategic Environmental Assessment Framework will be utilized. Analysis will be done against the following components:

- **Natural Resource Mapping**

  GIS based mapping of current status of resources available as a means of alternative livelihood options will be done using satellite imageries. For this satellite maps, cadastral maps will be procured from the relevant agencies and for cadastral maps ground true thing will be done using various PRA techniques. Mapping for Land-use classification, land-cover land-use change, delineating watersheds will also be done.

- **Agriculture Dependency Network**

  Agricultural activities are themselves dependent on a number of other sectors such as fertilizers, pesticides, power, irrigation, capital. Agriculture dependency network exercise will lead to a prioritized list of agricultural inputs.

- **Threat Environment**

  Since adaptation and vulnerability are in response to a threat climate change projections would be made using a variety of models to explore the range of possible changes in climate for relevant variables. Given the range of possible change we would look for adaptation options which are not dependant on a certain change occurring but are useful under a wide range of changes. This will ensure that uncertainty is addressed in the adaptation options.

- **Penetration Potential**

  Based on the climatic projections the impact on wheat and soya bean of the region would be studied

under various scenarios for green house gases emissions which are standard and have been widely applied. The impacts on wheat and soya bean would be an output against which the state should be prepared for.

- **Physical assets**

  Physical assets such as canals, dams, power plants, banks, agricultural supplies form the backbone of agriculture and there presence or absence could mean a significant difference in the vulnerability of the farmers.

- **Physical security**

  Surveillance and maintenance of the physical assets are important to provide dependable inputs for agriculture. Periodicity of monitoring and the means to do so in a cost effective manner would be important. Response time, once damage has been reported is also critical.

- **Policies and Procedures**

  State government policies provide the broad framework within which the state agencies operate and the sensitization of policies and their readiness to address climate change is imperative. The ability to decide on issues once a situation arises and the delegation powers at the state and district levels decides vulnerability to a large extent.

- **Infrastructure interdependencies**

  Different kinds of infrastructure such as electricity, canals and roads are linked to each other and therefore the dependence of one on others needs to be assessed.

- **Autonomous Adaptive Capacity**

  Even though governments and other institutions are and will always try to help society to adapt to climate change impacts, any given society (example agriculture) faces climate change impact on day to day basis on ground. Therefore communities come up with their own adaptation measures even without any institutional support. Autonomous adaptation has lower chances of being mal adaptation as they are a result of evolution as against revolution. Therefore there is a need to assess autonomous adaptive capacity and build upon it to provide adaptation options which are better suited locally and have higher acceptance within the community.

3. OUTPUT

The collection of information during the vulnerability assessments will be based on specific indicators for each of the above parameters and any other ones identified in the Stakeholders workshop. The output of the analysis will be:

- Hierarchical maps based on livelihood security
- Causal chains depicting impact of one event on another
- A profile of the categories of people, who are likely to have high adaptive capacity, be vulnerable and highly vulnerable.
- Contributions of various factors to the current and future vulnerability of the different categories of people

Presentation of Analyzed Information/data

The data collected through secondary literature and primary surveys will be collated and analyzed. The analyzed data will be projected on a GIS platform with the purpose to divide the study area into different vulnerable zones at community level with respect to socio-economic vulnerability associated with agriculture sector due to climate change impacts.

Annex 3

QUESTIONNAIRE FOR HOUSEHOLD SURVEYS

The questionnaire was prepared in order to obtain primary information from the households regarding their current vulnerability, exposure to climatic risks, coping mechanisms, adaptive capacities, and potential areas where adaptation planning might help them.

The data collected from the households through questionnaires pertained to the following broad areas:

- Basic information regarding the demography and coordinates of the family
- Economic status in terms of earnings, loans, capacity to pay back, lend money
- Livelihood profile: to ascertain various sources of income and diversifications being explored by the community
- Human capital in relation to education, employability and need for capacity development, migration patterns
- Health expenditure: to gauge finances spent on medical priorities and surplus estimation
- Social Capital: to estimate the trust levels and the ability of the community to come together and contribute for social good
- Natural Capital pertaining various ecosystem services available and accessible to the community
- Agriculture: to understand the land holding patterns and the managements practices, the kind of returns farmers are getting from farming activities, and coping mechanisms being adopted by them
- Irrigation: the type of irrigation available, its sufficiency, variability and constraints in expanding the network to rainfed areas

In Tikamgarh district, household level questionnaire was administered to 150 households.

In Dhar the questionnaire was used to collect data from 150 households.

A CASE STUDY VULNERABILITY ASSESSMENT OF DISTRICT TIKAMGARH, BUNDELKHAND REGION, MADHYA PRADESH

Executive Summary

Apart from been highly physical vulnerable, the state is also extremely low on adaptive capacity. The state ranks very poorly on most of the social indicators forming the adaptive capacity such as the inflation and inequality, low adjusted per capita consumption expenditure (Rs. 92/month), a high percentage of people below the poverty line (37.43% as against the national average of 26.10% for India), few households with access to toilet facilities (7.87% against national average of 49.32%), only half the population with access to safe drinking water, just 58% people having road connectivity at village level and a low literacy rate of 58% against the national average of 59%.

Objective

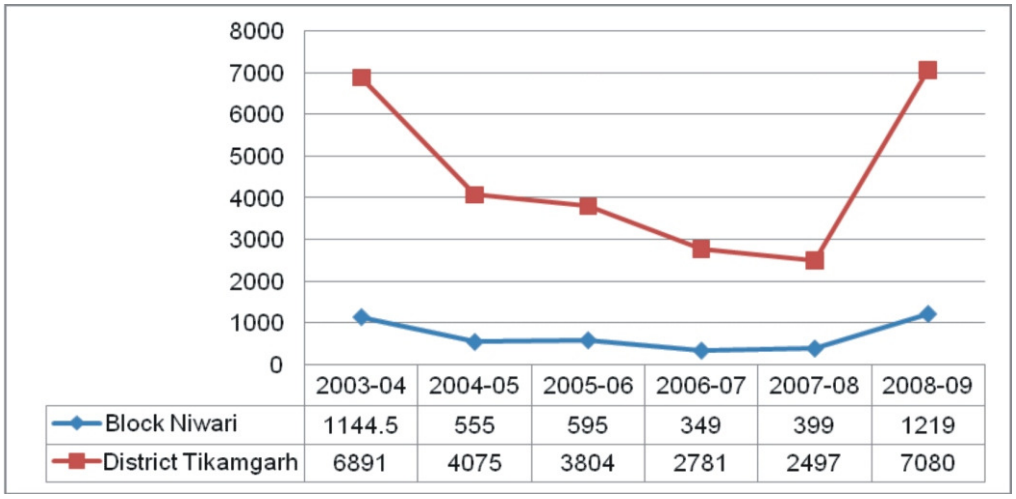
The secondary data was collated to generate the vulnerability profile of Tikamgarh district of Madhya Pradesh. For that a survey was conducted at the household and community level which helped in validation of secondary data.

Geographical Focus area

The elevation of Tikamgarh is 426.7 m above the mean sea level. The northern part of the district is at a height of 200 m from the mean sea-level while the southern part is at a height of 300 m. The climate of Tikamgarh district is of the monsoon type. The year may be divided into four seasons. The cold season is from December to February, followed by the hot season from March to about the middle of June. The period from about mid-June to the end of September is the rainy season. The months of October and November constitute the post-monsoon or the transition season. There is only one rain gauge station in Tikamgarh district. The average rainfall of the district is 1016 mm. It varies from 838mm to 1371mm, in different parts of the district. It is seen that amount of rainfall in the district in general increases from north-west to south-west. About 90 per cent of the annual rainfall in the district is received during the south-west monsoon season.

Temperature and humidity description that follows is based on the records of the observations in the neighboring districts. The month of May is generally the hottest with the mean daily maximum temperature at about 430C and a minimum of about 290C. On a typical summer day temperature may rise to about 470C. The relative humidity is high during the monsoon season, it being generally above 70 per cent. During the rest of the year, the air is comparatively dry. The literacy rate of the district is 55.73% which is below the state literacy rate 63.74% as well as the National literacy rate 65.38%. The female literacy rate is also much lower than state and National averages. The female literacy rate of the district is 40.99% which is lower then the state average 50.29% and National average 54.16%. Out of total population about 24.28% population is schedule case (SC) and 4.31% schedule tribe (ST). As per the District Statistical Book 2006,

Tikamgarh the district about 35.35 % of total rural families are below poverty line is little less than state average of 37.43 % but it is higher than the National average of 28.6 %.



	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
Block Niwari	1144.5	555	595	349	399	1219
District Tikamgarh	6891	4075	3804	2781	2497	7080

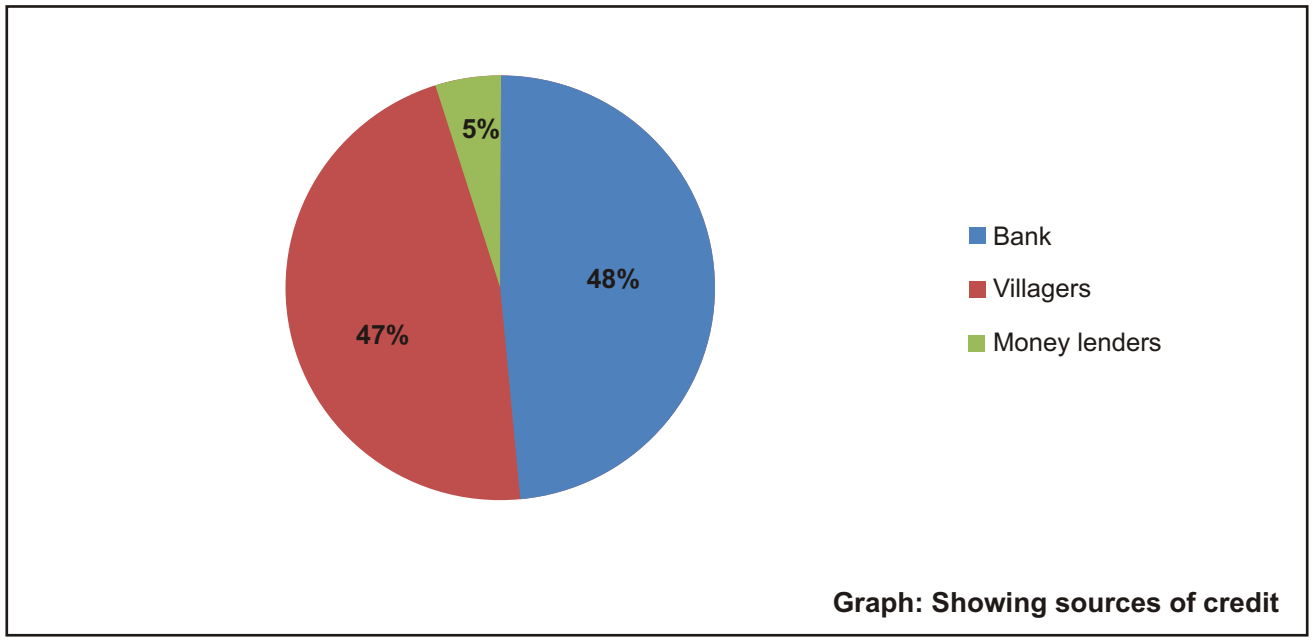
Graph: Average rainfall (mm) in Niwari block and Tikamgarh district

(Data Source - Statistical Book 2006, Tikamgarh)

The main crops of the district are Jowar, Wheat, Paddy, Urad, Til and Soybean. Sugarcane is grown to a certain extent. Thus, both of the cropping seasons, the Kharif and the Rabi are important in the district. Only about 37 % of the total land is under assured source of irrigation. Tikamgarh district has a southern tropical dry deciduous type of forest. About 6% of the total land is covered by forest. Earlier the area comprised dense forests but due to a rising demand for wood and agriculture expansion, the level of deforestation increased. No Industry of any significance seems to have been set up in Tikamgarh district during the past. It's an industrial backward district and categorized under 'C' category. However, minor village industries of a rudimentary nature, which are the inherent part of rural economy, exist in this district. These consist of wood work units, handloom, weaving, pottery, brick-making, utensil making, and gold, silver and lac ornament making. These are mainly run by the artisans' class who inherited the skill of their craft.

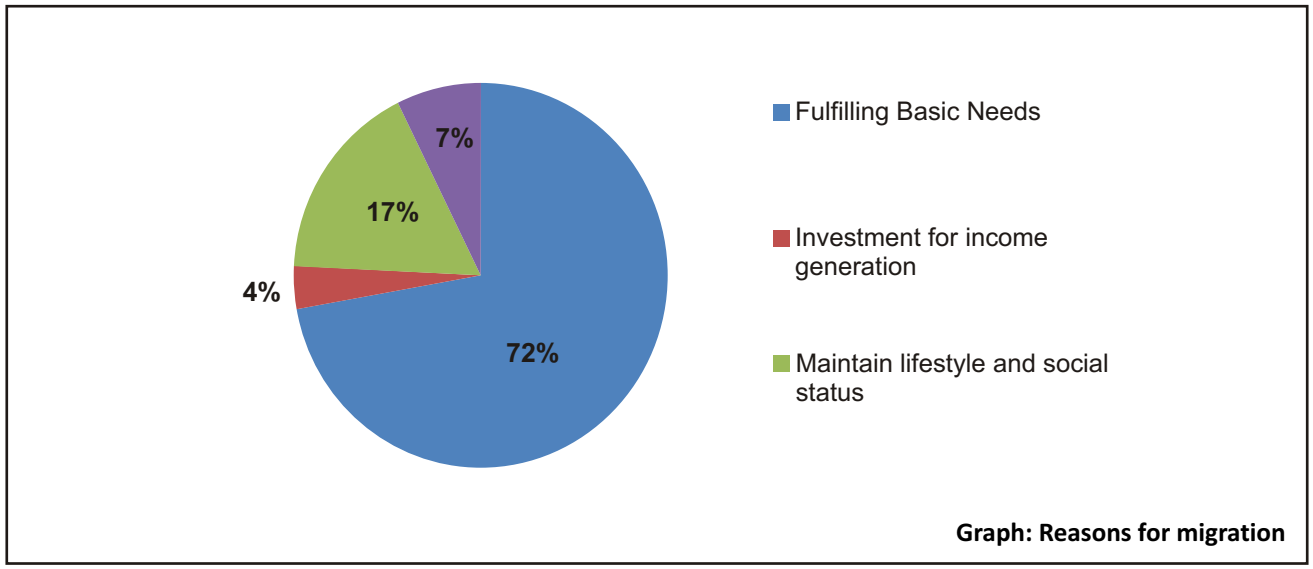
Key Findings

The data collected trough the questionnaire and interviews conducted at household and community level, with different stakeholders was fed into excels sheets and analysed. The data collected pertains to issues of socio-economic conditions, livelihood, human capital, natural resources, agriculture and irrigation. The farmers in the block are small scale with an average land holding size of 2 hectares. In addition the productivity is low and is dependent on weather conditions. Also, only a very small number of farmers were able to get access to crop insurance scheme of the government (3%). As wheat was perceived to require a larger quantity of water the farmers have switched to growing lentils and sesame as an autonomous adaptation/coping strategy. Farmers have also diversified their livelihood options and have started small scale enterprises such as selling vegetables in the adjoining urban centre. Households have an average debt of around Rs.9, 000 every year. Nearly half of the debt is coming from informal institutions such as money lenders and friends.



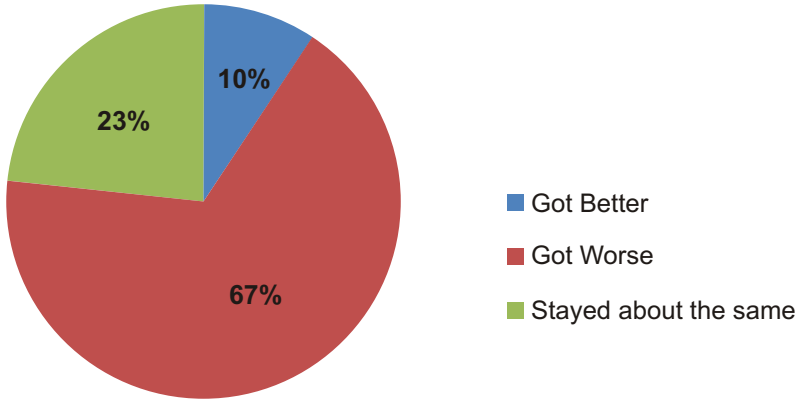
Graph: Showing sources of credit

This has forced farmers (55%) to migrate to urban regions of the country to fulfill basic needs. Most of the migrants end up in large cities as construction laborers.



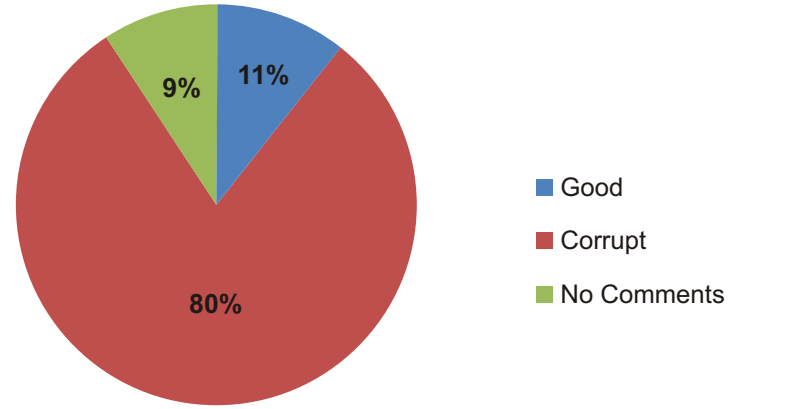
Graph: Reasons for migration

Children are not been able to complete their schooling owing to lack of money. Students drop their schooling after 8tth standard and the few go on to study till bachelor's or post graduate level. People instead spend the money in repaying their loan or invest in income generation activities. After 8th standard boys generally help out their parents in agricultural activities or move out to work as laborers while girls help in household activities. Over a period of time, people have tended to take advantage of the people who are in need of help and the money given as loan on trust is not being paid back. Due to these reasons the level of trust and a sense of fraternity in the villages have gone down.



Graph : Showing decrease in trust level among the villagers

People are dissatisfied with the way the government officials function. The major perception of the people regarding government officials is that they rarely visit villages. The survey shows that most community members perceived government officials to be corrupt.



Graph: Showing perception of village communities regarding government officials

In a few villages it was found that though the villages had been electrified, but for the past few years' electricity from the villages have been cut due to non payment of electricity bills. The villagers did not find it feasible to pay rental charges for a connection wherein the supply of electricity was not reliable. For this reason the community is not able to pump ground water for irrigation purposes and as a result this has decreases their yield in agriculture.

Adaptation Options

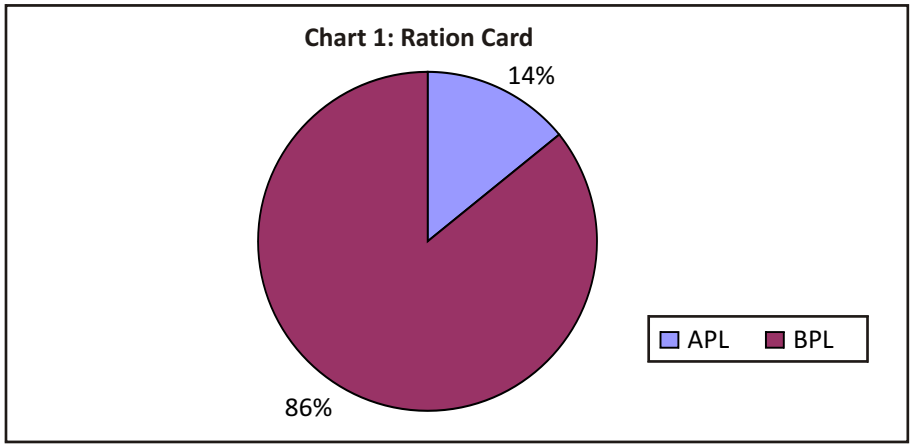
- Diversification of livelihood options is emerging as an option which according to a few researchers may have implications on food security. However in the present case it does not seem to be so.

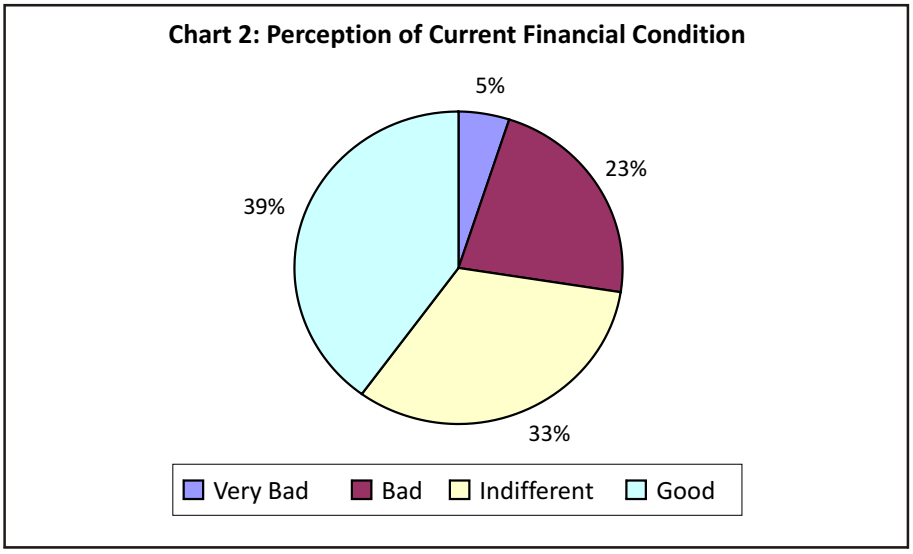
- The average land holding is 2 hectares and may be managed by fewer people thus leaving other people to be engaged in other productive livelihood options.
- The switch in crops being observed in the field (from wheat to lentils) needs to be researched and better options if existing need to be disseminated among the farmers.
- Weather indexed crop insurance will be better suited to the region as the current insurance is against loss of crops which is difficult and non transparent. Also, the number of farmers who re able to avail the facility of the insurance is very limited and efforts need to be put in to bring a larger number of farers within the ambit of the scheme.
- Given that water scarcity has been one of the major constraining factors stress needs to be given on conservation of water and on promotion of efficient irrigation techniques such as micro sprinklers and drip.

A case study Vulnerability assessment of District Dhar, Malwa Region, Madhya Pradesh

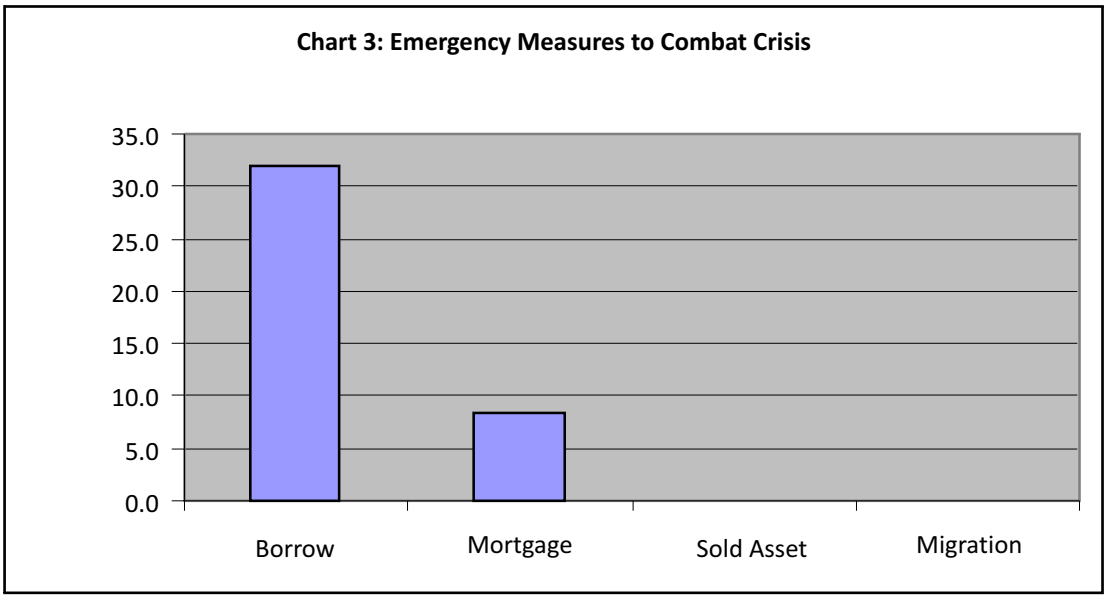
The data collected through questionnaire at household level was analysed by software STATA. The data reflects the issues of socio-economic conditions, livelihood, human capital, natural resources, agriculture and irrigation.

The people of the region are economically very backward with almost 86% of the households holding a ration card of Below Poverty Line category.



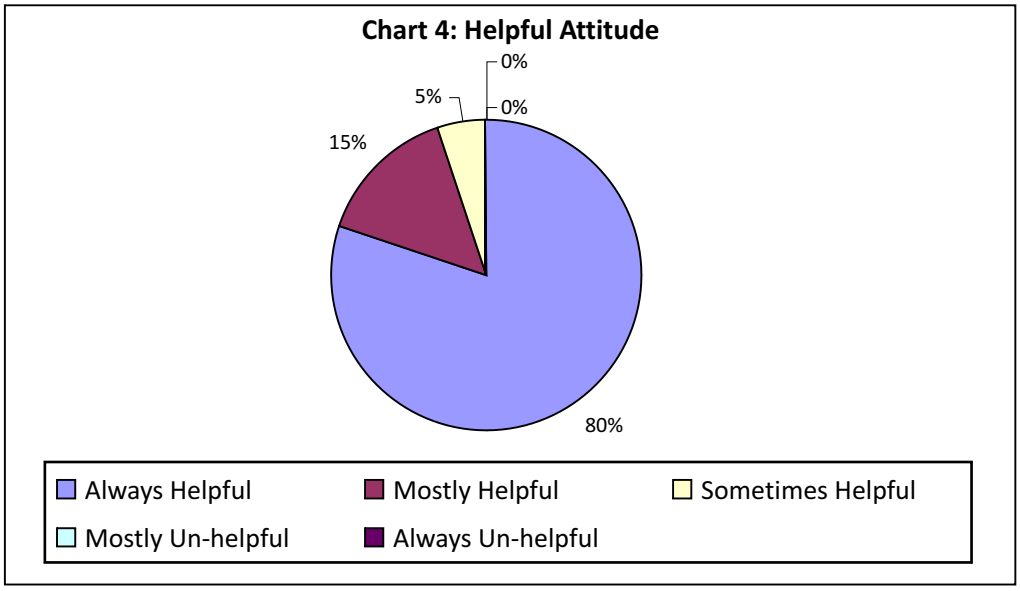


39% of the persons interviewed has expressed that the financial condition of their household is good, while 28% has reported to be either bad or very bad, whereas another 33% reported to be indifferent or neither good nor bad. However, 90% of the households are of the perception that their financial condition has improved over the last 10 years.

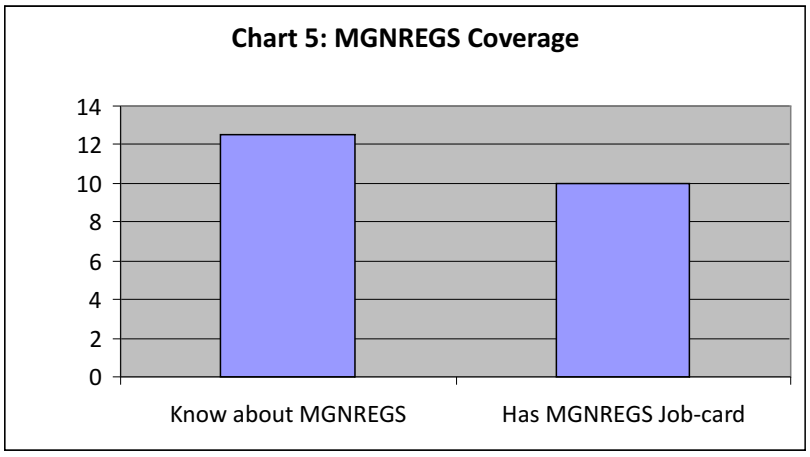


In adverse economic conditions, 32% of the people admitted to have taken loan from various sources. 8% of the respondents have mortgaged assets. However, no one reported distress sale of assets or out-migration for search of work.

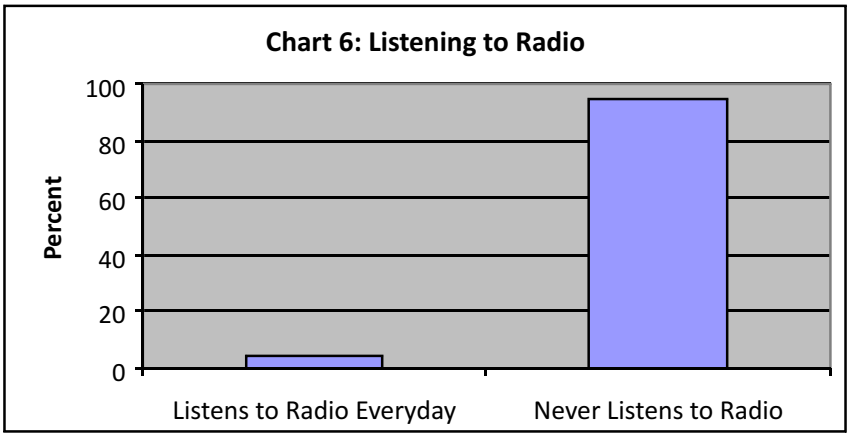
The villagers hare a cordial and mutually supportive relationship with each other. An overwhelming 80% of the persons questioned is of the opinion that his/her fellow villagers are always ready to help out others, while none has the perception that their fellow villagers are in anyway not helpful.

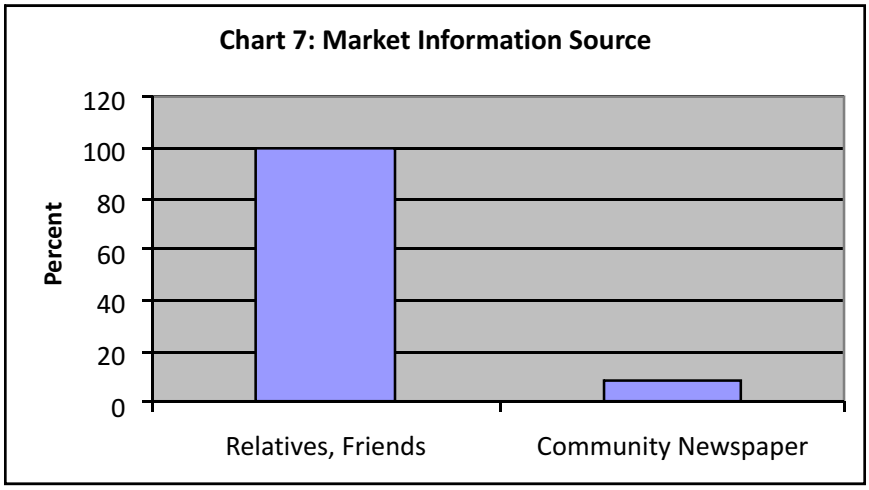


The centrally sponsored employment generation scheme Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) has very poor coverage in the region. Only 12.5% of the respondents knew about the scheme, while only 10% has job-card under MGNREGS.

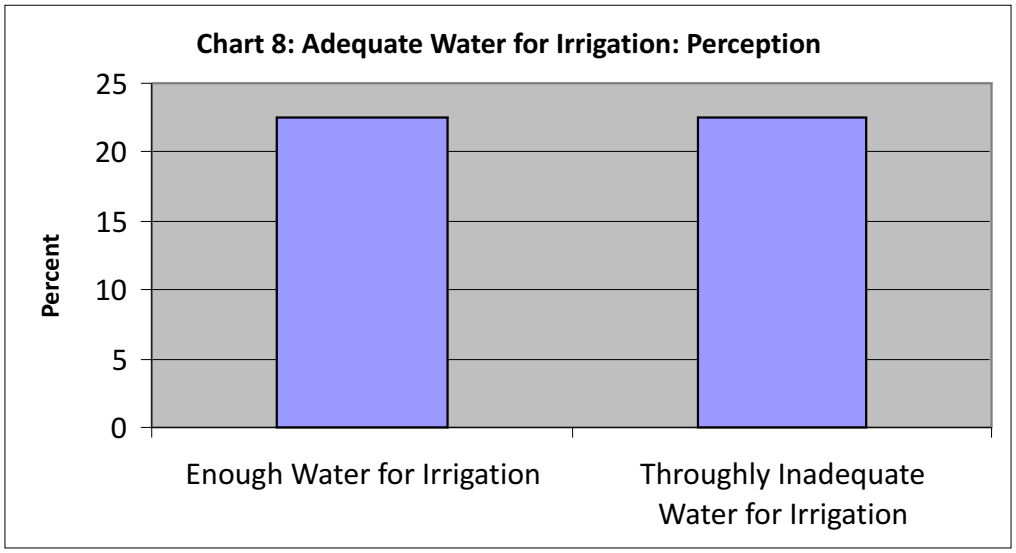


There seems to be lack of inflow of information from the outer world into the region. Only 2% of the respondents daily listen to radio, which is otherwise one of the most popular devices of entertainment as well as information in the rural regions, while 95% never ever listens to radio. Regarding information on market conditions, 100% of the respondents have reported informal sources like information from friends and relatives to be one of their most important sources of information; in contrast, even less than 9% of the respondents consider community newspaper as one of the important sources for such information.





The agricultural situation of the region is extremely fragile, particularly in the context of climate change. Only 22.5% of the respondents are of the opinion that there is enough quantity of water for irrigation purposes, while same proportion of the respondents feel that availability of water for irrigation is extremely inadequate.



Adaptation Options

From the above analysis, the following adaptation measures may be proposed:

- Improvement of irrigation situation in the region.
- Setting up information system, may be in the line of Radio Bundelkhand.
- Ensuring better implementation of Government schemes in the region.

Annex 6

State Level Vulnerability assessment and Adaptation Strategies, Launch Workshop Proceedings

1. BACKGROUND

The findings of the recent fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) has clearly brought out the seriousness of the climate change issues and the need for taking urgent measures for dealing with them. India is among the countries that are most vulnerable to adverse impacts of climate change with economic losses potentially as high as 5-9% of GDP (Stern Report).

To study these issues in detail, the Ministry of Environment and Forests (Government of India) and the UK Department for Energy and Climate Change (DECC) initiated the Indo-UK collaborative research program on the impacts of climate change in India. Under this program Development Alternatives (DA), Environment Planning and Coordination Organisation (EPCO) and Stockholm Environment Institute (SEI) are executing a study on **"Vulnerability and Adaptation Assessment for Madhya Pradesh State"**.

The study aims to integrate the climate change adaptation measures into the state policy to reduce vulnerability. The overall purpose of this assignment is to gain an in-depth understanding of how climate change induced vulnerability fits within the broader vulnerability context and therefore, how relevant resilience building and adaptation measures can be effectively incorporated within the existing development processes. The programme was launched in the state in a half day workshop held on 3rd March 2010 at EPCO Conference Hall, Bhopal. The purpose of this workshop was

- to launch the project in the state,
- to establish the need for an interdisciplinary inter-departmental team to holistically address the vulnerability and adaptation issues
- to get a commitment from the concerned departments to be a part of the research project
- to identify a broad framework for the research project including vulnerability and adaptation assessment

The workshop registered good participation with experts from multi-disciplines and from different state line departments, research institutions and civil society organisations.

SESSION I: THE INAUGURAL SESSION

Inaugural session was started with the brief introduction given by Mr. Lokendra (EPCO) about the programme purpose, process of initiation, conceptualization and partnership building.

The welcome address was given by Mr. Manoj Govil, Executive Director, Environment Planning and Coordination Organisation (EPCO). In his welcome address he gave a brief introduction about the

programme, purpose of launch workshop. He also provided some insight into climate change impacts on agriculture and water sector and associated social security in terms of water, food and livelihood in context to Madhya Pradesh. The inaugural address was given by Mr. Alok Srivastava, Principal Secretary, Department of Housing and Environment (Govt. of Madhya Pradesh). In his speech he mentioned that the state government is aware about the various implications of the projected climate change in context to agriculture and water sector in Madhya Pradesh and has been proactively involved in conducting climate change studies at various levels and scales. He also mentioned that there are number of small-2 research studies going in the state and emphasized that the results and proposed adaptation strategies should be integrated and implemented in a manner to have greater impact at larger scale.

He also requested and emphasized that each department (agriculture, irrigation, disaster management, planning and finance) to nominate people as resource personal to create a pool of experts having expertise in climate change research studies. In continuation to this, experts representing distinguished departments were requested to join a "mail group" with the purpose to exchange and share knowledge with respect to climate change research studies.

Mr. Alok Srivastva also released the programme brochure in the same event. The **technical session** started with the opening remarks given by Mr. Anand Kumar, Development Alternatives (DA). In his opening remarks he gave a brief introduction about the project purpose, purpose of launch workshop and expected cooperation from various line departments and other institutions. Mr. Anand also made a presentation explaining background, scope and methodology of the project. The session was closed with vote of thanks given by Mr. Manohar Patil (EPCO).

SESSION II: THE TECHNICAL SESSION

The technical session started with the presentation on "Vulnerability Assessment Methodology" being delivered by Ms. Neelam Rana, Development Alternatives (DA).The presentation focused on proposed methods and tools for data/information collection and analysis for assessing vulnerability with respect to socio-economic parameters in context to climate change impacts on agriculture and water sector. The process of conducting assessment is participator and analytical in nature. The presentation was shared with key stakeholders with the aim to validate it hence building consensus on overall project framework including "Vulnerability Assessment Methodology". Following the presentation the discussions were took place in a moderated session. Points of discussion are as follows:

- It was suggested that scope of the study should include other districts falling under other agrocilmatic zones apart from the chosen one i.e. Datia, Tikamgarh (Bundelkhand region) and Ujjain, Dhar (Malwa region).
- As the research study focuses only on two regions out of eleven agro-climatic zones in the state in that case how the study will ensure that the research outputs can be applied to other regions also.
- For above mentioned points it was suggested that the project should be implemented while keeping "landscape approach" in mind.
- As the study has the scope for conducting commissioned studies at one or two case study locations, it

was also emphasized that methodology should be field tested in some blocks before implementing it at larger scale.

- It was suggested that the project methodology should include "Resource Mapping" with respect to available resources at community level as means of alternative livelihoods.
- According to AR4 it is projected that number of events (malaria) related to health problems may increases due to change in climatic conditions, therefore it was suggested to include health aspect also under the scope of research study.
- How the study will ensure that the impacts assessed with respect to socio-economic, agriculture and other parameters are due to climate variability only. Therefore, establishing cause and effect relationship will be very important for this particular study.
- Clarifications were sought on scope of the assessments and suggested that rural assessments should be conducted to find out the vulnerability of small land and landless farmers.
- It was emphasized to conduct the review of existing and potential polices, plans, programmes in the light of climate change adaptation and mitigation.
- It was suggested to conduct a small study within the scope of project on assessing the human behaviour in terms of accepting the proposed adaptation strategies.
- It was suggested to include effect of climate change on hydro-geological cycle as it is related to water, food, livelihood security of vulnerable community. Assessment should focus on selecting most vulnerable villages in micro-catchment areas and that can be replicated to other blocks.
- Other suggestions points include inclusion of historical perspective, landuse change, biotic factors contributing to climate change, traditional crops as adaptation strategy and convergence with other studies done by different agencies, institutions.
- We can explore the potential of involving youth in such kind of programmes and research studies.

The closing remarks were given by Mr. Anand Kumar highlighting key discussion points. He also provided the details of immediate action plan:

- District level workshops and Data/information collection.

Annex 7

State Level Vulnerability assessment and Adaptation Strategies Workshop Proceedings - Tikamgarh and Datia Districts, Bundelkhand Region

1. INTRODUCTION

The potential impact of climate change is often broad and the immediate need to address the adverse impact of climate change is no longer in dispute. It has been realised that planned and comprehensive adaptation measures are required which specifically address the vulnerability of communities, to current and future climate changes and associated impacts.

Developing countries like India and within them agro-climatic regions such as those of semi-arid areas are considered particularly vulnerable to climate change due to dependence on climate sensitive sectors such as agriculture, fisheries, forestry and water and other natural resources as well as limited capacities to anticipate and effectively respond to climate change. Developing countries face the dual challenge of climate change mitigation and adaptation. Interventions which blend mitigation and adaptation are therefore highly pertinent.

2. KEY ISSUES IDENTIFIED

The key issues identified at that were raised are listed below.

(a) Uncertainties in the science of climate change with respect to the location, intensity, frequency and timing of impacts.

(b) Vulnerability of people in developing countries, especially the poorest to the impacts of climate change, due to the almost complete reliance on natural resources for their food, shelter and incomes. Women and farmers are the most vulnerable due to changing climate.

(c) Current carbon intensive agricultural practices and energy production and consumption.

(d) Need to generate the interest of the development community in climate change issues to enable Mainstreaming climate change actions (adaptation and mitigation) into development planning.

(e) Increasing amount of pressure from the international community to take up voluntary emission reductions.

3. LESSONS LEARNT

The workshop benefitted from the presence of practitioners from different semi-arid regions of the country who extensively shared their experiences and lessons related to various aspects of the processes to blend mitigation with adaptation. The practitioners representing different stakeholder groups: government functionaries, civil society and intermediary organizations and private sector

having worked in different states of the country shared their challenges as well as enabling factors as inputs into the possible direction that the State and Central Governments might pursue in semi-arid regions. The key learnings have been summarized below.

(i) **Knowledge Sharing**

- Gaps have been indentified in sources and access to information/knowledge. There is a need to provide different information solutions to different target groups. E.g. solutions for livelihood, food, water security to householders; Water use efficiency and agricultural practices to farmers, etc.
- In order to provide these solutions we need to map existing knowledge both traditional and scientific. Validation of traditional knowledge is needed to build confidence in the people to revive and use it.
- Multi way participatory communication solutions are needed. Information needs to flow vertically from the grassroots to the policy makers and back down to the ground. There is also a need for knowledge sharing horizontally between the same strata. Knowledge intermediatories are needed who can bridge gaps horizontally and vertically.
- Comparative analysis between different regions will help to discover, learn and replicate traditional best practices, new innovations and interventions.

(ii) **Capacity Building**

- There is a lack of trained people to disseminate information and solutions. Technical institutions can play an important role in filling these gaps.
- Capacity building of decision makers to integrate climate change into developmental planning is required. Panchayati Raj Institutions can be empowered to be change agents.
- Informal local institutions like Jaati Panchayat, Paani Panchayat, etc. have huge influence and can be used as an effective means of steering local communities towards climate sensitive practices.

(iii) **Mainstreaming climate change into developmental planning**

- Mainstreaming of environmental issues is already a part of developmental planning in India. The Government is the key actor in developmental planning processes. NGOs can provide value addition by sensitizing the process towards climate change.
- Mainstreaming climate change into developmental planning is a complex process that requires different tools at different levels. The main barrier faced is the compartmentalization of efforts (sectoral, institutional, approaches). Therefore integrated approaches are required to strengthen the process.
- Existing plans / policies /schemes can be entry points and support mechanisms to begin the process of mainstreaming.

- Replicability of pilots can play an important role in mainstreaming climate concerns into developmental planning. There should be mechanisms for feeding local learnings to national policies.
- Decentralization of planning can help in effectively integrating climate change with development issues starting at the finest governance level up to the national level.
- Institutional linkages between research organizations, governments, civil society organizations and communities should be promoted.
- Mainstreaming of climate concerns is also required at corporate levels. Corporate social responsibility is a good starting point.

(iv) **Risk management in light of climate change**

- There is a need to have diversified solutions for energy, water, nutrition, livelihood to reduce risk due to uncertainties of climate change impacts.
- Disaster risk assessment should be integrated to climate change approaches and concepts. It should include both preventive as well as curative measures.
- Linking climate change risk schemes such as crop insurance with weather forecasts rather than crop failure to give more benefits to farmers is required.
- Adaptation and mitigation have to be dealt with simultaneously.

(v) **Monitoring and Evaluation**

- There is a need for more efficient monitoring and evaluation system to track efforts of the community, Government, and private players. It should include implications of plan non action.
- Other government stakeholders like ministries of power, finance, industries etc. apart from environment ministry can play an active role into the Climate Change debate.
- Footprint assessment of policies to check implementation and impact and to suggest mid-course corrections can be undertaken.

(vi) **Market Mechanisms**

- Markets should be interlinked directly with farmers to optimize farm income for farmers.
- Scalable solutions that are affordable for livelihood, food, water security should be provided to key stakeholders.
- In conclusion development is a dynamic process driven by different stakeholders like people, market, institutions, Government etc. and there is a need to build symbiotic relationship for mainstreaming climate change into planning.
- There was consensus that certain groups are more vulnerable to the uncertainties of climate change impacts. This implies that there is a need to put in place systems and mechanisms that may be driven by the government, markets or civil society, that enable people to access appropriate and adequate knowledge and solutions to combat these impacts.

Annex 8

State Level Vulnerability assessment and Adaptation Strategies Workshop Proceedings - Dhar District, Malwa region

1. INTRODUCTION

The findings of the recent fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) has clearly brought out the seriousness of the climate change issues and the need for taking urgent measures for dealing with them. India is among the countries that are most vulnerable to adverse impacts of climate change with economic losses potentially as high as 5-9% of GDP (Stern Report). To study these issues in detail, the Ministry of Environment and Forests (MoEF), Government of India and the Department for Energy and Climate Change (DECC), Government of UK undertook the Indo-UK collaborative research program on the impacts of climate change in India. Under this program Development Alternatives (DA), Environment Planning and Coordination Organization (EPCO) and Stockholm Environment Institute (SEI) have undertaken a study on "Vulnerability and Adaptation Assessment for Madhya Pradesh". The study aims to integrate the climate change adaptation measures into the state policy to reduce vulnerability. The overall purpose of this assignment is to gain an in-depth understanding of how climate change induced vulnerability fits within the broader vulnerability context and therefore, how relevant resilience building and adaptation measures can be effectively incorporated within the existing development processes.

A half day launch cum stakeholders' workshop was organized on **18th June 2010 in Dhar District** of Madhya Pradesh State with the purpose:

- to launch the project in District Dhar
- to identify key issues and related vulnerabilities in the district concerning climate change
- to establish the need for an interdisciplinary inter-departmental team to holistically address the vulnerability and adaptation issues

The workshop registered good participation with experts from various disciplines and different district officials, research institutions and civil society organisations.

2. THE WORKSHOP

- **Inaugural Session**

  The workshop started with the opening remarks by Mr. Anand Kumar, Development Alternatives (DA). In his opening remarks he gave a brief introduction to the programme, its objectives, process of initiation, conceptualization etc. and purpose of the launch workshop. He highlighted issues relating climate change impacts on agriculture, water sector and associated social security in context to Madhya Pradesh. He emphasized on the need to capture local communities' perception and coping mechanisms related to climate change. He also made a brief presentation explaining the

background, scope and methodology of the project with the purpose to orient the audience to project and workshop's overall purpose and scope, and brought everyone on the same page.

- **Experience Sharing Exercise**

  In these exercise participants from various backgrounds; organizations shared their experiences of efforts in tackling climate change issues at the local level.

  Mr. Mahendra Vyas, Madhya Pradesh Rural Livelihood Project (MPRLP) shared the experience of introducing treadle pump for irrigation purpose under the MPRLP project in Dhar district. The advantages of applying drip irrigation system are three fold : water can be accessed at just 30 feet therefore motor pumping is not required hence no consumption of diesel leading to no green house gas emissions. He also emphasized upon the necessity to cater the sustainable livelihoods and energy needs of community especially rural tribal population in district Dhar. In his address Mr. Vyas also mentioned about other initiatives running under the MPRLP in district Dhar. These include promotion of biogas plants and compact fluorescent lamp (CFL) exchange programme, which is presently covering about 20 villages in the district.

  Mr. Tomar, Horticulture Department, laid emphasis on using drip irrigation system especially in case of large scale plantation drives. He highlighted some of the benefits that drip irrigation system offer such as availability of 20 80 per cent Government subsidy, increase in yield of vegetables upto four times and reduced water consumption by approximately 60 per cent.

  Mr. Tomar also highlighted some of the prevailing issues in the Dhar district in face of climate change. Studies have shown decreased trends for wheat yield, a major food crop in Madhya Pradesh, and vegetables such as cauliflower. He shared with the audience some of the adaptation measures, which can be implemented for example: fruit bearing tree varieties should be encouraged (for enhanced income, food and nutrition security), promotion of organic farming, careful selection of crop verities and development of small dams upstream while big dams down stream.

  Mr. Aggarwal from Irrigation Department highlighted the importance of irrigation and water conservation for social up-liftment and reform. He informed the audience that the average rate of land development using Participation Irrigation Management (PIM) is about 1000 ha/year.

  Mr. Panday, Agriculture Department suggested that to capture the diversity in district Dhar the current Indo UK project can be implemented in Jhabva, Nimar, Dhar regions.

  Mr. Gagan, Project Manager, CARD shared the experience of working with tribal communities and mentioned that the prime motive of tribal communities is to have sustaining livelihoods. He stressed that communities should be encouraged to participate in developing plans and overall decision making process.

Mr. Satish, Vasudha, draw the audience's attention to the grim problem of Flouride contamination in ground water in District Dhar and its linkages to climate change. In his address he laid stressed on the importance of low cost adaptation measures for lower strata in the community.

Mr. K.C. Ahirvar from Pitampura Horticulture Department, highlited the serious problem of industrial pollution in the district.

Mr. Anshu Sharma, Raja Bhoj Foundation, talked about the river rehabilitation project. The river is surrounded by barren catchments area unsuitable for agriculture. Under the rehabilitation project survey was carried out and different interventions were applied such as dredging, formation of check dams, stop dams. To seek active participation and engagement from the community activities such as "Mela" was also organised.

The inaugural session was ended with the concluding remarks by Mr. Lokendra Thakkar, EPCO. Mr. Lokendra stated that forestry, agriculture, water, health are some of the priority sectors / issues in face of climate change for Madhya Pradesh (M.P.) Government. The M.P. Government has taken up different initiatives especially for adaptation to deal with these issues and the establishment of "Climate Change Cell" is one of them. The state's Chief Minister is the Secretary of this cell.

The next session started with the small exercise aiming at key issues identification in district Dhar. The summary of the

3. KEY ISSUES IDENTIFIED IN DHAR

For identifying the prevailing issues in district Dhar an exercise was carried out. Participants were asked to list down major issues, impacts pertaining to climate change and possible response measures in terms of adaptation and / or mitigation. The outcome of this exercise is given below:

Sl. No.	Sectors	Major Issues	Impacts	Response measures	Remarks
1	Climate	• Increase in temperature	• Reduced rainfall • Increase in extreme events such as droughts, floods	-	• Tribal population is high as compared to other districts chosen for the study
2	Forest	• Deforestation in general and in hilly areas	• Soil erosion	• Plantation , Afforestation • Plantation of income generation trees such as Bamboo, Amla etc,	• High Forest Area

Sl. No.	Sectors	Major Issues	Impacts	Response measures	Remarks
				• Stop unsustainable extraction of forest produce from tribal areas • Stop land use change from forest to agriculture or any other • Use contour farming, contour trench	
3	Water	• Unsustainable groundwater extraction • Decrease in water table • No or less Rain water harvesting		• Restriction on excessive usage of tube wells • Establishment of Rain water harvesting structure • Recharging of abandoned wells, ponds • Water conservation and management • Watershed management in hilly areas by developing trenches and converging them to a pond • Construction of dams on small rivers, streams' • Increased access to efficient irrigation methods • Construction of "Balram" tanks to increase the water table	
4	Agriculture	• Unsustainable usage of fertilizers, pesticides • leading to decreasing soil fertility • decreasing yield • Lack of pasture lands and fodder		• Organic farming • Vermi-composting • Utilization of Green manure • Promote Vegetable farming. • Need to improve varieties and breeds of milking animals • Use of hybrid seeds for vegetables. • Livestock / animals census should be carried out by governments	• Higher prevalence of non – mechanized farming in Dhar district as compared to Ujjain district
5	Health	• Problem of "fluorosis" at the community level due to high levels of fluorine in ground water • Increasing Population		• Measures for Population Control • Economically viable solutions for filteration purpose	-

Sl. No.	Sectors	Major Issues	Impacts	Response measures	Remarks
7	Energy	• Energy efficiency Burning of agricultural residues	• Pollution	• Use of agricultural residues (Bt. cotton) for energy generation • Sustainable use of fossil fuel • Promotion of Renewable energy • Promote to energy conservation technologies. • Irrigation by paddle pump.	-
8	Livelihood Security	• Less employment opportunities leading to increased migration and crime • Sustainable income for Tribal families		• Alternative options for livelihood security and enhanced income	-
9	Stakeholders engagement	• Lack of education and awareness in the region specifically in tribal areas • Involvement of local communities in		• Need to involve local communities more active participation • Awareness programmes in villages regarding climate change • Feeling of ownership among communities is to be developed • Increased accountability for government and administrative units	-
10	In general			• Traditional knowledge and practices should bepromoted • Promotion and use of innovative technology • Establish Village Committees to tackle the issue of climate change at the finest level	-

4. KEY LEARNING'S OF THE WORKSHOP

District Dhar is uniquely positioned in the project as it has the highest amount geophysical variability therefore site selection will be more crucial and complex as compared to in other districts. The district also has highest tribal population and will thus help to make the study more comprehensive. Madhya Pradesh Rural Livelihood Project (MPRLP) has undertaken a number of interesting initiatives particularly in Participatory Irrigation Management (PIM) which may serve as replication models in other parts of the state.

5. OUTCOME OF THE WORKSHOP

Various line departments of the government and CSOs have been made aware of the project. Cooperation of the local government has been secured which will help in efficient implementation of the current project. Key climate change issues and adaptation strategies (existing and proposed) compiled.

6. NEXT STEPS

The way forward from the workshop is listed below:

(a) The learning's of the workshop will be consolidated and shared with the key stakeholders.

(b) The outputs of the ongoing projects in Dhar district that are being taken up by the various organizations and agencies will be used as a base for the current study.

(c) Based on the inputs and suggestions provided site selection for detailed survey at district level will be carried out.

(d) Adaptation options will be formulated keeping in mind the identified issues and suggested solutions provided by the participants at the workshop.

Annex 9

State Level Vulnerability assessment and Adaptation Strategies Workshop Proceedings - Ujjain District, Malwa region

1. INTRODUCTION

The findings of the recent fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) has clearly brought out the seriousness of the climate change issues and the need for taking urgent measures for dealing with them. India is among the countries that are most vulnerable to adverse impacts of climate change with economic losses potentially as high as 5-9% of GDP (Stern Report). To study these issues in detail, the Ministry of Environment and Forests (MoEF), Government of India and the Department for Energy and Climate Change (DECC), Government of UK undertook the Indo-UK collaborative research program on the impacts of climate change in India. Under this program Development Alternatives (DA), Environment Planning and Coordination Organisation (EPCO) and Stockholm Environment Institute (SEI) have undertaken a study on 'Vulnerability and Adaptation Assessment for Madhya Pradesh'. The study aims to integrate the climate change adaptation measures into the state policy to reduce vulnerability. The overall purpose of this assignment is to gain in-depth understanding of how climate change induced vulnerability fits within the broader vulnerability context and therefore, how relevant resilience building and adaptation measures can be effectively incorporated within the existing development processes.

A half day regional workshop was organized on 8th October 2010 in Ujjain district of Madhya Pradesh State with the purpose:

- to launch the project in district Ujjain
- to identify key issues and related vulnerabilities in the district concerning climate change
- to establish the need for an interdisciplinary inter-departmental team to holistically address the vulnerability and adaptation issues

The workshop registered good participation with experts from various disciplines and different district officials, research and academic institutions and civil society organisations.

2. THE WORKSHOP

Inaugural Session

The workshop started with the welcome note by Mr. Lokendra Thakkar, Environment Planning and Coordination Organisation (EPCO). He extended warm welcome to the participants and thanked them for attending the workshop. He gave a brief introduction to the project, its objectives, process of initiation, conceptualization and purpose of this regional workshop. He highlighted issues relating climate change impacts on agriculture, water sector and associated social security in context to Madhya Pradesh. He

emphasized on the need to capture local communities' perception and coping mechanisms related to climate change. He also mentioned that the project outputs and outcomes will also contribute to the State Action Plan on Climate Change being prepared by Government of Madhya Pradesh. In his welcome note, Mr. Lokendra also highlighted the role of key stakeholders in this process.

Opening remarks was provided by Mr. Anand Kumar, Development Alternatives (DA). He also made a brief presentation explaining the background, scope and methodology of the project with the purpose to orient the participants to project and workshop's overall purpose and scope, and brought everyone on the same page.

Mr. Lokendra Thakkar welcomed Ms. M. Geeta, District Collector (Ujjain) and presented her a flower bouquet. Ms. M. Geeta started her address by emphasizing that 'Vulnerability' is a very broad term and it changes across regions and people. It's very challenging to assess vulnerability of a region like Malwa *(two of the four case study districts i.e. Ujjain and Dhar fall under this region)* with so much diversity. She also suggested that, if possible, project scope with respect to vulnerability assessment should be narrowed down to specific sectors as the project seeks to influence policy. Ms. Geeta also pointed out the importance of engaging local communities in such kind of studies as these are the ones who are experiencing climate change impacts and dealing with it. She also emphasized the need of establishing 'Knowledge Dialogue' with local communities to capture their traditional wisdom/knowledge in dealing with issues such as climate change. Further to emphasize her point Ms. Geeta gave the example of State Government's two such programmes *'Jal Samvaad'* and *'Janpad Sadsay'*. The main aim of these programmes is to engage local communities (within the village) in local planning process by giving them platform to discuss and share their experiences through *'Gram Sabha'* meetings. Through these programmes 'Biodiversity Assessments' were also carried out for different villages engaging local communities. She ended her address by stressing on the need to re-activate these kinds of committees and engaging local academic institutions in such kind of projects.

Technical Session

Inaugural session was followed by the Technical Session. Technical session was started with the brief introduction by the participants.

Followed to introduction session 'moderated discussion' was held. Mr. Anand Kumar provided the audience with very brief intro to the session. The purpose of this session was to identify key issues and challenges in Ujjain district with respect to climate change and various response measures taken to deal with. The outcome of this session has been enumerated in chapter 3.

3. KEY ISSUES/CHALLENGES IDENTIFIED IN UJJAIN DISTRICT

For identifying the prevailing issues in district Ujjain moderated discussions were held. Participants from varied background and expertise shared their point of views on major issues and challenges pertaining to climate change that Ujjain district is facing Discussions were also led to identification of possible response measures to identified climate change issues in Ujjain district.

Major issues identified in Ujjain district are as follows:

1. Decreased Agriculture Yield: Due to erratic rainfall, increased temperature and extreme events (droughts) has led to decreased crop production in most of the regions in Ujjain district
2. Ground water depletion: The problem of ground water depletion has gotten worsen in all five blocks out of six in the district. This is direct implication on availability of water for drinking purposes as well as for agriculture
3. Ujjain district is traditionally been a grass land area. Percentage area under forests is very low. Due to changing climate and environment degradation / exploitation many of the grass verities are on verge of extinction
4. Change in cropping pattern in Malwa region. Traditional crops such as cotton and groundnut have been gradually replaced by soyabean and wheat. This has led to huge biodiversity loss both in terms of insects/ microorganisms and native plant varieties
5. Climate change (increased temperature) has also led increased insect population
6. Failure of coordination and implementation system is very much evident in every sector (loans, certified seeds to farmers)
7. Agriculture Practices
   (a) Mono-cropping system of agriculture is prevailing (approximately 95 per cent cultivated area is under soyabean cultivation in *Khariff* season in Ujjain)
   (b) Very populated seed sowing habits
   (c) Excessive utilization of chemical fertilizers and pesticides has led to decrease agricultural yield
   (d) Farmers grow crop verities that are not scientifically approved
8. Inferior quality seeds
9. Marginal farmers are at greater loss
10. Monoculture of plants under the afforestation or plantation drives and less importance to traditional varieties
11. Effect of climate change is very much evident on livestock fodder
12. Farmers have very little knowledge about livestock health. Farmers use growth hormones to increase milk production
13. One of the major area of concern for Ujjain is growing number of urban sprawls and lack of proper planning
14. Although research efforts are there but are not lined to end-user that is farmers

Response measures identified in Ujjain district are as follows:

1. Climate change impacts and vulnerabilities should be studied at local level (community)

2. Department of Agriculture main objective is to increase the agriculture productivity using low input and low cost measures
3. Research institutions such as CRIDA and others are involved in developing early crop varieties
4. For past two years agriculture department is conducted training programmes for farmers under the name of 'Farmers Field Schools' (FFS)
   (a) The main purpose of this programme is to demonstrate and provide training to the farmers on good agricultural practices strating from 'sowing to harvesting'
   (b) The programme also includes awareness generation activities on seed verities(promoted by agriculture department), sowing and harvesting methods
   (c) Demonstration and trainings are provided on farmers' land at village, Gram Panchayat (GP), block and district level.
5. Mono-cropping partner needs to be changed to other practices such as inter-cropping.
6. In Ujjain district soyabean and maize are suitable for inter-cropping in *Khariff* season. At-least 15-20 % area under maize remaining for soyabean is promoted by agriculture department
7. In Ujjain district wheat and gram are suitable in *Rabi* season for inter-croppings
8. Crop diversification and agriculture diversification (agriculture with horticulture or agriculture with diary) is promoted by agriculture department and KVKs
9. Promotion of bio-fertilizers and pesticides (organic agriculture)
10. Promotion of Balanced Nutrient Management through application of both chemicals and organic based nutrient management system to agricultural fields
11. Promotion of Integrated Pest Management (IPM)
12. Good seed quality should be ensured
13. Water recharging structures such as small ponds ,pits have been made in Ujjain district after scientifically studying the region
14. Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) is considered to have positive implications on climate change as major activity under the programme in Ujjain district has been plantation and micro-irrigation
15. Need to protect grasslands in the region
16. Need to bridge the gap between research and farmers.
17. Information dissemination to farmers related to Weather conditions
18. Education and awareness generation on agriculture for farmers is needed
19. Need to capture traditional knowledge among the communities
20. Need to involve and engage local communities in local planning process

4. OUTCOME OF THE WORKSHOP

Various line departments of the government, CSOs and academia have been made aware of the project. Cooperation of the local government, Krishi Vigyan Kendra (KVK) and CSO have been secured which will help in efficient implementation of the current project.

5. NEXT STEPS

The way forward from the workshop is listed below:

(a) The learnings of the workshop will be consolidated and shared with the key stakeholders.

(b) Based on the inputs and suggestions provided site selection for detailed survey at district level will be carried out.

(c) Adaptation options will be formulated keeping in mind the identified issues and suggested solutions provided by the participants at the workshop.

Brochure - English

Programme Approach

As stakeholders' active engagement is a must for main-streaming adaptation into the planning process at different levels (village, panchayat, district, state), therefore our efforts in the state are guided by principals of participatory and analytical research to get insights and create knowledge, propose and implement adaptation measures for further planning and informed action.

What difference will this make?

Agriculture is the mainstay of Madhya Pradesh economy. It is important that an adaptation plan is put in place for agriculture sector. Therefore, current initiative will aim for:

- Draft policy goal for adaptation related to agriculture in the state;
- Prioritised adaptation options including traditional and non-traditional;
- Policies that need to incorporate prioritised adaptation options within the existing programmes; and
- The costs to state exchequer for doing so.

Development Alternatives
B-32 TARA Crescent,
Qutab Institutional Area
New Delhi – 110016 (INDIA)
Phone : +91-11-26134103, 26890380
Fax : 011-26130817
Website: www.devalt.org

Environmental Planning & Coordination Organization
E-5 Arera Colony, Paryavran Parisar
Bhopal, Madhya Pradesh - 462016 (INDIA)
Phone: +91- 0755-2464318, 2466859
Fax: 0755-2462136
Website: www.epco.in

Stockholm Environment Institute
Florence House 29
Grove Street
Summer Town, Oxford
OX2 7JT, UK
Phone: +44-1865426316
Website: www.sei-international.org

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Project Partners:
Development Alternatives
Environmental Planning and Coordination Organisation
Stockholm Environment Institute (UK)

Vulnerability and Adaptation Assessment for Madhya Pradesh

An Indo-UK Climate Change Adaptation Research Programme

About the Programme

India is among the countries that are most vulnerable to adverse impacts of climate change. To study these issues, Ministry of Environment & Forests (MoEF), Govt. of India and Department of Energy & Climate Change (DECC), Govt. of UK initiated a Indo-UK Collaborative Research Programme on the impacts of climate change and development of adaptation strategies.

Project Partners

Development Alternatives in association with Environmental Planning & Coordination Organisation (EPCO) and Stockholm Environment Institute (SEI) is conducting a research study on "Vulnerability Assessment and Adaptation Plan for the Madhya Pradesh State".

Climate Change Vulnerability in Madhya Pradesh

Several research studies have clearly indicated that Madhya Pradesh is among the most vulnerable states in India. Natural calamities like droughts, floods and hailstorms are a common feature of the state, with at least one part of the state generally being hit by one of these natural calamities. Along with high physical vulnerability, the state is also extremely low on adaptive capacity.

What makes Madhya Pradesh more vulnerable to impacts of climate change is its dependence on agriculture. Agriculture contributes about 45 per cent of State Domestic Product (SDP) and more than 70 per cent of rural labor force finds employment in this sector. Thus making the state more vulnerable to impacts of climate change and impacting a large number of people and their livelihoods.

Programme Purpose

The over all purpose of the programme is to gain an in-depth understanding of how climate change induced vulnerability fits within the broader vulnerability context and therefore, how relevant resilience building and adaptation measures can be effectively incorporated within the existing development processes.

To fulfill this purpose, we are actively involved in:

- Conducting impact and vulnerability assessments for agriculture sector at household, community and district level.
- Identifying criteria and best practices of successful adaptation options.
- Analyzing existing adaptation practices and assessing the techno-socio-economic feasibility of options for supporting adaptive practices at various scales.
- Ensuring main-streaming of research outputs to existing developmental activities.
- Identifying potential areas for capacity development to effectively support adaptive processes and activities.

Shubh Kal

Shubh Kal (for a better tomorrow) is an initiative of Development Alternatives to bring about the immediate attention of the entire community to the risks of climate change. Our Shubh Kal campaign is a step forward towards providing low carbon pathways to achieve 8 missions of National Action Plan on Climate Change.

About the Partners

Development Alternatives (DA) is a 26-years-old research and implementation focused not-for-profit organization. The activities of DA broadly cover the areas that underlie any form of sustainable development process. The Climate Change Centre has been established in the organization since 1990. The Centre has made active contributions to research, advocacy and outreach programmes related to Climate Change Mitigation and Adaptation.

Environmental Planning and Coordination Organisation (EPCO) is the Madhya Pradesh State's premier organization in the field of environment related matters. It is a think-tank for environmental matters, and works extensively with the state government. The organisation is currently working on initiatives in the field of climate change adaptation with government departments.

Stockholm Environment Institute (SEI) is an independent international research organisation bridging science and policy in core areas of environmental change. The SEI Oxford Centre leads international partnerships through the SEI's Risk, Livelihoods and Vulnerability Programme and the weADAPT.org platform on climate adaptation.

Brochure - Hindi

Picture Gallery - Workshop





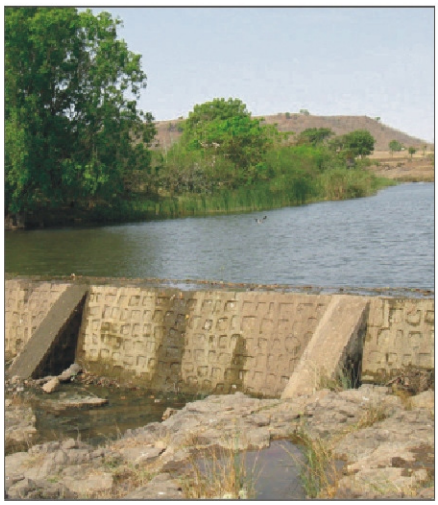



Picture Gallery - Field Survey









Media Coverage

दैनिक भास्कर | धार और आसपास | इंदौर - शनिवार, 19 जून 2010 | 9

कार्यशाला | जलवायु परिवर्तन को लेकर दिए सुझाव, धार समेत चार जिलों का चयन

पर्यावरण पर होगा शोध

धार. कार्यशाला को संबोधित करते एप्को के लोकेंद्र ठक्कर और उपस्थित प्रतिनिधि।

भास्कर संवाददाता | धार

धार के पर्यावरण पर शोध होगा। इसमें यहां की खेती, पानी और मौसम के तकनीकी और गैरतकनीकी पहलुओं के बारे में तथ्य जुटाए जाएंगे। यह भारत व ब्रिटेन सरकार द्वारा प्रदेश के चार जिलों में किया जा रहा है, जिसमें धार भी शामिल है।

अध्ययन की शुरुआत को लेकर शुक्रवार दोपहर एक होटल में कार्यशाला हुई, जिसमें पर्यावरण एवं वन मंत्रालय द्वारा अधिकृत डेवलपमेंट अल्टरनेटिव, इप्को और स्टॉक होम इन्वॉयरमेंट इंस्टिट्यूट के प्रतिनिधि शामिल हुए। विभिन्न सरकारी विभागों के अधिकारी व कर्मचारी भी मौजूद थे, जिन्होंने जलवायु परिवर्तन रोकने के लिए सुझाव दिए। अधिकांश ने वृक्षों की कटाई रोकने, पौधारोपण करने, ग्राउंड वाटर रिचार्जिंग और फसल काटने के बाद बचे ठंडल नहीं जलाने पर जोर दिया। कार्यशाला में डेवलपमेंट अल्टरनेटिव से डॉ. आनंद कुमार और एप्को (इन्वॉयरमेंटल प्लानिंग एंड को-आर्डिनेशन आर्गेनाइजेशन) से लोकेंद्र ठक्कर व मनोहर पाटील आए थे, जिन्होंने अध्ययन का उद्देश्य व फायदे बताए। धार के अलावा इस तरह का अध्ययन उज्जैन, दतिया और टीकमगढ़ में होगा।

[रिसर्च] चार जिलों में धार भी शामिल, मूल्यांकन शुरू

जलवायु परिवर्तन पर जाने विचार

■ राज न्यूज़ नेटवर्क

धार। डेवलपमेंट ऑल्टरनेटिव संयुक्त रूप से एनवारमैंटल प्लानिंग एंड कोआर्डिनेशन आर्गेनाइजेशन तथा स्टाकहोम एनवायरमेंट इंस्टीट्यूट के साथ मप्र में जलवायु परिवर्तन अनुकुलन तथा संवेदनशीलता पर शोध अध्ययन संचालित कर रहा है।

इसके लिए प्रदेश के चार जिलों को शामिल किया गया है जिसमें मालवांचल के दो जिले उज्जैन तथा धार को भी शामिल किया गया है। इसी के तहत शुक्रवार को जलवायु परिवर्तन एवं अनुकुलता तथा संवेदनशीलता पर आई टीम ने लोगों से विचार जाने और प्राप्त विचारों पर चिंतन किया। डेवलपमेंट अल्टरनेटिव संस्थान के डॉ. आनंद एपको संस्थान से आए लोकेंद्र ठक्कर एवं मनोहर पाटिल ने बताया कि मप्र जलवायु परिवर्तन के प्रति भारत के सर्वाधिक संवेदनशील राज्यों में से एक है। कृषि के क्षेत्र में मप्र का देश में अपना अलग ही स्थान है। लोगों को खाद्यान्न उपलब्ध कराने में प्रदेश का 45 प्रतिशत योगदान है तथा यहां की 70 प्रतिशत आबादी कृषि से जुड़कर रोजगार पा रही है।

इस प्रकार की स्थिति से जलवायु परिवर्तन के प्रभावों के प्रति यह प्रदेश और भी संवेदनशील हो जाता है जिसका प्रतिकूल प्रभाव अनेकों लोगों व उनकी आजीविका पर पड़ता है। कार्यक्रम में वन विभाग, जल संसाधन विभाग, कृषि विभाग एवं उद्यानिकी विभाग के अलावा एनजीओ के सदस्यों ने भी भाग लिया।

साथ ही उपस्थित सदस्यों ने जिले की भौगोलिक स्थिति और उसमें किस प्रकार से परिवर्तन संभव है इस पर अपने विचार रखे। भोज फाउंडेशन के अंशुल शर्मा ने सादी नदी के पुर्नउत्थान उसके उदगम स्थल तथा नदी की वर्तमान स्थिति से दल को अवगत कराया। दल के सदस्यों ने शोध कार्यक्रम में उपस्थित जनसमुदाय से जलवायु परिवर्तन के लिए कौन कौन जिम्मेदार है और उसके लिए क्या प्रयास किए जा रहे है इसके लिए सभी से अपने विचार जाने। इन विचारों को एकत्रित कर दल के सदस्यों ने संबंधित विभागों से चर्चा कर अपना प्रतिवेदन तैयार करने की बात कही। कार्यक्रम का संचालन प्रेमविजय पाटिल ने तथा आभार लोकेंद्र ठक्कर ने माना।

कार्यक्रम का उद्देश्य

कार्यक्रम का मुख्य उद्देश्य है कि व्यापक संवेदनशीलता के संदर्भ में जलवायु परिवर्तन से प्रेरित संवेदनशीलता के सामंजस्य को गंभीरता से समझना और यह जानना कि वर्तमान विकास प्रक्रियाओं में जलवायु परिवर्तन से संबंधित प्रतिरोधकता निर्माण एवं अनुकूलन उपायों को कैसे कारगर रूप से समाहित किया जाए।

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बद से बदतर | धार के नौगाँव क्षेत्र में बद से बदतर हो चुकी सड़क से क्षेत्र के ग्रामीणों को न जाने कब मुक्ति मिलेगी। आंदोलन के बाद आश्वासन जरूर मिलता है। विभाग को गड्ढे भरने में जरा भी विश्वास नहीं है। फोटो : नईदुनिया

जलवायु परिवर्तन पर कार्यशाला

जल संरक्षण, वन विकास व कृषि बदलाव पर खास जोर

धार। मप्र के 4 जिलों में जलवायु परिवर्तन का अध्ययन होना है। इसी के अंतर्गत धार जिले में होने वाले अध्ययन के लिए शुक्रवार को यहीं कार्यशाला रखी गई। इसमें एक महत्वपूर्ण बात सामने आई कि शासकीय विभागों से लेकर गैर-शासकीय संगठन यह सोचते हैं कि जलवायु परिवर्तन जैसे अहम मसले से लड़ने के लिए पेयजल संरक्षण, सघन वन विकास से लेकर कृषि क्षेत्र में विभिन्न परिवर्तन लाना होंगे। आगामी 6 से 8 माह तक इस दिशा में सतत अध्ययन जारी रहेगा। इसके बाद मप्र सरकार को मालवा के धार व उज्जैन जिले की रिपोर्ट सौंप दी जाएगी।

भारत सरकार के पर्यावरण और वन मंत्रालय तथा इंग्लैंड के उर्जा व जलवायु परिवर्तन विभाग के संयोजन से यह अध्ययन होगा। इस कार्य में सहयोगी के रूप में डेवलपमेंट आल्टरनेटिव यानी डीए, मप्र सरकार के पर्यावरण संगठन एप्को तथा स्टॉकहोम एनवायरनमेंट इंस्टीट्यूट द्वारा मप्र में जलवायु परिवर्तन की अनुकूलता व संवेदनशीलता मूल्यांकन पर कार्यशाला का आयोजन किया गया। इसमें डीए के वरिष्ठ परियोजना मैनेजर आनंदकुमार ने बताया कि किस तरह जलवायु परिवर्तन पर अध्ययन होगा। उन्होंने कहा कि इसके पीछे मकसद यह है कि विशेष रूप से कृषि, आजीविका, मौसम सहित अन्य कई मसलों पर सूक्ष्मता से अध्ययन हो। उनके अनुसार सबसे पहले यह जाना जाएगा कि जिले में किन-किन क्षेत्रों में जलवायु परिवर्तन संबंधी मुद्दे क्या हो सकते हैं। इसके अलावा उनके प्रभाव क्या पड़ रहे हैं। प्रभाव से बचने के लिए वर्तमान में कौन-कौन से विभाग क्या कार्य कर रहे हैं। कौन-सी रणनीति अपनाकर कार्य किया जा सकता है। इसी के लिए जल संसाधन, कृषि, उद्यानिकी, वन विभाग तथा जिला पंचायत व ग्रामीण आजीविकीय परियोजना के अधिकारी व कर्मचारी कार्यशाला में शामिल हुए। इसमें वन विभाग की ओर से वरिष्ठ कृषि विस्तार अधिकारी आरके पांडे, जल संसाधन विभाग की ओर से अनुविभागीय अधिकारी श्री अग्रवाल, उद्यानिकी विभाग की ओर से श्री तोमर, ग्रामीण आजीविकीय विभाग की ओर से महेशचंद व्यास के अलावा गैर-शासकीय संगठन की ओर से गगन मुद्गल, सतीश वाणी, अंशुल शर्मा आदि भी विचार रखे। इन संगठनों ने अपने अनुभव भी सुनाए और क्या होना चाहिए, इस पर विस्तार से बात रखी।

अध्ययन के बाद प्रदेश में भी लागू होगा प्लांट

दरअसल 6 माह तक सतत इसमें तकनीकी और व्यावहारिक रूप से अध्ययन किया जाएगा। डॉ. आनंद ने बताया कि विभिन्न अध्ययनों के माध्यम से जो निष्कर्ष निकलेंगे, उसको मप्र सरकार को सौंपा जाएगा, जिसके अनुसार जलवायु परिवर्तन की अनुकूलता पर कार्य होगा। इसके साथ ही महत्वपूर्ण रूप से क्षमता विकास पर भी ध्यान दिया जाएगा। कार्यशाला में एप्को की ओर से जलवायु परिवर्तन सेल के समन्वयक लोकेंद्र ठक्कर तथा मनोहर पाटिल भी उपस्थित थे। आभार श्री ठक्कर ने माना। -नि्प्र

रैपिड न्यूज़

जलवायु परिवर्तन पर जाने विचार

धार। डेवलपमेंट ऑल्टरनेटिव संयुक्त रूप से एनवार्नमेंटल प्लानिंग एंड को-आडिनेशन आर्गेनाइजेशन तथा स्टॉकहोम एनवायरमेंट इंस्टिट्यूट के साथ मप्र में जलवायु परिवर्तन अनुकूलन तथा संवेदनशीलता पर शोध अध्ययन संचालित कर रहा है। इसके लिए प्रदेश के चार जिलों को शामिल किया गया है।

इसी के तहत शुक्रवार को जलवायु परिवर्तन एवं अनुकूलता तथा संवेदनशीलता पर आई टीम ने लोगों से अपने विचार जाने और प्राप्त विचारों पर चिंतन किया। डेवलपमेंट अल्टरनेटिव संस्थान के डॉ. आनंद एपको संस्थान से आए लोकेन्द्र ठक्कर एवं मनोहर पाटिल ने बताया कि मप्र जलवायु परिवर्तन के प्रति भारत के सर्वाधिक संवेदनशील राज्यों में से एक है। कृषि के क्षेत्र में मप्र का देश में अपना अलग ही स्थान है। सदस्यों ने जिले की भौगोलिक स्थिति और उसमें किस प्रकार से परिवर्तन संभव है, इस पर अपने विचार रखे। भोज फाउंडेशन के अंशुल शर्मा ने सादी नदी के पुनरुत्थान, उद्गम तथा नदी की स्थिति से दल को अवगत कराया।

भूखण्डों के विक्रय

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Development Alternatives
B-32 TARA Crescent, Qutub Institutional Area
New Delhi – 110016 (INDIA)
Phone : +91-11-26564444, 26544212, Fax : Fax: +91 11 26851158
Website: www.devalt.org

Environmental Planning & Coordination Organization
E-5 Arera Colony, Paryvaran Parisar
Bhopal, Madhya Pradesh - 462016 (INDIA)
Phone: +91- 0755-2464318, 2466859
Fax: 0755-2462136
Website: www.epco.in

Stockholm Environment Institute
Florence House 29, Grove Street
Summer Town, Oxford, OX2 7JT, UK
Phone: +44-1865426316
Website: www.sei-international.org