Climate Resilient Agriculture Strategy for Chhattisgarh: Impacts and Recommendations

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A Study done by DFID's Action on Climate today Programme for Chhattisgarh State Centre for Climate Change, Raipur, Chhattisgarh


The opinions expressed in this report are those of the authors and do not necessarily represent the views of the Department for International Development.

Contents

Abbreviations and Acronyms

ACT	Action on Climate Today
ACZ	Agro-climatic Zone
AGVI	Agriculture Vulnerability Index
AWD	Alternate Wetting and Drying
CBA	Community Based Adaptation
CCAFS	Climate Change, Agriculture and Food Security
CCIP	Climate Change Innovation Programme
CGIAR	Consultative Group on International Agricultural Research
CRA	Climate Resilient Agriculture
CRIDA	Centre for International Dryland Agriculture
CSA	Climate Smart Agriculture
CSAPCC	Chhattisgarh State Action Plan on Climate Change
CTA	Technical Centre for Agriculture and Rural Cooperation
DOA	Department of Agriculture
DSSAT	Decision Support System for Agrotechnology Transfer
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion
FYP	Five Year Plan
GDP	Gross Domestic Product
GOC	Government of Chhattisgarh
HDI	Human Development Index
IFPRI	International Food Policy Research Institute
IGKV	Indira Gandhi Krishi Vishwavidyalaya
IMD	Indian Meteorological Department
INDC	Intended Nationally Determined Contribution
ITK	Indigenous technical knowledge
IWMP	Integrated Watershed Management Programme
JFM	Joint Forest Management
KII	Key informant interview
KVK	Krishi Vigyan Kendra
LGP	Length of Growing Period
LRPE	Long-range Planning Exercise
LWE	Left-wing Extremism

MAFW	Ministry of Agriculture and Farmers' Welfare
MCA	Multi-Criteria Analysis
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
NAPCC	National Action Plan on Climate Change
NDC	Nationally Determined Contribution
NEM	North-east monsoon
NGO	Non-government organization
NICRA	National Initiative on Climate Resilient Agriculture
NTFP	Non-Timber Forest Product
PMFBY	Pradhan Mantri Fasal Bima Yojana
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PTD	Participatory Technology Development
RCCRA	Resource Centre for Climate Resilient Agriculture
SAP	State Agriculture Plan
SC/ST	Scheduled Tribe, Scheduled Caste
SDC	Swiss Development Cooperation
SWM	South West Monsoon
SRI	System of Rice Intensification
UNDP	United Nations Development Programme
VCA	Value Chain Analysis
WBG	World Bank Group
ZARS	Zonal Agriculture Research Stations

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Executive Summary

Short Summary

This report, "Climate Resilient Agriculture strategy for Chhattisgarh: Impacts and Recommendations" was undertaken on the basis of the findings of a long-term planning exercise undertaken for the Action on Climate Today-Climate Change Innovation Programme (ACT-CCIP) in collaboration with different stakeholders, principally from government. A need for a study is also identified in the Chhattisgarh State Action Plan on Climate Change, and this was backed by the State Centre for Climate Change within the State Forestry Research and Training Centre.

The report finds that significant changes in weather patterns are already happening, albeit gradually, jeopardizing the livelihoods of farmers who are dependent on agriculture and allied activities. Monsoons are becoming more unpredictable and erratic. This is leading to adverse impact on productivity in agriculture, and will affect the livelihoods of more than 70% of the state's population. The productivity of major crops such as rice and wheat is expected to fall, and using insights from modelling techniques, predictions are made in the report regarding these declines in different agro-climatic zones under different future climate scenarios.

This is expected to affect the availability of food grains, and to impact food security and nutrition especially for the poorest. Farmers attribute significant impacts on productivity and livelihoods to the changing climate. Agricultural, allied and forest-based livelihoods are equally affected. Livestock herd sizes is falling, and animal productivity and fertility are decreasing owing to the lack of quality fodder and water scarcity. Forest production and non-timber forest products (NTFPs) on which many forest-based livelihoods depend are also on the decline, particularly in the Northern Hills region. The most vulnerable people are those whose livelihoods is least diversified, which in Chhattisgarh are small mono-cropping rice farmers in the Central Plains. Farmers are aware of the changes, but not equipped to address them. Key Informant Interviews with stakeholders suggest the need for awareness on climate change impacts and sector-level attributions. Agricultural research and extension should realign to enable the State to design better adaptation policies and programs. The report proposes the establishment of a multi-stakeholder Resource Centre for Climate Resilient Agriculture in Raipur which can coordinate research, policy and implementation.

Full Summary

Agriculture is an important sector for growth and development in Chhattisgarh. While production levels are increasing, the sector is not realising its full potential due to several constraints. Both current and future productivity of the sector is at risk from climate change, particularly increasing temperatures, erratic rainfall patterns and extreme weather events.

Chhattisgarh is highly vulnerable to climate change and its impacts. The state has a large population that is dependent on subsistence agriculture, which is largely rain-fed, and its economic viability is becoming precarious in the changed pattern of erratic rainfall that is becoming the norm. Less than one third of the total arable land in Chhattisgarh is covered by irrigation facilities such as canals, reservoirs and tanks. The rest is fed by seasonal rivers. Lack of proper irrigation facilities and limited residual soil moisture levels leave nearly half of the arable land fallow for the second crop, increasing risk exposure. Models developed for this study show that there is a severe likelihood of agriculture drought in parts of Chhattisgarh over the next 30 years, despite increase in annual rainfall.

Climate Resilient Agriculture (CRA) addresses real climate risks that are faced by the sector. CRA production contributes to food security by addressing different aspects of current and projected climate change impacts through adaptation and mitigation actions. CRA aims to strengthen livelihoods and food security, especially of smallholders, by improving the management and use of natural resources and adopting appropriate methods and technologies for the production, processing and marketing of agricultural goods. As such it is an approach which is wholly compatible with Chhattisgarh's circumstances, and has the potential to respond to the challenges of climate change.

A study on CRA was proposed by the Government, which would look for local impacts of climate variability and extreme events on agriculture, documenting local innovation and coping mechanisms in the most highly vulnerable agricultural systems. The overall objective was to identify the current challenges in promoting CRA in Chhattisgarh. The study aims to inform and offer specific options or recommendations to the Directorates of Agriculture, Horticulture and Livestock Production, and aid the design of CRA interventions in the state. The study has used a robust "mixed-methods approach", combining field insights from primary data corroborated by secondary data and model outputs for crop-level climate impacts. Modelling outputs have aided the development of insights from field investigations on local impacts of climate change. Sampling and survey strategies have placed emphasis on vulnerable production systems in the remote forest-fringe areas.

The Chhattisgarh State Action Plan on Climate Change (CSAPCC) includes 'agriculture and allied' among the eight sectors outlining both short and long-term strategies to address climate change. These strategies are all relevant, appropriate and of fundamental importance to the climatic change circumstances facing Chhattisgarh. CSAPCC components promoting CRA practises in Chhattisgarh are: the need for a diversified agriculture to spread risks; the need to adopt integrated approaches that maximise the benefits of natural, biological processes; a strong focus on farmer-driven participatory technology development; organic and low input farming, reducing reliance on non-renewable external inputs; a need to work through market value chains, addressing farmers' access; and the necessity of working with rural producers, in particular women, and of relating to their knowledge and practices. The CSAPCC notes that *"currently, no comprehensive analyses of possible impacts of climate change on agriculture in Chhattisgarh are available, nor are systematically documented anecdotal references to impacts from farmers."* This study aims to address this shortcoming.

There is overwhelming evidence that the climate has already changed, and that the risks are growing in Chhattisgarh. In all three Agro-Climatic Zones (ACZs) farmers have observed profound changes in the weather that supports their livelihoods. The most dramatic effects are taking place regarding rainfall. The southwest monsoon has become more erratic. Previously rains started dependably and consistently on 10-12 June and ended by 15 September. Now they are starting at least 15 days later and are ending sooner. Every farmer reported that the overall quantity of rain is reduced, with nearly two-thirds reporting that this reduction is severe. There are indications that the Northern Plateau is more severely affected. Drought is becoming more common across all districts and ACZs, with dry periods of up to 21 days being reported as now frequent. Intense, unseasonal rainfall events and flooding are happening more often; earlier patterns of slow but continuous rainfall have given way to erratic high intensity rainfall resulting in lower soil percolation and overflowing of reservoirs and tanks. Soil erosion as a result of flash-flooding is also occurring. There are more days when temperatures are very high, with temperatures frequently rising above 40 degrees Celsius. An unprecedented high of 49 degrees was reported in Bilaspur District during 2017. Farmers report that these trends have become noticeable over the last five years. This is too recent to enable reliable comparison with long-term official weather data.

The survey has demonstrated that the effects of climate change on the lives and livelihoods of rural people in Chhattisgarh are both wide-ranging and profound. There is scarcely an element of their livelihood and farming systems that remains untouched either directly or indirectly by the changes in the climate. The growing impact of climate change on vulnerable people is will be overwhelming, tipping the poorest further into poverty and destitution.

Projected declines in productivity of major crops especially rice and wheat are significant. The yields of rice and wheat may reduce by 10 percent by 2030. Modelling techniques, it is estimated that by 2050 wheat productivity can be expected to decrease by 28, 18 and 24 per cent respectively for the Central Plains, Northern Hills and Bastar Plateau agro-climatic zones (ACZ). Rice productivity is expected to fall by 35, 21 and 14 percent respectively for these ACZs. Whist technological advances have so far been able to keep up with a worsening climate, it will be very challenged in the future to continue to meet this yield gap.

Livelihoods assets, and levels of household income, are being eroded. Soils are becoming degraded due to a variety of factors including the changing climate, and fertility is in decline. With both crop and horticultural production, the impacts of reduced and erratic rainfall mean that people are planting a smaller overall area, that yields are in decline, and that the quality of produce is more likely to be poor. Households reported that the incidence of food shortage periods is on the increase. For livestock producers, farmers report that access to quality fodder is getting increasingly difficult, with both fodder areas and quality falling because of their perceptions of unfavourable weather and inadequate rainfall. This leads to reduced numbers of animals, inadequate nutrition and hence reduced productivity both of meat and milk.

The most vulnerable people are those who rely solely on agriculture, and where the large part, or all, of household income comes from farming. This includes those farmers who rely on rice monocropping. In addition to being dependent on a single crop they also rely heavily on costly external inputs such as improved seeds, fertilizers and pesticides. This group is the most vulnerable. Those households with more diversified livelihoods have a greater level of resilience arising from a variety of sources, and are less vulnerable. This includes the populations of SC/ST in ACZs 1 & 3, who firstly have a wide range of crops under cultivation in traditional mixed farming situations, secondly have livelihoods that are more diversified in nature, and thirdly who are much less reliant on external inputs – where these are used at all. In addition, some local (desi) varieties may show greater levels of resilience than improved varieties.

Households relying on both agriculture and forest-based livelihoods face a double threat. Virtually all tribal communities rely both on agriculture and non-timber forest produce (NTFPs) which they collect from local forest areas. Farmers in the field survey reported that NTFPs – including Mahua flower, lac, medicinal plants, gums, tendu leaf, sal and multiple other products - are also being adversely affected by the increasing temperatures and more erratic rains. In addition, the deterioration of forests has seen more exotic species thrive, to the detriment of native species, further reducing fodder availability. Although these communities may be more resilient than mono-cropping households their vulnerability will still increase. These forest-dependent communities contain the poorest of the poor, and are often landless. In addition to livelihoods from forest and agriculture they also sell their labour for a daily wage. It is likely that declining agricultural productivity will lead to reduced employment opportunities.

Rice is the most vulnerable of the crops observed. Yields are very dependent on the south west monsoons, and it is not a crop that can tolerate long intermittent dry spells. The livelihoods of farmers who are dependent on sole-cropping systems are the most vulnerable to increasing variability of levels and distribution of the South West Monsoon (SWM). Maize is grown largely rainfed, but is also irrigated if another crop of maize is taken after kharif harvest, and in the short-term is less susceptible. In the longer term as irrigation sources become less reliable through more erratic rainfall and falling water tables, this advantage may be threatened. Kodo and Ragi, also kharif crops, are better able to withstand prolonged dry periods and offers greater levels of resilience. Winter wheat yields will become more susceptible to increasing temperatures during the rabi season.

As a result of weather changes, the insect pest, disease and weed spectrum is changing. This affects livestock production, horticultural and agricultural crops. For example, farmers report that sucking pests such as aphids on rice were previously seen only in the dry season, but these now can survive because of an increasing frequency of unseasonal rains in the growing season, and cause greater damage. The incidence of smuts, rusts, and blights is on the increase. The use of pesticides is increasing across all the ACZs. This trend towards an increasing reliance on chemical control is alarming. There is a strong need to encourage integrated pest management and other more ecologically friendly means of control.

Kharif crops are being planted later. Previously monsoon rains started dependably and consistently on 15th June and ended 15th September, but now rains begin later and end earlier. Whilst previously famers would always plant in June, now there is a tendency to plant in July, and farmers have shifted their planting dates. This has implications for the rice crop, where long-duration varieties no longer have sufficient time to reach maturity.

Over three-quarters of all cattle owned by the survey sample are local breeds which are less productive but more resilient. Farmers and many others working in animal husbandry believe that local desi cattle are more resilient than improved hybrids, and have qualities well suited to a changing climate. They are small and well adapted, but not very productive in terms of milk yield. Indian breeds are preferred, and among the high quality and national breeds are Gir, Sahiwal, and Red Sindhi. Kosali is a recognized local breed and may be more adaptable. This may be used to improve the indeterminate local desi types.

There is a dramatic and growing shortage of fodder for livestock. Climate change has impacted fodder production both directly (reduced fodder crop yields in both field and forest) and indirectly (less area to fodder, more to agriculture). Farmers are reacting to this by reducing the numbers of animals they hold. Livestock productivity is falling. Larger producers are reported to be using greater levels of cereal-based food concentrates to boost milk yields.

Migration to urban centres for employment has been occurring for many years, and respondents noted an increase in water scarcity-induced migration of agricultural labourers and cultivators to urban centres. Households and individuals were asked if there had been any change in the patterns of migration as a result of climate change, and this is a growing trend. There were incidences of distress migration in all ACZs.

Examples of community-led responses to climate change are rare. One example was reported of a community grain bank. All respondents felt the need for an early warning system that would permit them to make allowances for unfavourable changes in weather. A large majority recognised that community-owned lands were being overused for grazing purposes, and that this situation is deteriorating. Communities are accessing government employment schemes to provide themselves with short-term financial support. Of these Mahatma Gandhi National Rural Employment Guarantee Act (MNREGA) is the most used (80%), and the overall reliance on this as a source of income and livelihoods was high.

Looking for positive aspects to climate change. New opportunities may exist if farmers can adapt and make things work to their advantage, but few have started to do so. Agricultural research has many potential answers, such as from drought resistant crops. Yields of potato, soybean, grams and mustard for example may benefit from increased levels of carbon dioxide. However, up-take of technology in the state has been slow at least in part through scarce extension services, and farmers are not using these widely. There is a need to find the early adapters/ adopters and work with them, firstly to validate their ideas through on-farm testing, and then replicating and taking these ideas to scale. There is a strong need for some participatory adaptive research, and piloting new adaptive technologies should become an investment priority.

This report reaches its conclusions, and recommendations are made for government to consider, summarized in the table below. Given the high and growing threat posed by climate change, there is a need for urgency in actioning these. The priorities marked in the table below as 'highest' should be adopted by government with immediate effect. These are:

- Integrate CRA into the State Agriculture Policy
- Capacity building within government.
- Constitute an inter-departmental Resource Centre for CRA in Raipur (RCCRA).

Recommendations	Knowledge/ Practice/ Technology	Markets	Institutions	Policies
Highest priority				
I. Develop a roadmap for CRA implementation			*	*
II. Capacity building at all levels of government	*		*	
III. Approve, establish and develop a new Resource Centre for Climate Resilient Agriculture (RCCRA).			*	*
Medium priority				
IV. Appoint Principal Points-of- Contact for climate change within key ministries.			*	
V. A focus on local ACZ effects.	*			
VI. Adaptive on-farm research.	*			
VII. New drought resistant rice varieties	*			
VIII. Promotion of minor millets	*			
IX. The need to diversify livelihoods.	*			
X. Prioritise drought-resistant fodder species and varieties.	*			
XI. Integrated weed, pest and disease management.	*			
XII. Prioritise improved and integrated water management.	*			
XIII. Review the policy of subsidising the use of concentrates in animal feedstuffs.				*
Lower priority				
XIV. Freeing up NTFP markets		*		*

The three high priority actions are mainly concerned with institutions and policies, and should be undertaken by government with immediate effect. Many of the medium and lower priority actions relate to knowledge and technology, and can be addressed by the RCCRA when it has been established.

Section 1: Introduction and Background

Section 1 of this report looks at agriculture in Chhattisgarh State and the associated policies and institutions, at climate change more broadly, and at how Climate Resilient Agriculture (CRA) may be used as an approach to address the emerging issues. In Section 2, the approach and methodology used in this study are detailed. Section 3 includes a review of the secondary data that has been used in the study, at global and national levels. Sections 4 and 5 look more closely at the meteorology involved. In Section 4, the climatic trends already observed are analysed, and some projections for the future and the risks that may be encountered are made. The implications of those risks for agriculture are addressed in Section 5, which looks also at trends in yields of some main crops. Farmers' perceptions of how the climate is changing were gathered through several techniques including a field survey; the results of this work are presented in Section 6. Section 7 assesses the overall levels of vulnerability, and identifies which areas and communities are most susceptible to changes in climate. Some farmers are already adapting to these changes, and these are reflected in Section 8. Sections 9 and 10 contain conclusions and recommendations.

Chhattisgarh

Chhattisgarh is the 10th largest state in India. With an area of 135,190 km2 it is one of the richest in natural resources. It is also a major source of electricity and steel, accounting for 15% of the total steel produced in the country. Industry is burgeoning, and growth rates have been consistently above 10% per annum over the last decade making it one of the fastest-developing states in India.

But poverty indicators tell a different story. In 2011, the state recorded the lowest Human Development Index (HDI) value in India. Nearly half of Chhattisgarh's population is estimated as being below the poverty line, nearly double the all India average. Marginalised groups proliferate, and constitute some 50% of the state's population. These groups are located mainly in the densely-forested areas on in the north and southern plateaus. Scheduled Castes and Tribes (SC/ST), particularly the latter, lie at the bottom of social development indicators in the state rankings. There is also a high incidence of left wing extremism (LWE) in these districts.

This indicates high levels of vulnerability, and this will be made worse by climate change. An overall reduction in more erratic rainfall is already happening and will get worse, especially in several drought prone districts. This will have an impact on the livelihoods of the poorest, who will feel a double blow to already meagre livelihoods gained both from farming and forest.

Agriculture in Chhattisgarh

Some 80% of the population depend on agriculture and allied sectors including forestry as the main source of their livelihoods, with 5.8 million hectares of its area under crop. The agriculture sector contributes 20% of the state's GDP and employs approximately two-thirds of the state's population, while the industrial sector, which contributes over 40% of the state's GDP, employs as little as 5%. Most recent census data (2011) indicate a decadal decline of 11.6 per cent in the number of cultivators from 2001 even as the number of farm laborers has increased by 9.8 per cent in the same period. This exacerbates the sensitivity to climate-induced vulnerability. Agriculture was the only sector that witnessed a robust growth in the recent decade (2005-2015) when both the manufacturing and services sectors witnessed contraction. Agriculture growth rate increased from 2.2% in 2005 to 3.8% in 2015, while growth rates in manufacturing sector nearly halved. Enabling policies and consistent focus by the governments have ensured that the primary sector continues to attract public resources.

There are three Agro-Climatic Zones (ACZs) that make up the state. These are the Central Plains, the Northern Hills and the southern Bastar Plateau. The latter two are comprised of more hilly terrain, with more marginal soils and an almost entirely rain-fed agriculture.

Climate Change and Agriculture in Chhattisgarh

Chhattisgarh is potentially highly vulnerable to climate change and its impacts[1]. The State has a high level of reliance on rainfed, subsistence agriculture, in a situation where increasingly erratic rains are likely to become the norm. Less than one-third of the total arable land in Chhattisgarh is covered by irrigation facilities such as canals and reservoirs; the rest is fed by seasonal rivers. Lack of proper irrigation facilities and residual soil moisture leaves nearly half of the arable land as fallow for the second crop, increasing the risk exposure of the state. Increasingly, this has led the State to spend a significant share of its budget on risk mitigation measures such as loan waivers for drought-hit farmers and crop insurance schemes, depriving the sector of real investments to improve efficiency.

Productivity in the State is already among the lowest in India. Available data from the Department of Statistics[2] indicate that the state falls short of the national average in the productivity of cereal crops, oil seeds and pulses. Chhattisgarh ranks among the bottom 10 states in priority sector lending (<40%). Over the last decade, there has been a shift in trend from public to private irrigation sources and from surface to groundwater-dependent.
In a nation-wide assessment of agricultural vulnerability, the Central Research Institute for Dryland Agriculture (CRIDA) in 2014 underscored the importance of enhancing agricultural- water use efficiencies in Chhattisgarh. The study highlighted the projected increase in number of drought years as the major exposure factor, while a higher share of net-sown area and a correspondingly lower proportion of net-irrigated area contributed to the higher vulnerability of the agricultural sector by increasing sensitivity and reducing adaptive capacities respectively[3].

Agriculture is thus an important sector for growth and development in Chhattisgarh. While production levels are increasing, the sector is not realizing its full potential due to several constraints. Both current and future productivity of the sector is at risk from climate change, particularly increasing temperatures and erratic rainfall patterns.

Climate Resilient Agriculture (CRA)

CRA addresses agriculture with a strong focus on the very real climate risks that are faced by the sector. Climate resilient agricultural production contributes to food security by addressing different aspects of current and projected climate change impacts through adaptation and mitigation actions. Among the principles to which it adheres, and particularly relevant to Chhattisgarh, are illustrated below:

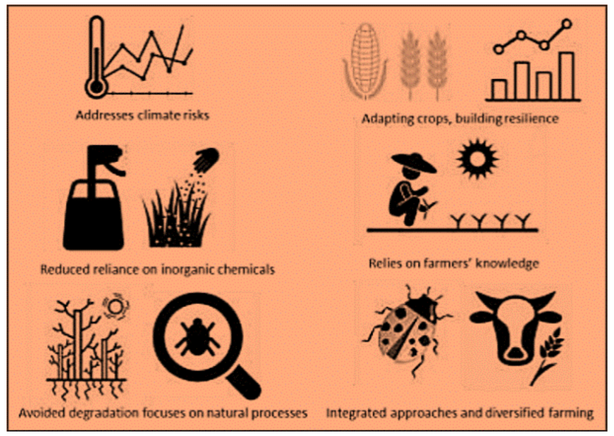

Figure 1: Climate-resilient agriculture; key principles

CRA thus aims to strengthen livelihoods and food security, especially of smallholders, by improving the management and use of natural resources and adopting appropriate methods and technologies for the production, processing and marketing of agricultural goods. As such it is an approach which is wholly compatible with the circumstances which Chhattisgarh State finds itself, and responds to its requirements. CRA brings together practices, policies and institutions that are not necessarily new but are used in the context of climatic changes, which may be unfamiliar to farmers.

ACT in Chhattisgarh

The Action on Climate Today (ACT) initiative began its work in Chhattisgarh in late 2014. Initially it sought to identify pieces of work that would integrate climate change adaptation into government thinking through their policies and programmes. Several early activities were initiated, some of which are still in play.

Following this, ACT held a Long-Range Planning Exercise (LRPE) during June 2015 with the objective of understanding priority issues and challenges in the state due to climate change and for identifying and developing work streams under the project. The goal was to define a vision for the agriculture sector which is productive and resilient to climate change. After several follow-up initiatives like developing and piloting climate resilient agriculture practices and policies CRA work emerged, with the Government of Chhattisgarh (GoC) nominating it as a high priority activity.

Institutional and Policy Context

Agriculture

At the national level, Ministry of Agriculture and Farmers Welfare (MAFW) is the nodal ministry involved in policy and planning for the impact of Climate Change on Agriculture. Within Chhattisgarh State, the Department of Agriculture (DOA) is the key player in developing a climate-focused agricultural programme.

Chhattisgarh developed a draft State Agriculture Plan in 2012 with a view to revitalising the agriculture sector. Sustainable agriculture is a key theme running through the SAP, but climate change risks and their possible impacts are not directly addressed. The Draft Agriculture Policy developed in 2012 proposed five strategies: (a) protection and enhancement of the health of the land, (b) conservation, management and utilisation of natural resources with a focus on water and micro irrigation; (c) timely disbursement of agricultural loans; (d) post-harvest management integrated with the development of food processing; and (e) reducing the time lag and the gulf between transfer of knowledge from lab to the land/farm. However, this draft policy does not recognise the risks posed by climate change, and that the future vision of the agriculture sector needs to adapt to the reality of water scarcity and higher temperatures. The concept of climate resilient agriculture is yet to be integrated into the government's planning and decision-making processes.

Climate Change Institutions

The main federal nodal ministry responsible for climate change is the Ministry of Environment, Forests and Climate Change, where climate change is placed within the Environment Wing of the Ministry. India released its National Action Plan on Climate Change (NAPCC) in June 2008. The plan aims to identify measures to mitigate and adapt to climate change, and runs until 2017.

The Chhattisgarh State Action Plan on Climate Change (CSAPCC)[4] has included 'agriculture and allied' among the eight sectors outlining both short and longer-term strategies to address climate change[5]. These strategies are all relevant, appropriate and of fundamental importance to the climatic change circumstances facing Chhattisgarh. CSAPCC Components promoting CRA practises in Chhattisgarh are:

- The need for a diversified agriculture to spread risks;
- The need to adopt integrated approaches that maximise the benefits of natural, biological processes;
- A strong focus on farmer-driven participatory technology development,
- A strong focus on organic and low input farming, reducing reliance on non- renewable external inputs;
- A need to work through market value chains, addressing farmers' access;
- The necessity of working with rural producers, in particular women, and of relating to their knowledge and practices.

[1] Government of Chhattisgarh, 2014. State Action Plan for Climate Change: Inclusive Growth for Improved Resilience. Raipur, March 2014.
[2] Department of Statistics of the Ministry of Agriculture, Government of India
[3] Rama Rao C A, Raju B M K, Subba Rao A V M, Rao K V, Rao V U M, Kausalya Ramachandran, Venkateswarlu B and Sikka A K (2013) Atlas on Vulnerability of Indian Agriculture to Climate Change. Central Research Institute for Dryland Agriculture, Hyderabad P 116.
[4] Government of Chhattisgarh, March 2014
[5] See CSAPCC Pages 43-44, and in detail in its Annexures Pages 117-119

The CSAPCC notes whilst it is evident that a changing climate can pose serious threats to the existing crops and agricultural practices in Chhattisgarh, and that fluctuations may have dramatic effects on agricultural productivity and food security, that "currently, no comprehensive analyses of possible impacts of climate change on agriculture in Chhattisgarh are available, nor are systematically documented anecdotal references to impacts from farmers." This study addresses these shortcomings.

Other institutions

In Chhattisgarh, the state agriculture university i.e. the Indira Gandhi Krishi Vishwavidyalaya (IGKV) has responsibility for agricultural education, research and extension within the state. It also houses the Department of Agricultural Meteorology. Research is conducted through several Zonal Agricultural Research Stations (ZARS), of which there are a total of 16 located within the 3 Agro-climatic zones (ACZs) of Chhattisgarh. Agricultural Extension is conducted through Krishi Vigyan Kendras (KVKs), of which there are a total of 23 located within the state. These government research and extension institutions play a key role in disseminating knowledge and building capacity regarding climate change.

A regional office of the Indian Meteorological Department is also established in Chhattisgarh State, and is responsible for weather forecasting.

Section 2: Approach and Methodology

Objectives of the Study

This work, **"Climate Resilient Agriculture strategy for Chhattisgarh: Impacts and Recommendations"** was undertaken on the basis of the findings of a long-term planning exercise undertaken for the project in collaboration with different stakeholders, principally from government. A similar need is also identified in the Chhattisgarh State Action Plan on Climate Change.

The overall objective of the study is to identify the climate impacts on agricultural sector, the current challenges on promoting climate resilient agriculture to provide the foundations for development of a work plan for strengthening government and other stakeholders on promoting climate smart agriculture in Chhattisgarh[6]. The study aims to inform and offer specific options or recommendations to the Departments of Agriculture and Horticulture and aid the design of appropriate short (1-3 years), medium (3-5 years) and long term (>5 years) CRA interventions in the state.

Approach to Study

This Study has adopted a participatory approach, taking in the views of all major stakeholders and building these into secondary and primary data collection processes, gaining maximum feedback at all stages. It worked with the existing institutions that are engaged in agriculture and climate change, and aims to support them to identify capacity gaps and address how these may be filled with suitable training. A strong working partnership was developed with the Department of Agricultural Meteorology Unit of IGKV, in Raipur.

The study has used a robust "mixed-methods approach", combining field insights from primary data corroborated by secondary data and model outputs for crop-level climate impacts. Modelling outputs have aided the development of insights from field investigations on local impacts of climate change. Sampling and survey strategies have placed emphasis on vulnerable production systems in the remote forest-fringe areas. CRA is an approach that requires site-specific assessments to identify suitable agricultural production technologies and practices, recognizing that options will be shaped by local contexts and capacities and by the social, economic, and environmental situation there. It is through provision of this more locally specific information that the ACT study has aimed to support the DOA.

[6] The full Scope of Work is in Annex 1

Methodology

The study uses an exploratory mixed-methods approach, which has drawn on and integrated quantitative and qualitative analyses. This ensures that the quantitative and qualitative methods build on each other's strengths, and corroborate and triangulate each other's findings. A mixed-methods approach is the means to achieving alternative, or more in-depth, understanding of certain facets of outcomes and impacts of climate variability on agriculture. Furthermore, by combining quantitative and qualitative research methods from the start of the assignment, the results are more rigorous, complete, and comprehensive in answering survey questions.

Common shortfalls of the use of mixed-methods include poor coordination between quantitative and qualitative research, and unclear acknowledgement of what contribution qualitative research brings to mixed-methods. To prevent this, concrete junctures of interaction are established between quantitative and qualitative approaches in both the design and analysis stages of the research. This iterative process improves coordination across the two types of research, and enhances the value and confidence of qualitative findings in complementing and triangulating quantitative evidence. Having the same researchers involved in the design of both quantitative and qualitative tools enhanced harmonization.

The methods used for collection of primary and secondary data are summarized below.

Process Mapping

As the first step, an inception workshop to identify the broader issues and challenges in the context of political, institutional, technical and social issues around climate change and agriculture was organized with the active participation of government staff, academia, research and extension bodies, Non-Governmental Organisations/ Community-based organizations, and private sector players. This was then followed by a field survey covering 120 farmers in 6 districts (two districts from each ACZ). In parallel to the field surveys, the recent literature on climate impacts in agriculture and the specific changes in the state were scanned to update the understanding and define the problems better.

A computer-driven, scenario model was run on the available climate information in the state to produce estimates of the changes in rainfall, temperature, extreme events and the impacts on crops. Findings from the field and outputs from the scenario-based models were corroborated and verified through multiple rounds of semi-structured, expert interviews (35 interviews) and stakeholder-driven Focus Group Discussions (3 ACZ-wise FGDs and 1 women-focused FGD).

Representatives from the Departments of Agriculture and allied sectors; State Forest Department, representatives of Farmers' Associations, scientists of the Indira Gandhi Agriculture University (IGKV), Krishi Vigyan Kendras (KVK) and the Indian Meteorological Department (IMD) were consulted. An indicative diagram of the process is shown below.

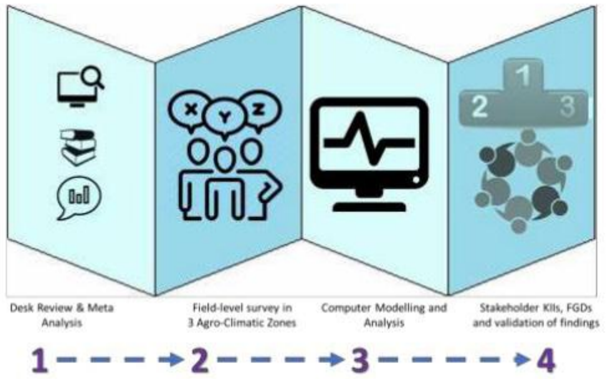

Figure 2: Indicative research process

The study reviewed secondary data on climate resilient agriculture as a concept, and records best practice and successful case studies from international and national sources. Existing research literature was reviewed on the local impacts of climate change in the three ACZs of Chhattisgarh, sources of indigenous technical knowledge (ITK) and local coping strategies in the context of adaptation to extreme events and climate variability.

The state agriculture university (Indira Gandhi Krishi Vishwavidyalaya - IGKV) was a key partner in this process. A detailed review of available crop yield data sets in agriculture was completed to supplement and corroborate the insights obtained from the field survey, and these are summarized in Section 5. A detailed list of literature reviewed is in Annex 7.

Analysis of Weather Data

India Meteorological Department published daily rainfall data of 0.250 x 0.250 and daily temperature data of 0. 50 x 0. 50 was extracted for a period of 30 years from 1981 – 2010 for Chhattisgarh state and used for further analysis. Seasonal means were computed from the daily data and mapped for understanding the spatial variability. As the Southwest monsoon is the major rainy period for Chhattisgarh, the onset and cessation were computed. The period in between the onset and cessation of rainfall was considered as the length of growing period (LGP). Trend analysis was conducted to understand the rainfall changes at agro climatic zone level. Extreme rainfall event analysis was conducted using five-year intervals, by computing the frequency of occurrence of one-day rainfall with >50, > 75, >100, >125 and >150 millimetres of rain. Similarly, spatial variability of temperature and its trend was also computed to understand temperature changes. The future climate of Chhattisgarh was projected using the ensemble value of 29 Global Circulation models used by the IPCC. To understand the impact of climate variability and climate change on rice and wheat productivity over Chhattisgarh, representative locations from three agro climatic zones were chosen and the Decision Support System for Agrotechnology Transfer (DSSAT) model was employed to predict the yield.

Summary Map

A map summarizing the various activities and locations for this study is illustrated in the figure below.

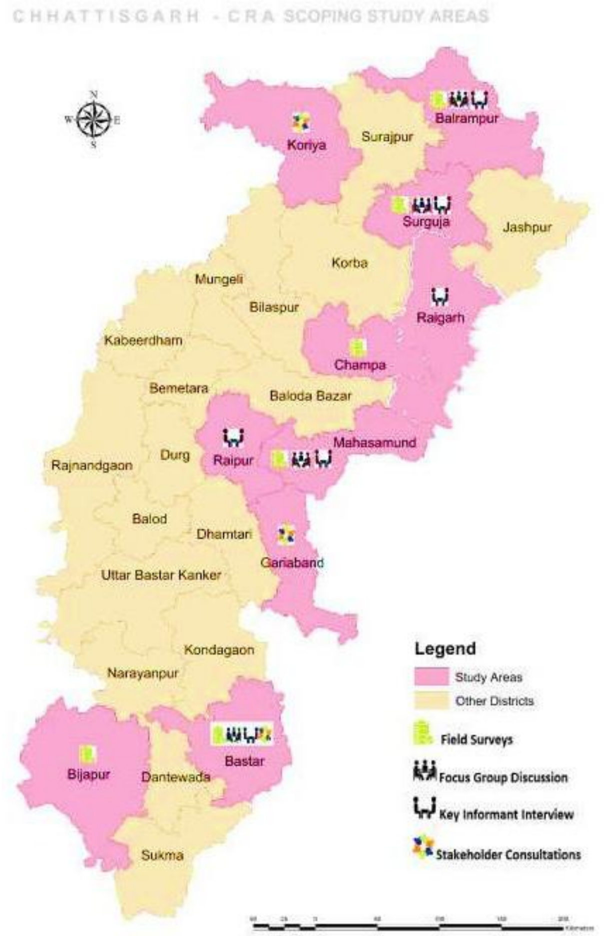

Figure 3: Map of the different activities undertaken in Chhattisgarh State for the study on CRA.
[Source: ACT Office, Chhattisgarh].

Section 3: Climate Resilient Agriculture - *A Secondary Data Review*

This section describes the history and evolution of climate-smart and climate-resilient agriculture. It defines what it means, and reviews the evidence. This is dealt with at three levels: on a global front; more locally, where there are a growing number of initiatives within the sub-continent, and within India; and within the CPDG programme itself where there are several examples and a growing knowledge base.

Global Experience

Background

Climate-smart agriculture (CSA) is a term first coined by FAO in a background document prepared for the 2010 Hague Conference on Food Security, Agriculture and Climate Change. FAO have produced a Sourcebook which outlines its potential and limitations, as a reference tool for planners, practitioners and policy makers working in agriculture, forestry and fisheries at national and subnational levels[7]. The CSA concept was developed with a strong focus on food security (FAO's mandate), including adaptation to climate change.

CSA and Climate Resilient Agriculture (CRA) are similar, and the two are used interchangeably here. CRA reflects the more recent focus on address vulnerability through building resilience, and since this is at the core of the Government of India's philosophy[8] this is the term used in this study. There are huge uncertainties in the way climate change will directly and indirectly impact agricultural and food systems, and related vulnerabilities. Building resilience now is central to preparing for future changes. The notion of resilience enables examining together various domains – biophysical (ecosystems), economic, social and institutional – and scales of operation[9]. CRA is a holistic approach to the problems of food security, climate resilience and climate mitigation. It is an integrated approach suited to meeting the food security, demographic and climate challenges that confront the world at large.

7 Food and Agriculture Organization of the United Nations (2013). Climate-smart agriculture sourcebook. Rome

8 See Government of India's NICRA, National Initiative on Climate Resilient Agriculture

9 Building Resilience for Adaptation to Climate Change in the Agriculture Sector. Proceedings of a Joint FAO/OECD Workshop April 2012. http://www.fao.org/docrep/017/i3084e/i3084e.pdf

What is CRA?

CRA overlaps with the concepts of sustainable agriculture and disaster risk reduction, and some of its techniques, such as rainwater harvesting, have been practiced for centuries. What is different about CRA is its emphasis on climate risks. While all activities under CRA are likely also to represent sustainable agriculture practices, vice versa may not be the case. It is not a 'one size fits all' set of practices. In any specific location, its form is defined by the context and associated priorities[10]. CRA involves developing technologies, policies and institutions, mobilizing investments and bringing all these into alignment in pursuit of three pillars as described below in the diagram[11]:

Figure 4: The three pillars of CRA

Increasing adaptive capacity, Pillar 2, is thus central to CRA. Climate change threats can be reduced by increasing the adaptive capacity of farmers as well as increasing resilience and resource use efficiency in agricultural production systems[12].

10 http://www.actiononclimate.today/act-on-knowledge/climate-smart-agriculture-and-the-need-to-scale-up/#_ftn2
11 http://www.fao.org/docrep/018/i3325e/i3325e00.pdf

Crucial CRA Actions

Governments and partners seeking to implement CRA can undertake a range of actions to provide the foundation for effective policies, programmes and projects. Four major types of actions are generally considered to be essential[13]:

- Review and expand the evidence base. Knowledge and data are vital in identifying agricultural strategies for reducing vulnerability that integrate necessary adaptation and mitigation;
- Build policy frameworks. Building policy frameworks to support implementation at scale;
- Strengthening institutions. Strengthening national and local institutions to enable farmer management of climate risks and adoption of context-suitable agricultural practices, technologies and systems;
- Leveraging finance. Enhancing financing options to support implementation, linking climate and agricultural finance.

Lessons Learned

A full summary table of lessons learned is included in Annex 11.

A CGIAR study identified sixteen cases of large-scale actions in the agriculture and forestry sectors that have adaptation and/or mitigation outcomes, and distils lessons from these. Among them are that strong government support is crucial to enable large-scale successes.

Upfront costs may be substantial and can be met from multiple sources. An iterative and participatory learning approach with investment in capacity strengthening is critical[14].

Work at IFPRI concluded that the negative effects of climate change on food security can be counteracted by broad-based economic growth—particularly improved agricultural productivity—and robust international trade in agricultural products to offset regional shortages. In pursuit of these goals, policymakers should increase public investment in land, water, and nutrient use and maintain relatively free international trade[15]. IFPRI produce Food Security Climate, Agriculture and Socio-economic maps – interactive Climate, Agriculture, and Socio-Economic Maps.

12 www.nature.com/nclimate/journal/v4/n12/full/nclimate2437.htm
13 https://ccafs.cgiar.org/climate-smart-agriculture-0#.WQmWQ1N95AZ
14 https://ccafs.cgiar.org/publications/large-scale-implementation-adaptation-and-mitigation-actions- agriculture#.WQmsTFN95AY

A further IFPRI/FAO analysis, bringing together detailed modelling of crop growth under climate change with insights from an extremely detailed global agriculture model, concludes that agriculture and human well-being will be negatively affected by climate change. In developing countries, climate change will cause yield declines for the most important crops, and South Asia will be particularly hard hit. Yields for all crops in South Asia will experience large declines. They recommend aggressive agricultural productivity investments to offset the negative impacts of climate change[16].

Based on experiences from its climate change projects across the globe, with case studies from Asia, Africa and Latin America, FAO has synthesised some of the main lessons to come out of its fieldwork[17]. These are summarised in Annex 9.

CRA in South Asia

As a region, South Asia has one of the world's highest incidences of food insecurity and poverty. Climate, population growth and agricultural investment trends combine to exacerbate the situation. Recent assessments suggest that by 2050, South Asian rice production is set to fall by 14%, wheat production by up to 49% and maize production by up to 19%[18]. At the same time, the South Asian rural population is expected to peak in the next 20 years[19]. In South Asia, as in other parts of the world, examples of good CRA practice are showing what can be achieved, and there are a growing number of success stories, some of which are shown in Annex 9[20].

15 http://www.ifpri.org/publication/food-security-farming-and-climate-change-2050
16 http://www.fao.org/fileadmin/user_upload/rome2007/docs/Impact_on_Agriculture_and_Costs_of_Adaptati on.pdf
17 http://www.fao.org/3/a-i2207e.pdf
18 Nelson, G.C., M.W. Rosegrant, J. Koo, R. Robertson, T. Sulser, T. Zhu, C. Ringler, S. Msangi, A. Palazzo, M. Batka, M. Magalhaes, R. Valmonte-Santos, M. Ewing and D. Lee (2009). Climate Change: Impact on Agriculture and Costs of Adaptation. Washington: International Food Policy Research Institute.
19 IFAD (2011) cited in Food and Agriculture Organization of the United Nations, the Consultative Group for International Agricultural Research and the Research Program on Agriculture, Climate Change and Food Security (n.d.). Knowledge on Climate Smart Agriculture: Questions and Answers.
20 https://cgspace.cgiar.org/bitstream/handle/10568/42432/About%20CSA_Q%26A.pdf?sequence=1

Other Success Stories

The World Bank Group (WBG) aims to deliver CSA through all its operations, increasing its focus on adaptation and resilience[21]. It screens all its projects for climate risks, and supports client countries to implement their Nationally Determined Contributions (NDCs) in the agriculture sector. The WBG quotes successful examples of CSA in its projects in Mexico.

Morocco, Senegal, and Uruguay. It also supports African farmers in the Evergreen Agriculture programme which promotes minimal use of costly fertilizers; in Zambia maize yields tripled when grown under Faidherbia trees[22].

In Uganda, use of more efficient water-management technologies such as advanced drip irrigation and solar irrigation have proved effective approaches to adapt to climate change. Scientists are using beneficial microbes to strengthen plant resilience to increased drought, diseases and pests brought on by climate change. Farmers are also actively participating in the collection of climate-related data.[23] In New Mexico an organic dairy farmer responded to increasing drought by transitioning to zero-tillage to save water.[24]

There are by now many other case histories on record where CSA/CRA has had an impact. The list is growing, and suggests that the approach is comprehensive and sound. A series of success stories of climate smart agriculture in action, has been released by the Technical Centre for Agricultural and Rural Cooperation (CTA) and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) to demonstrate the varied ways climate smart agriculture can take shape.[25]

National Focus

The Prime Minister's National Action Plan on climate change has identified agriculture as one of the eight national missions.[26] Recognising the vulnerability faced by India and the disproportionate impacts of the risks posed by climate change to the nation, the Indian Council of Agricultural Research constituted the National Initiative on Climate Resilient Agriculture (NICRA) in February 2011. NICRA actions are multi-stage and strategic in addressing climate risks. The initiative promotes strategic research on core areas, technology demonstration for coping with current variability, capacity building and financing of critical research gaps. The interventions are layered and focus on four modules; natural resources, crop production, livestock and fisheries and institutional interventions. Drought-prone districts of Chhattisgarh are covered under the technology demonstration component of the programme.

The Pardhan Mantri Krishi Sinchayee Yojana (PMKSY)[27] Program to promote efficient irrigation practices and improve water use efficiency; the Integrated Watershed Management Program (IWMP)[28] on natural resources conservation; as well as India's Intended Nationally Determined Contribution (INDC) as presented to the COP21 in Paris to address the adverse effects of climate change are earmarked as priority flagship programs by the national government.

Individual initiatives from multi-lateral and bilateral development agencies such as World Bank, SDC, Norwegian Development Assistance, Deutsche Gesellschaft für Internationale Zusammenarbeit, and the Embassy of Netherlands also promote actions that are in line with the government priorities for climate resilient agriculture in India. The Consultative Group for International Agricultural Research (CGIAR) working with national agricultural research centres are engaged in developing location-specific crop varieties that are resistant to climate variability. The $10 billion Green Climate Fund[29] has identified climate-resilient agriculture as one of its five investment priorities. The Bill and Melinda Gates Foundation[30] also allocates approximately $100 million per year to agricultural research centres.

21 http://www.worldbank.org/en/topic/agriculture/brief/foster-climate-smart-agriculture
22 http://www.worldbank.org/en/news/feature/2013/03/18/an-evergreen-revolution-cuts-fertilizer-costs-for-africa-s-farms
23 https://farmingfirst.org/tag/climate-smart-agriculture/
24 http://blogs.edf.org/growingreturns/2014/09/25/what-is-climate-smart-agriculture/
25 https://farmingfirst.org/tag/climate-smart-agriculture-success-stories-from-farming-communities-around-the-world/

26 https://www.gktoday.in/what-are-the-8-missions-of-indias-national-action-plan-on-climate-change/
27 http://pmksy.gov.in/
28 http://iwmp.telangana.gov.in/
29 http://www.greenclimate.fund/home
30 https://www.gatesfoundation.org/Where-We-Work/India-Office

ACT-Climate Change Innovation Programme Experience

Aligned to the overall goal of safeguarding economic growth from climate uncertainties in the region, ACT aims to identify, prioritise and enable governments to build resilience in the sector through a multi-pronged approach. ACT interventions in agriculture sector aim to build and improve the resilience of marginal and vulnerable farmers by helping governments identify and prioritize climate resilient crops and improve their value propositions through value chain analyses and policy interventions. A Multi-Criteria Analysis (MCA) tool developed by the project, has been instrumental in identifying three broad categories of resilient crops from a set of indicators identified through bibliographic, expert consultation and peer review, as characterised by: low input use (water, energy, nutrients, labour); ability to reward better economic returns; preference small and marginal farmers and lesser risk exposure to climate variability (temperature, rainfall and extreme climate events).

Appreciating the socio-economic and policy incentives behind successful diversification to climate resilient crops, ACT works with client governments in Assam, Bihar, Maharashtra, and Odisha adopting in some cases a value chain approach to map the impacts of climate change on climate resilient crops, identify the stakeholders and principal actors and strengthen their market linkages to optimize the profitability of these crops in the context of a changing climate. ACT has also been supporting the government and the nodal agencies build capacities in intervention design and accessing domestic and international adaptation financing, which enables them to be prepared for uncertainty and new risks – a 'no regret' approach that is valid whatever changes happen – is to reduce vulnerability and increase resilience of a given system.

Section 4: Observed and Projected Climate Patterns

This section looks at the weather patterns that have already been recorded, and using modelling techniques looks to the future to make some predictions. Chhattisgarh State experiences a hot and humid tropical climate due its proximity to the Tropic of Cancer. The average annual rainfall is 1288 mm, of which 88 per cent is contributed by the southwest monsoon, from June through September. The temperature varies between 30 and 47°C during summer and between 5 and 25°C during winter. However, extremes in temperature are observed, falling to less than 0°C in winter and up to 49°C in summer.

Observed Climatic Patterns and Trends; Rainfall

General Rainfall Characteristics

The distribution of rainfall in space and time plays a critical role in climate-based decision-making. Annual and seasonal normal rainfall of different districts of Chhattisgarh analysed for 30 years (1981 – 2010) using IMD data.[31] Rainfall received during different seasons over the three agro climatic regions are presented in the table below.

Table 1: Mean annual and seasonal rainfall of Chhattisgarh

Agro Climatic Zone	Winter	Summer	SWM	NEM	Annual
Chhattisgarh Plains	25 (2.2)	45 (3.93)	995 (87.0)	78 (6.8)	1143
Bastar Plateau	18 (1.3)	60 (4.21)	1260 (88.5)	85 (6.0)	1423
Northern Hills	25 (2.0)	31 (2.50)	1110 (89.7)	72 (5.8)	1238
Chhattisgarh State	23 (1.8)	45 (3.57)	1122 (88.5)	78 (6.2)	1268

Note: Figures in () are % to the annual rainfall

Among the three ACZs, Bastar plateau zone receives the highest maximum rainfall during the peak monsoon season at 1260 mm in 51 rainy days, followed by the Northern Hill zone at 1110 mm in 50 rainy days and with the lowest rainfall of 995 mm in 47 rainy days in the Central Plains.

The contribution of the southwest monsoon (June to September) is 88.5 % (1121 mm) of annual rainfall.

In other seasons only a small amount of rainfall is received and has no significance for irrigation or agricultural planning purposes. The quantity of rainfall received during the northeast monsoon (October – December) is 78.3 mm, summer (March – May) is 45.3 mm and winter (January – February) is 22.7 mm.

Spatial distribution of annual and southwest monsoon rainfall is presented in the figure below. Large spatial variability in rainfall is observed over Chhattisgarh. A higher level of rainfall is observed over the southern parts of the State, and Sukuma district receives the highest. This is followed by Bijapur, Bastar and Dantewada districts. The rainfall gradually decreases moving northwards, and least rainfall is observed around the central region of Chhattisgarh (Kawardha, Bemetera, Raipur, Baloda Bazar and Mahasamund districts). The quantum of rainfall further increases towards the north of the state with more rainfall around Jashpur district.

31 Note: IMD 0.25 x 0.25 degree gridded

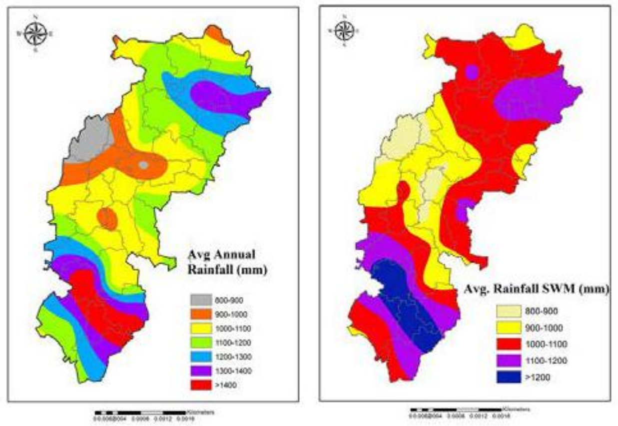

Figure 5: Spatial Distribution of rainfall over Chhattisgarh

Length of Growing Period with Onset and Cessation of Southwest Monsoon

The onset of SWM was investigated at district scale across Chhattisgarh state using 26 years of observed rainfall data (1991-2016). Cessation of the monsoon occurred in September, in that the last day where the rainfall is less than 2.5 mm was considered as the indicator of cessation. The period in between the onset and cessation of rainfall was considered as the length of growing period (LGP). The information is presented in the figure below.

Onset of rainfall first occurs in the southeastern parts of Chhattisgarh, proceeds to southwestern and central part region, and finally to northern areas. Withdrawal of rainfall happens first in the north and central region, moves to western and southwestern parts, and ends in the southeast.

Due to early onset and late withdrawal of monsoon rainfall, Bastar Plateau has the longest growing period (23 – 26 weeks), followed by the Northern Hills (21 – 22 weeks) with least LGP recorded in the Central Plains with less than 20 weeks.

Trends in Monsoon Rainfall

A number of districts show decreasing trends in levels of the monsoon, and those are largely in the Bastar Plateau and Northern Hills ACZs, which appear most vulnerable. These include Kondagaon, Janjgir-Champa, Raigarh, Jashpur, Sarguja and Balrampur. There is a decreasing trend in the number of rainy days observed in particular in the eastern parts again of the Northern Hill ACZ, including Jashpur, Sarguja, Raigarh and Balrampur.

a. Onset of monsoon – Start of growing season | **b. Cessation of monsoon – End of growing season** | **c. Length of growing season**

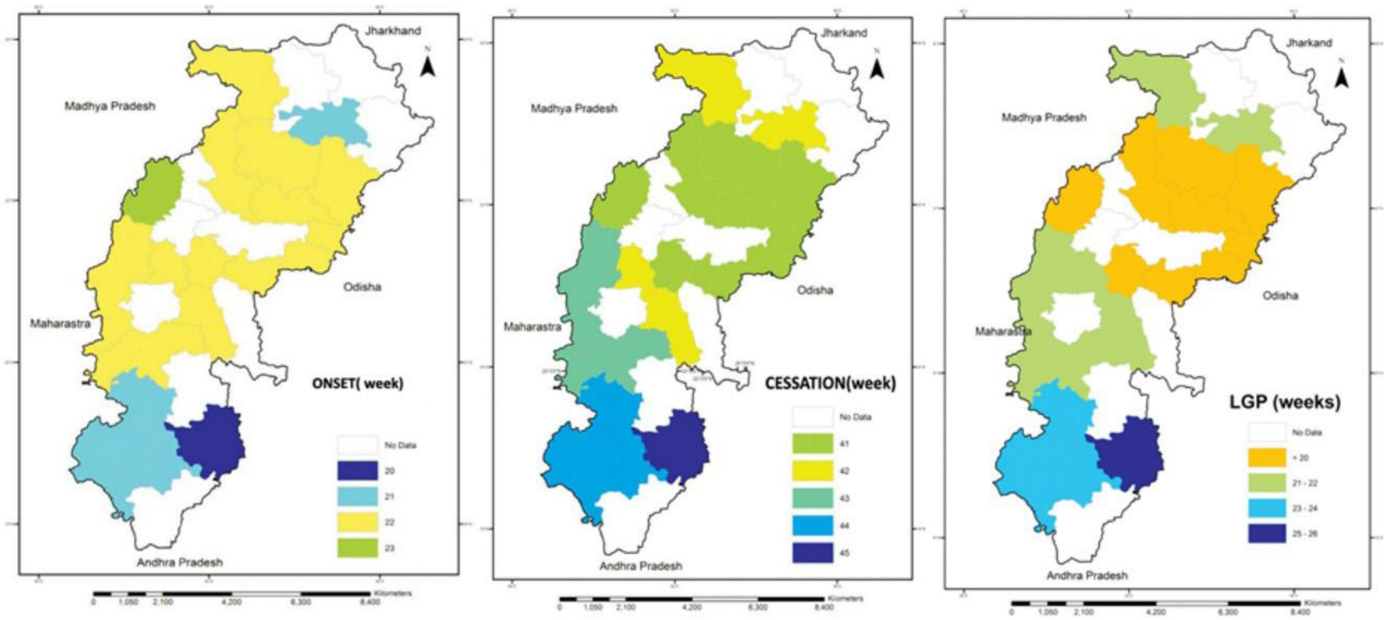

Figure 6: Onset, Cessation and LGP during SWM over Chhattisgarh

Extreme Rainfall Events Analysis

The frequency of one-day extreme rainfall event was analysed and is presented in the figure below.

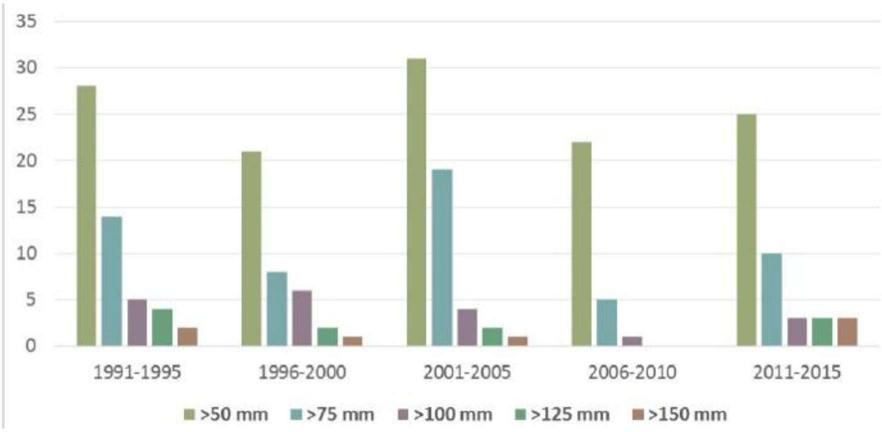

Figure 7: Frequency of one-day extreme rainfall event in NHR

Rainfall events with >50, > 75, >100, >125 and >150 mm is increasing in recent years indicating an increase in frequency of high intensity rainfall in a single day. In an undulated hilly terrain, this will have large consequences especially on soil erosion.

Observed Climatic Patterns and Trends; Temperature

Temperature analysis was conducted using IMD temperature data.

Maximum Temperature

Maximum temperature across Chhattisgarh over different seasons is presented in the figure below.

When annual maximum temperature was interpreted spatially, no wide variation is observed.

All districts had a temperature ranged between 31.6 to 33.3°C with mean annual maximum temperature of 32°C. Among the Districts, Durg recorded the highest temperature followed by Balod, Rajnandgaon and Sukma, while the lowest was recorded in Korea followed by Jashpur, Balrampura, Surajpur and Sarguja districts.

Chhattisgarh observes highest temperatures in summer, followed by during the SWM. In these two seasons, wide spatial variations were not witnessed. Winter and North-east monsoon (NEM) show considerable spatial variation. Summer temperatures range between 34.4 and 39.4°C with a mean of 38°C. Minimum temperature analysis is in Annex 10.

Temperature Trend Analysis

To analyse the observed trend in rainfall and temperature, three weather stations were chosen (Ambikapur, Raipur and Jagdalpur, representing ACZs Northern Hills, Central Plains and Bastar Plateau respectively).

An increasing temperature trend is observed for maximum and minimum temperatures. Minimum temperatures are increasing more than maximum.

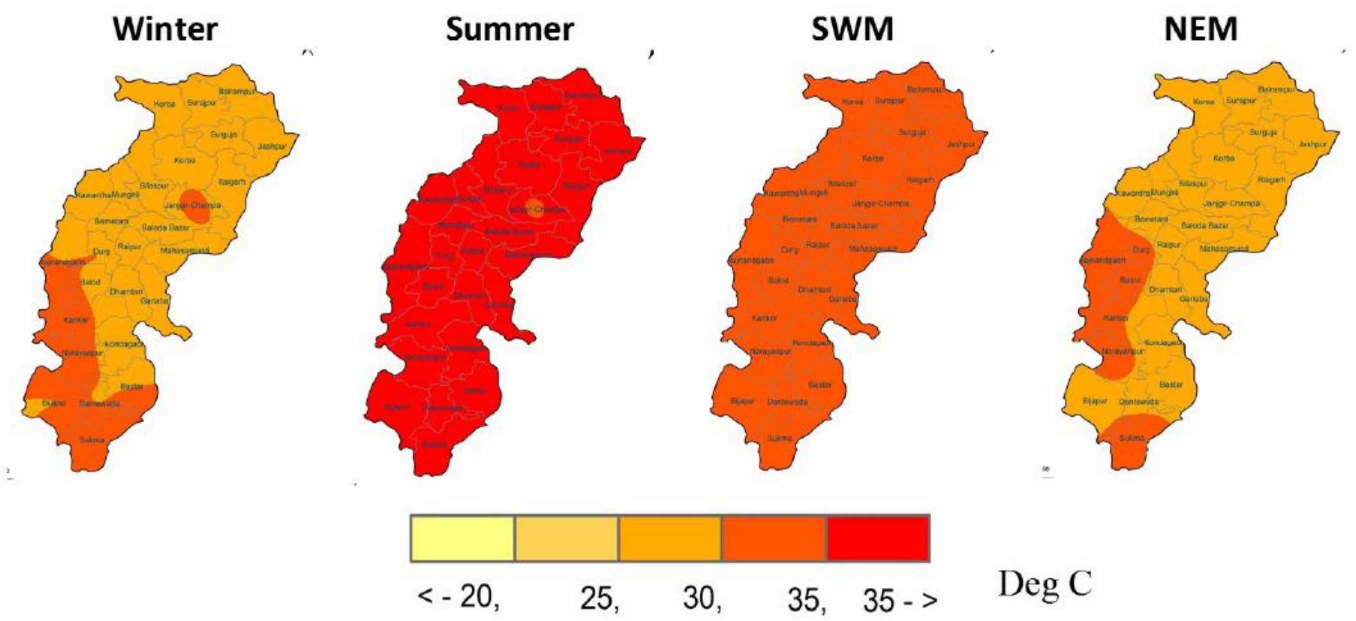

Figure 8: Seasonal distribution of Maximum Temperature over Chhattisgarh

Increases are observed mainly during the post monsoon season (October and November). In the Central Plains, maximum temperatures across the seasons are increasing, in particular in the winter season. During winter the diurnal variation is increasing. On the Bastar Plateau there is an increase in maximum temperatures during winter season.

Temperature Extremes

The historically lowest maximum and minimum temperatures were extracted and are presented in the figure below.

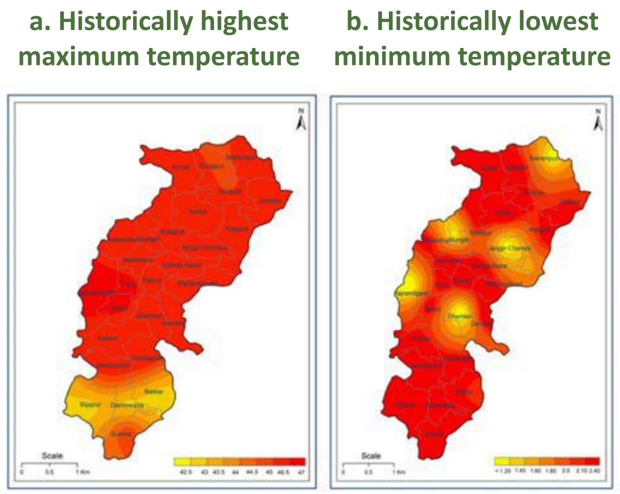

Figure 9. Historically extreme maximum and minimum temperatures

Historically Bastar Plateau has recorded the lowest maximum temperatures, but with a high of 49 degrees recorded at Bilaspur in 2017 this seems likely to be changing. Among the 27 districts, 14 districts have witnessed 0°C as their lowest ever recorded value. Bijapur, Dantewada and Bastar had the highest minimum temperature among the locations at 11.6°C. Both extremely high and low minimum temperatures are likely to have deleterious effects on livestock and crop production, and increase the vulnerability of peoples' livelihoods.

Future Climate Projections for Chhattisgarh

Future change in climate over Chhattisgarh has been projected and analysed to understand the expected changes in temperature and rainfall towards the middle of the century. This is shown in the figure and table below.

In the maps above A and B, darker the shade the higher the rainfall. In the maps C and D above, the darker the shade higher the increase in temperature. For all four maps above the time frame is 2040-2069. The table 2, demonstrates the expected change in the different agro-climatic zones level in the temperature as well as in the rainfall as compared to present climate parameters. Maps A, B,C and D provides spatial spread these changes in the given timeframe.

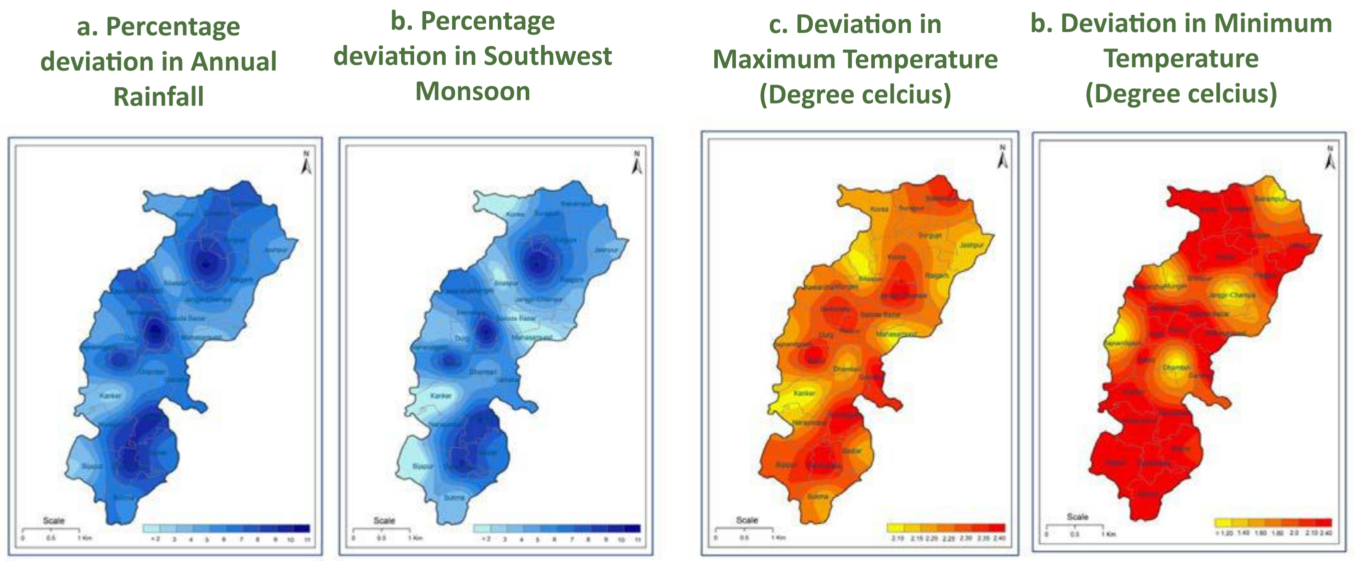

Figure 10: Spatial variation of anticipated change in rainfall and temperature

Table 2: Anticipated changes in future climate for Chhattisgarh (2040-2069)

Zone	Current climate			Expected changes in mid century		
	Tmax ^{0}C	*Tmin ^{0}C*	*Rainfall mm*	*Tmax ^{0}C*	*Tmin ^{0}C*	*Rainfall % change*
BPZ	31.1	18.7	1143	+2.3	+2.2	7.3
CPZ	32.6	20.6	1423	+2.2	+1.9	6.3
NHZ	29.8	16.6	1238	+2.2	+2.0	6.4

Rainfall is expected to vary over the next century, but projections from different climate models vary significantly and this is subject to uncertainty. However, taken collectively there is an overall increase of 6.4 to 7.3 per cent predicted by mid-century.

Maximum and minimum temperatures are expected to increase. The range of increase for maximum temperature is between 2.1 to 2.4°C, for minimum temperature the range is 2.1 to 2.3°C. The Northern Hills and Bastar Plateau ACZs are expected to experience a higher increase in maximum temperature. In case of minimum temperature, the Bastar Plateau may expect highest increases followed by the Northern Hills.

Section 5: Climate Risks and Implications for Agriculture

Like other parts of the country, the livelihood options in Chhattisgarh continue to be predominantly dependent on natural resources - land, forest and water – but also equally on rain and weather patterns. Being an agrarian state, variability in climatic conditions such as declining, late or early rains have adverse effects on agricultural production and livelihoods. The climate risks and implications for agriculture are discussed in this section.

Current and Future Climatic Risks of Chhattisgarh

Rural areas are most vulnerable to the impacts of disasters and climate change. With a significant population dependent on rain-fed agriculture, animal husbandry, fisheries, and forest-based livelihoods, any change in precipitation and temperature patterns could significantly impact lives of the vulnerable communities.[32] **An analysis of the rainfall data for Chhattisgarh plateau reports that the region is experiencing frequent droughts**.[33]

Drought and Intermittent Dry Spells

The probability (%) of moderate and severe drought in Chhattisgarh is illustrated in the figure below.

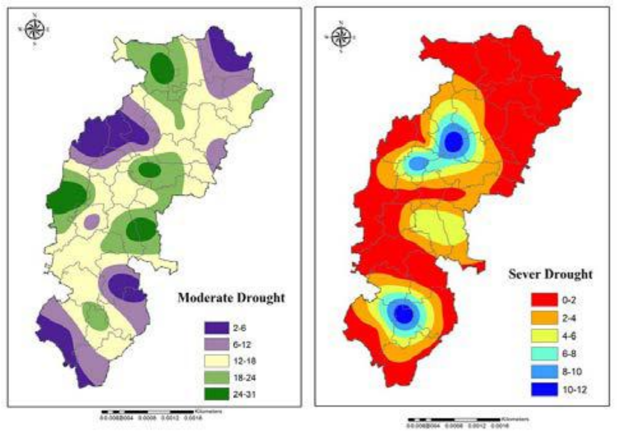

Figure 11. Probability of moderate and severe drought in Chhattisgarh during 2040-69 (%)

32 Recognised by the Planning Commission, Government of India, 2011
33 http://www.agrophysics.in/Published/2015-2/5.pdf

The likelihood of drought for the Central Plains and Northern Hill ACZs is 24 – 31 %, meaning that moderate drought may be expected every 4th year, severe drought every 10th.

The above analysis is drawn from observed historical climate data of past thirty years. The above figures give existing climate risks from the data available. Similar conditions and rainfall pattern shifts are expected to prevail in future as well for most of the areas during 2040-69. Because of the reduction in number of rainy days, agriculture drought may prevail affecting the crop yields.

Excess Rainfall and Flooding

Change in frequency of occurrence of excess rainfall (> 75mm) was analysed and the full results are in Annex 10. The results indicate that in the Chhattisgarh plains regions the frequency of getting excess rainfall in a single day is a growing trend. In the future climate projection, rainfall is expected to vary with an overall increase over 7% by 2050, with greater intensity.

Analysis of the daily rainfall data indicates that the total number of rainy days per year decreased. Rice is the main crop grown in the area in kharif under rainfed conditions. The change in rainfall patterns and a shift in the monsoon in terms of delayed onset makes rice farmers most vulnerable. A trend towards short or medium duration rice varieties is apparent already.

Increase in maximum and minimum temperatures Maximum and minimum temperatures are expected to increase, between 2.1 to 2.4°C, and 2.1 to 2.3°C respectively.

Climatic Variability and its Impact on Agriculture and Livelihoods

Cultivation is conducted mainly on three types of land. These are Dirsa (upland, crops like paddy, arhar, sesame, gram, and mustard are grown); Barha (the land holds water and is suitable for cultivation of long duration paddy of up to 140 days); and Dipra (high dry land, found in the foothills of the plateau zones). While paddy and kodo millet (Panicum miliare) are grown as main food crops, arhar, sesame, gram, alsi, and mustard are grown for domestic consumption with surplus sold for income generation in these areas. Some of the likely impacts of climate change on livelihood systems are summarized in the table below.

For assessing the impact of climate variability on agriculture, past rainfall data and the data on corresponding years' productivity of some major crops have been accessed, selecting those for which meaningful data is available. Correlating the two provides an assessment of the impact of climate variability on crop productivity.

Rice Production

Similar to other rice growing regions in India, rice yields in Chhattisgarh have been rising steadily, and within the 20-year timeframe used in this analysis this increase has been in the order of an additional 600 kg/ha. This increase has been possible through improved varieties and more advanced agricultural technology practices.

These yield increases are observed across all the ACZs, with the Central Plains generally recording slightly higher yields than others. This can be seen in the graph below. Where yields are noticeably low or high in any year, that these variations are largely

Table 3: Impact of fluctuation in local weather on agriculture and livelihoods

Month	Regular season	Impact of fluctuation on local weather
June, July	Sowing and nursery preparation; transplanting rice, planting pulses and oilseed crops	Delay in sowing and transplanting often get exposed to intermittent dry spell and terminal season drought that resulted in fewer panicles, poor grain filling, increased sucking pest menace and reduced production, besides hampering the timing and intensity of the second crop
October, November	• Harvesting of paddy, oilseeds and pulses • (ii) Sowing of oil-seeds and pulses	Rain during this period affects harvesting of the crops and affects the grain quality It also leads to delay in sowing of the second crop. It results in reduced acreage as farmers refrain from sowing
December, January	• Flowering and grain development of Rabi crops • Harvesting of pulses and oil seeds • Preparatory stage for the economically important forest produce 'Mahua'	• Crops are vulnerable to prolonged rain, excess cold, fog and frost • Economic loss due to rains during harvesting • Too much cold affects the formation of its 'kunchi' – the early stage of bud root • Increase in minimum temperature impacts flowering, panicle formation and ripening of wheat crop.
March, April	Important period for the forest produce collection incl mahua	Rain during this period makes the flowers drop prematurely or destroys flowers, and some flowers turn upward and do not even fall

observed across all ACZs, seen in the depressed yields of the years 2000, 2002 and 2009.

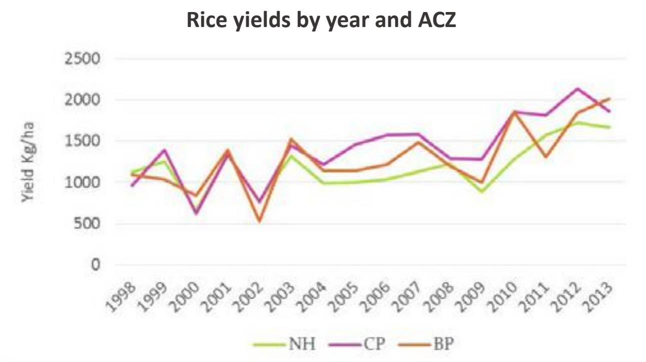

Figure 12: Rice yields by year and ACZ

A large amount of the yield variability can be attributed to the levels of rainfall received in the south west monsoon. The figure below shows mean rice yields and total rainfall received during the SWM, and illustrates the close relationship between the two.

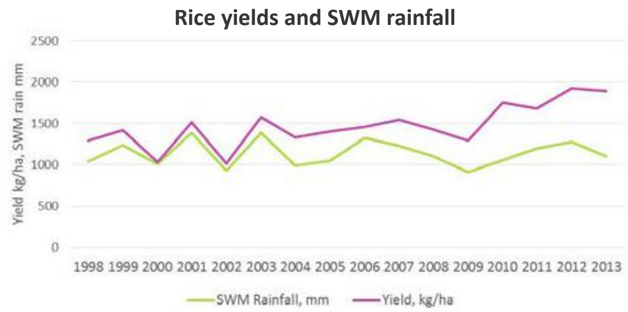

Figure 13: Rice yields and South West Monsoon rainfall by year

Figure 14: Impact of climate change on rice yield for Chhattisgarh state

Correlating rice yield data with SWM rainfall shows an overall positive relationship, particularly strong in the Central Plains ACZ (R2 = 0.64), meaning that higher the seasonal rainfall, the more the rice will yield. Future variability in the level and distribution of the monsoon caused by climate change is very likely to have an impact on rice yield. This is especially the case as rice yields in Central Plains are more affected by varying rainfalls than in other regions. Thus, a varying or shifting monsoon, as projected in the near term (up until 2030s) would mean fluctuating fortunes for paddy mono-cropped area.

Future change in rice productivity has been simulated using the Decision Support System for Agro-technology Transfer (DSSAT) model, analysed to understand possible impacts of climate change towards 2050. Rice productivity is expected to decrease by 35, 21 and 14 per cent in Central Plains, Northern Hills and Bastar Plateau ACZs respectively from the current yield level. This is illustrated in the figures below. The mid-line of the box plot below indicates the mean yield and the dotted line indicates the spread or variability in yield over years.

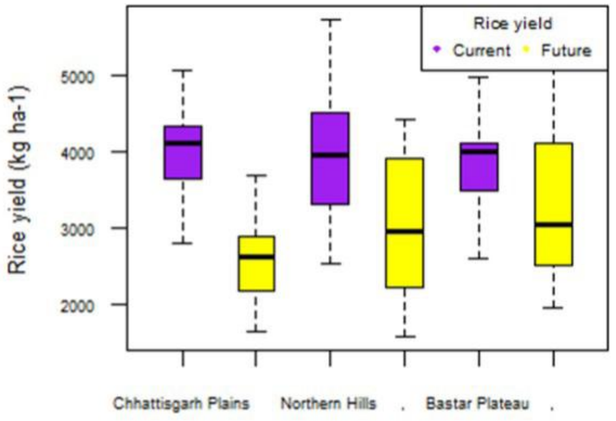

Figure 15: Rice productivity under current and future climatic conditions.

Maize Production

As with rice yields, a steady increase in maize productivity has been recorded over the time frame analysed. However, the increase is less, maize yields have been more variable, and the 'fit' of the linear trend is less accurate. The high level of variability shown is also observed across all three ACZs. There is a marked level of similarity between ACZs, as with rice. Yield levels are marginally higher in the Bastar Plateau and Northern Hills ACZs.

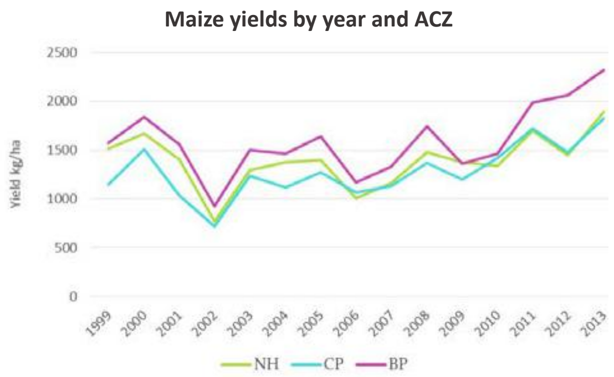

Figure 16: Maize yields by year and ACZ

Maize is a photo-insensitive crop, and thus can theoretically be grown all-round the year. It is also very sensitive to waterlogging which can cause large decreases in yield, and more sensitive to drought than most other cereal crops. Despite there being a marked depression in yields observed in 2002 when rainfall was also low, there is no clear correlation between maize yields and monsoon rains. This suggests that maize yields are less dependent on monsoon rains than rice. Compared to the rice crop, maize requires less water.

Maize is usually grown in the second season as an irrigated crop, suggesting that future drought conditions will need to be managed with supplemental irrigation. Although in the short-term maize may appear to present a more resilient cropping option, in the longer-term as sources of irrigation dry up this is unlikely to continue., and maize yields are likely to fall.

Finger Millet Production

Finger millet is grown in kharif season, and is more prevalent in the Northern Hills and Bastar Plateau Zones. Finger millet yields have not increased significantly over the period observed. The yield data is patchy, with many missing values both from districts and years. Much of the ragi harvest is consumed domestically, records are variable, and it is hard to draw meaningful conclusions.

This high level of variability in yields is more acute when observed across the three ACZs, and is particularly acute in the Northern Hills Zone, where data is most erratic. This is shown in the graph below. Records post-2010, after which more comprehensive data has been accumulated, are more reliable.

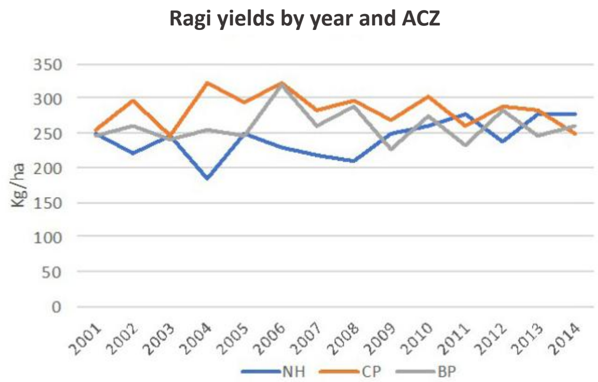

Figure 17: Finger millet yields by year and ACZ

Correlating finger millet yields with SWM rainfall, using post-2010 data only, shows high levels of correlation in particular on the Bastar Plateau (R2 = -0.73) and in the Central Plains (R2 = 0.85). This suggests that finger millet is vulnerable to variation in monsoon rains. However, it is a crop which is more resilient to drought than most, and has the capacity to provide a yield even under conditions of water shortage, and is rarely grown under irrigation.

Wheat Production

Wheat is grown in the rabi season, and is usually irrigated. Wheat yields have also increased steadily over the years recorded. This has also been achieved through improved varieties and husbandry. There is a high level of variability between years. There is no correlation between wheat yields and rainfall, from either the southwest of northeast monsoons. Wheat is not a crop that depends on summer rainfall, making it a more resilient cropping option. It is dependent on residual moisture from the monsoon. Despite frequent reports that maximum temperatures are rising and that this is likely to have a negative effect on wheat yields, there was no correlation between the two.

Looking to the future, the DSSAT model simulating wheat productivity indicates that climatic variability has impacted the yield considerably. This can be seen in the figure below.

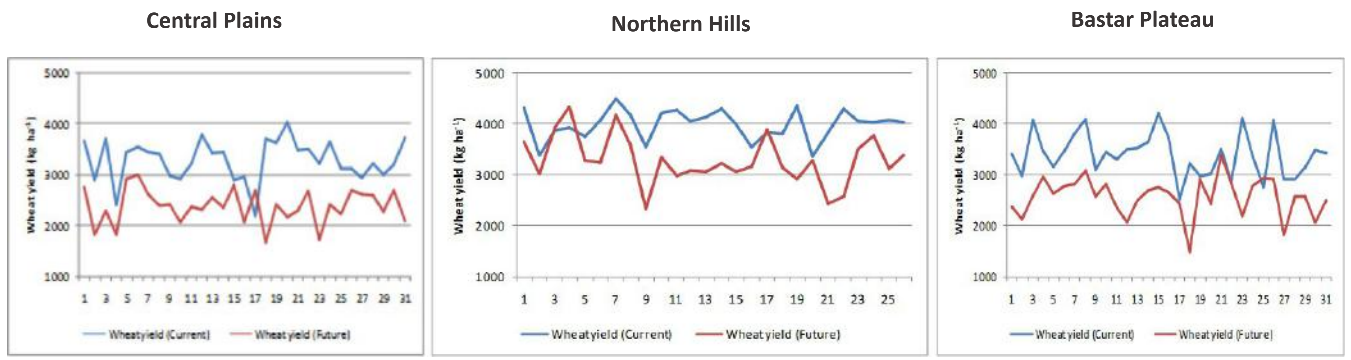

Figure 18: Impact of climate variability and climate change on wheat yield

Wheat productivity is expected to decrease for Chhattisgarh by 28, 18 and 24 per cent in Central Plains, Northern Hills and Bastar Plateau respectively by 2050.

The mid-line of the box plot below indicates the mean yield and the dotted line indicates the spread or variability in yield over years. Wheat productivity is expected to decrease for Chhattisgarh by 28, 18 and 24 per cent in Central Plains, Northern Hills and Bastar Plateau respectively by 2050.

To conclude, temperatures in all the ACZs are expected to increase, rainfall intensity and quantity is also expected to increase but in fewer rainy days. These variations will have negative impact on major crops productivity including rice, wheat and maize.

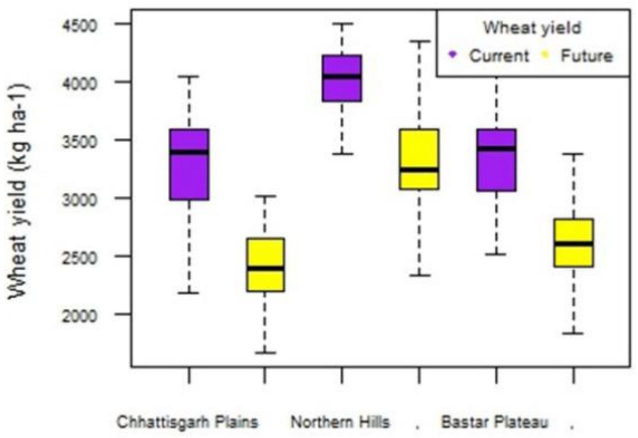

Figure 19: Wheat productivity under current and future climatic conditions

Section 6. Farmers' Perceptions of Climate Change in Chhattisgarh

This section uses three sources of information in seeking to identify the changes in climate that are already taking place within the state. Firstly, it has used the field survey as a major source of primary information taken directly from farmers across all three ACZs, to gather their opinion. Secondly views and opinions from a range of different players, within government and from outside, were gathered in key informant interviews. Finally, it includes information from a series of stakeholder workshops conducted within the three ACZs.

Increasingly Erratic Rains

Rains are becoming untimely and erratic. Previously rains started dependably and consistently on 15th June and ended 15th September, but now rains begin later and end earlier. The previous peak rainfall over July/August has gone, and dry periods now occur mid-rainy season. The number of dry days and the intensity of rains have both increased; rainfall has become more inconsistent and less reliable.

Rainfall patterns have changed, and this has been reported by all farmers. These changes were moderate (68% of respondents) or severe (32%). Effects were more pronounced in the Northern Hills. In Balrampur District the highest proportion of farmers (65%) reported that changes had been severe. Farmers from all districts noticed that effects had been noticed for between 3 to 5 years. Rainfall has become unevenly distributed and erratic; previously there was always 7-10 days of continuous rainfall, but this can no longer be predicted.

The **seasons** have changed. Whereas before the four seasons were clearly distinguished and distinct, now the difference is blurred. Summers and winters are longer, spring and autumn are shorter and less distinct. People reported that they feel the entire flora and fauna is changing, and all crops are affected.

The **arrival of monsoon** rains is now delayed. Over the last 4-5 years the onset of the monsoon is later by some 15 days. Previously this was between 12-15 June, but this is now 20-28 June. Over 80% of farmers reported that these effects were either moderate (46%) or severe (42%). The highest occurrence of severe change was noted within the Bastar Plateau ACZ, and Bastar District more specifically, where 55% of farmers had observed severe delays. Farmers had been observing these monsoon delays for the last 3-5 years, and again this was for longer in the Northern Hills.

Monsoons are now **ending sooner**. Nearly 60% of farmers reported that this effect was moderate, and 43% that it was severe. No farmers recorded that these effects were slight, or they had not been observed at all. This effect was also observed equally across the ACZs and across districts, showing strong consistency. These effects had been observed over the last 3-5 years.

Overall levels of rainfall are lower. On average, previous rainfall levels were from 1200–1400 mm/year, but this is now 1100-1200, a shortfall of some 200 mm. The majority of farmers (58%) noted that this was a severe effect, the remainder moderate (42%). No respondents had observed a slight change, or no change at all. Among the ACZs, more severe effects were observed in the Northern Plains, with the Bastar Plateau more moderate. District-wise, respondents in four districts – Bijapur, Mahasamund, Balrampur and Sarguja – all reported more severe changes with 65% in this category. These changes had been observed over the last 3-5 years.

There is a greater **frequency of intense rains**. Three quarters of farmers reported an increase in the frequency of these extreme events. Responses were strongest from the Northern Plateau ACZ, in particular Sarguja and Balrampur Districts.

Increasing Frequency of Drought

There are increasing **drought periods**. Two-thirds of farmers (66%) reported a moderate increase, with 34% feeling that these were becoming severe. No respondents reported that the effects of drought were slight, or that they did not occur at all. This effect was noted equally across the 6 districts, and across the ACZs. On average, the duration of these dry spells was in the region of 21 days, and there were no real differences between districts on this issue. Women in both Bastar Plateau and Northern Hills reported that drought in 2015 resulted in crop failure, leaving households entirely dependent on government support for food.

The Northern Hills ACZ again was worst affected and with a severe increase in **flooding**, in particular in Balrampur District in 2016. There was also severe flooding reported in Bastar District in 2016. Flooding resulted in soil erosion in the districts concerned.

Rising Temperature

Temperature is rising, noticeably. The number of days witnessing over 40 degrees Celsius during summer are now much more frequent, and extreme summer temperatures are becoming the norm. In May 2017, the maximum temperature in Bilaspur touched 49oC, the hottest ever recorded in the state. Winter maximum temperatures are also higher, and this is affecting winter (rabi) crops. Bastar Plateau ACZ was the worst affected, with nearly 40% of respondents in Bastar and Bijapur reporting severe change. Other ACZs also reported higher temperatures. One positive effect in the Northern Hills ACZ was that potentially damaging frosts no longer occur.

In the Northern Hills ACZ a quarter of farmers reported either severe or moderate increase in the frequency of **extreme wind storms** during summer months. This was also reported in Bastar Plateau, but to a lesser extent. These were not observed by farmers in the Central Plains ACZ.

Some Experiences by ACZ

The Bastar Plateau ACZ experiences minor cyclones due to its proximity to the coastal areas of Andhra Pradesh. In past 5-8 years the frequency of small cyclones has increased causing lowered crop yields. In 2014 the region was struck by the Hudhud Cyclone and farmers in some villages lost most of their crops. Drought was declared in 1966-67, 1990, and again in 2015. During drought periods households rely heavily on minor millets *(kodo, ragi and kutki)* and rice soup for survival. Women reported that *kodo, ragi* and *kutki* are resilient to temperature variations and its ability to grow with less water makes it a good crop to rely upon in years of drought. Crop insurance was paid to farmers in 2015,[34] and Public Distribution shops were also another source of food.

Over the past 5-6 years rainfall has become much more erratic on the Plateau. The monsoon used to begin in June, but now it does not set in until July. At the time of rice transplanting, water is sometimes not available. Unpredictable rainfall can cause up to 50% loss of agricultural crops and even more than this with tomato and other vegetable crops. There is a decrease in fodder availability for the cattle in the village, leading to a decline in cattle numbers. They often observe 3 or 4 dry periods during the monsoon, which is a new feature.

There is a huge area of prime forest on the Bastar Plateau, and many forest-dependent SC/ST groups living there. There were widespread reports of reduced availability of NTFPs, and of livelihoods under threat. Households were relying more heavily on agriculture, and illicit clearing is placing forest areas under greater threat. Farmers and many others believe that the resulting increase in deforestation is leading to an increase in temperature and more erratic rainfall on the plateau.

In the Northern Hills ACZ, as with other zones, rainfall has become more erratic. Previously during the monsoon once rains had started they continued

34 Crop insurance schemes such as Pradhan Mantri Fasal Bima Yojna, restructured weather-based crop insurance for horticulture crops, and other contingency plans are available, providing the District Collectorate with tools for taking action for relief measures

for 30 days, but now they continue for only 6-8 days. In some years the bulk of the rainfall now arrives late in the monsoon period. Sometimes the rainfall is very intense, causing extensive damage. The number of dry days has increased.

Extreme weather events such as flooding, drought and hail storms have become more frequent, leading to high levels of crop loss and destruction. Weather forecasts do not pick up the likelihood of hailstorms. There has been an increase in temperature in villages around forests over the past 6-7 years, though local inhabitants attribute this to increased deforestation. Women reported that these increased temperatures provided much tougher working conditions for them. Temperatures in Sarguja, for example, never rose above 40 degrees previously in summer; this now happens every year. Winter temperatures are also higher, threatening the rabi wheat crop. Desi varieties were reported to be more resilient than hybrids. Reduced fodder for livestock is leading to reduced animal numbers.

The Northern Hills ACZ, like Bastar, is home to a huge area of primary forest, but reports suggest that this area is under threat from clearance. Levels of productivity of NTFPs are down, and livelihoods of forest-dwellers has become more difficult.

Ground water levels are reported to have fallen dramatically, owing to poor recharge from erratic rainfall. Women reported that the level of water in wells has gone down, with impacts on drinking water availability. Water levels in streams and rivers is less than previously.

Pests and diseases are on the increase, and there were reports of increased incidence of blight on vegetable crops including potato, with increased humidity and fog cited as one cause.

People living in the Central Plains also report that rains have become erratic and untimely. The monsoon onset is delayed, rainfall mid-monsoon is lower, and intense rains are observed late-monsoon. Overall rains are now scarcely adequate to sustain the main rice crop, and the opportunity for double- or even triple-cropping previously practiced in some areas is becoming very rare. Drought periods are more common, and rice production is very dependent on adequate rainfall and is thus threatened by these. Residual moisture used to keep the soil wet until March, but now by November all is dry, and multiple cropping or relay cropping options are reduced in rabi season.

Farmers report a dramatic increase of pests and diseases on rice. Aphid attacks are more common. Sheath blight, smuts, rice blast and other infestations are more common.

Fodder is in short supply, and households reported that many animals have been sold as they cannot be productively sustained. There were reports from farmers that the reproductive cycle of cattle was changing, with cows ready for next calving earlier; this may be a positive impact. Viral and other diseases were reported to be on the increase.

Section 7: Impact and Vulnerability

This section discusses climate vulnerability and its potential impacts in Chhattisgarh, from the perspective of agriculture and allied sectors. First, by analysing the existing thresholds of vulnerability across the districts from existing literature; secondly, by analysing farmers' perceptions of climate-induced, vulnerability and perceived impacts on their livelihoods; thirdly, expert views and opinions on vulnerability and their impacts on agriculture and allied sectors are incorporated. The various sources of information are triangulated and corroborated with multiple, agroclimatic zone-wise, stakeholder insights.

Vulnerability Context

Following the CSAPCC, an analysis using simulation models was completed with the support of United Nations Development Programme (UNDP).[35] The study developed an Agriculture Vulnerability Index (AGVI) for the 27 districts of Chhattisgarh using a range of 16 agriculture indicators that used a baseline (1961-1990) to make estimates for a 'mid-term scenario', i.e. 2012-2050 using the statistical Principal Component Analysis method. The study helped to assess the climate impacts on key sectors including agriculture, in addition to spatial-level insights into climate change in the state.

The assessment highlighted the 6 districts located in North-Eastern and South-Western regions of Chhattisgarh with very high agriculture vulnerability. This very high vulnerability cluster of districts included, Jashpur, Janjgir-Champa, Korba, Surguja, Raigarh, and Uttar Bastar Kanker. The assessment forecasts an increase in the overall agricultural vulnerability of Chhattisgarh districts in the 2030s.

The approaches used by UNDP assessment leans heavily towards a production model. In 2013, the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, under the National Initiative on Climate Resilient Agriculture (NICRA), using a comprehensive set of 36 indicators for exposure, sensitivity and adaptive capacity, estimated the district-level vulnerability indices for all states in India. Kabirdham, Surguja and Rajnandgaon were identified as the most vulnerable districts in Chhattisgarh by the CRDIA-NICRA study in 2013. The illustration below highlights the data points and indicator sets used by the studies for a static assessment of vulnerability in Chhattisgarh. Over 60% of the identified, top-ten highly vulnerable districts are common in both assessments. The CRIDA assessment of vulnerability includes a detailed set of indicators that map the adaptive capacities of agricultural sector in Chhattisgarh. The simulations (UNDP assessment) indicate an all-round warming over Chhattisgarh. CRIDA-NICRA assessments also indicate a systematic warming and increase in frequency of drought incidents in Chhattisgarh.

Key drivers of agricultural vulnerability, as identified by the assessments in Chhattisgarh, include; a projected increase in drought proneness and the number of drought years, higher proportion of net sown area, low per-capita production in key crops; rice, wheat and maize, a larger proportion of wastelands, groundwater and surface water deficits, resulting in lower net irrigated area, and a high dependence on agricultural income.

35 UNDP, 2014. Vulnerability Assessment of Chhattisgarh towards Climate Change. Report # 5. INRM Consultants Pvt. Ltd, New Delhi. June 2014

Stakeholder discussions, key informant discussions and survey results indicate that erratic rainfall and increased temperature in the past 5-6 years has been observed in all the agro-climatic zones, whereas isolated extreme events such as hailstorms (Northern Hills) and increased frequency of weak cyclones (Bastar Plateau) were also observed.

Farmers' Perceptions of Climate Change Impacts

This section attempts to present a perception analysis of climate change impacts by the farmers in three different ACZs as evident from the stakeholder consultation workshops and surveys. The survey has demonstrated that the effects of climate change on the lives and livelihoods of rural people in Chhattisgarh are both wide-ranging and profound. An extensive field survey conducted in six districts in 2016, followed by a series of Focus Group Discussions and stakeholder level workshops have produced the following headline messages:

Agro-ecological Impacts

- The insect pest, disease and weed spectrum is changing e.g. sucking pests on rice were previously seen in dry season, but now with erratic rainfall, these pests can survive and cause damage in drier seasons too. Field reports indicate a spike in infestation by aphids and case worms and sheath blight and blast in rice and smut in wheat. Farmers also noticed that pests and diseases caused the most damage in horticultural crops, followed by unfavourable weather conditions and a lack of access to irrigation.
- Some 93% of survey respondents observed that pest infestation was either moderate (60%) or severe (33%) in their fields due to climate variability. 75% of farmers who reported increased pest attacks, attributed climate-induced changes causing the flare up. 24% believed that climate change led to the emergence of a pest-disease complex.
- Stakeholder discussions from three ACZs reveal that the impacts in horticulture are visible in reduced fruiting, increased flower shedding in higher temperature and increased levels of insect/pest attacks before fruiting. Decrease in the productivity of rain fed crops like-tomato, brinjal, papaya, banana, mango and deterioration in the quality of due to erratic rainfall are concerns.
- Indigenous farming practices are experiencing changes; the old system of relay cropping the paddy crop with '*khesari*' dal (Lathyrus spp, which produced a crop on residual moisture) is discontinued. Instead of Bushening (Byasi – intercultural operation in rice) farmers are now increasingly adopting herbicide application. "Utera", a relay cropping practise is gradually being abandoned, as farmers increasingly prefer short-duration crops of less than 120 days.
- Groundwater levels have fallen rapidly by 100-200 ft. over successive cropping seasons. Residual moisture which supported the Rabi crop until March is now depleting by October-November.
- *Aflatoxin* contamination in animal feed has increased with a spike in day-time temperature. Research evidence supports the hypothesis of increased *Aflatoxin* (and other fungal toxins) content in green fodder with a +2°C rise in temperature. Increased contamination of the toxin is harmful to the livestock and impairs the milk quality.
- The availability of green fodder and lack of water in forests is increasingly observed. Persistent drought-like situations in certain areas adjoining forest fringes have led to noticeable changes in forest flora (grass spp.). This has forced a reduction in herd size of livestock and resulted in increased incidences of human-animal conflicts in the forest fringes. Two-thirds of the respondents opined that green fodder availability from forests and common grazing lands have reduced. Among the three-quarters who made up the majority, 57% reported this to be a moderate effect, and 18% severe.

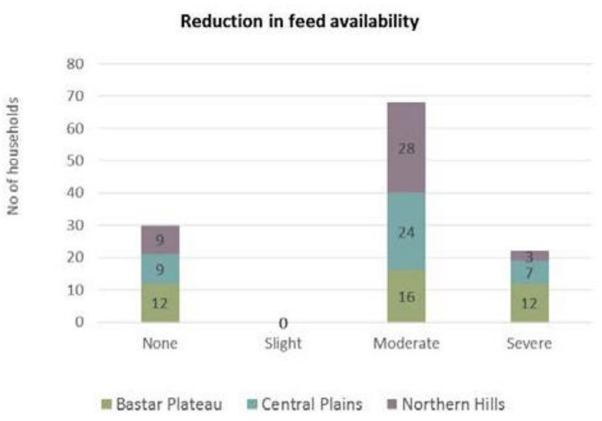

Figure 20: Reduction in livestock feed availability

- Over 30% of farmers who responded to surveys, reported a loss of soil fertility attributable to climate change. Vulnerability assessments by UNDP and CRIDA and Stakeholder consultations followed by key informant interviews in Koriya revealed the heightened levels of vulnerability caused by soil erosion in the Northern Hill regions.
- Stakeholders engaged in fisheries noted that deforestation has led to decreased levels of humus production and consequently lower feed availability in streams. Weakened stream flow has also impacted fish breeding. Variations in temperature has led to increase in water hyacinth and other weed population and dwindling fish population.

Socio-Demographic Impacts

- FGDs with women farmers and agricultural labourers from three different ACZs indicated that increased weed and pest attack in the past 4-5 years in field and horticultural crops have led to the need for increased levels of plant protection, mostly by engaging women. Due to irregular rainfall, weeds grow more and most of the time is spent by women farmers in weeding.
- Drought in the year 2015 resulted complete crop failure and left them dependent on Government support for food. Due to poor rainfall and drought there is a lack of employment in the fields (as the farmers leave large areas fallow, to avoid huge losses and hence employ few labourers for the reduced area under cultivation) and consequently severely impacting the incomes of daily-wage labourers.
- Due to the increase in temperature working conditions have become tough for women who perform most of the agriculture labour work. Migration from villages to urban areas has increased in 4-5 years due to high risk and losses in agriculture. With men mostly gone to cities for labour work women bear additional responsibility of household, field and cattle protection.
- All farmers claim that crop production costs are rising, and over 80% of them feel that these rises are severe. Though the attribution to climate change is weak in their responses, farmers feel that climate change has resulted in weakened monsoons or frequent droughts and increased pest populations that has triggered the costs.

Livelihood and Economic Impacts

- Harvesting of Kharif crops are delayed due to erratic rainfall and sowing, leading to a delay in the succeeding Rabi crop (wheat, mustard, lentil, linseed). The full potential of Rabi crop is not realized as residual soil moisture is lost by overlapping crops and higher diurnal variations in temperature. Deterioration in quality of crop produce was perceived to be a major problem in all ACZs.
- Crop losses due to extreme weather events have increased; occasional heavy rainfall and drought like situations have led to loss of standing crop in the regions surveyed. Heavy rains led to significant damages for the standing soybean crop last year. Unseasonal rainfall events not only affect standing crops, but harvested produce as well. Post-harvest losses due to rains while harvest is still in farm (stored for drying and threshing) has affected farmers adversely.

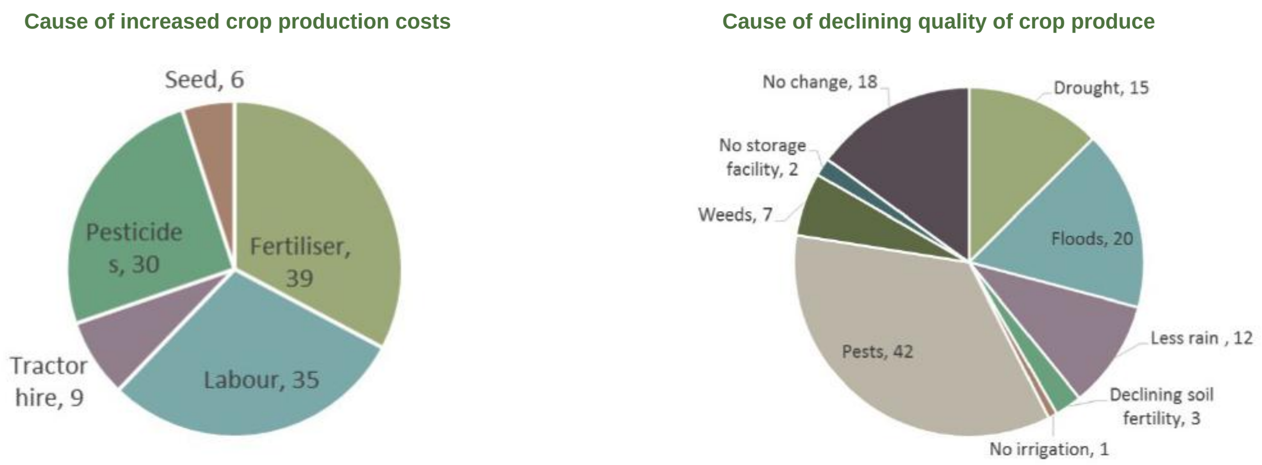

Figure 21: Causes of rising crop production costs and declining crop quality

- Increased temperature is also believed to cause a delay in milch animals coming to heat in addition to adversely impacting the conception rates in dairy animals and impacting the efficiency of Artificial Insemination programs. Increased temperatures and shortage of drinking water has also led to reduced immunity levels in livestock, and consequently increasing the anti-biotic drug content in milk. The flush period is reduced, whereas lean season has prolonged to 70:30 as compared to 50:50 earlier. 78% of the surveyed respondents opined that milk quantity and quality have reduced; there were 7% that had noted some slight change, 37% moderate

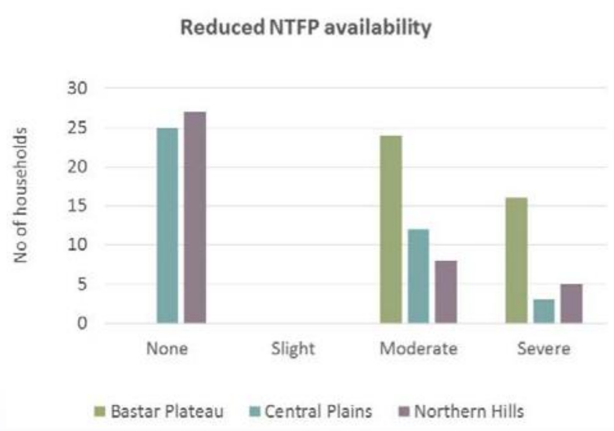

Figure 22: Reduction in NTFP availability

and 35% severe. There were no obvious trends across districts or ACZs.

- Tribal households rely on non-timber forest produce (NTFPs) which they collect from forest areas around them. NTFPs – and in particular gums, medicinal plants, lac, *Mahua* flower, *Tendu* leaf and Sal - are also being adversely affected by rising temperatures and more erratic rainfall, and thus more than a single livelihood source is being threatened; although they may be rather more resilient than mono-cropping households they are still likely to be more vulnerable than previously.
- In two districts in Bastar Plateau, all respondents had noticed either a moderate or severe change in NTFP availability.
- Farmer responses on NTFP income correlated closely with availability. All respondents surveyed in the Bastar Plateau reported loss in income because of climate-induced changes. Other ACZs were less affected, but this was still a very significant factor in districts where there is still a large amount of forest cover, with an associated population that rely on NTFPs for their livelihoods. Degradation in the quality of forest cover was attributed to be the main reason behind falling NTFP-dependent incomes.

Section 8: Coping Strategies

The previous sections of this report have dealt with how farmers understand a changing climate and perceive the many impacts on agriculture and their dependent livelihoods. This section looks at the kind of adaptation and coping strategies already being adopted by households from field surveys, key informant discussions, focus group discussions and stakeholder consultations at multiple levels and ACZs.

Farm-level Adaptation Strategies

Crop Production Management

Rice is the predominant crop in all ACZs, and there is a higher proportion of rice-only farmers in the Central Plains. More crop diversification exists in both the Bastar Plateau and Northern Hills, with a diversity including but not restricted to buckwheat, minor millets, groundnut, maize, banana, potato, wheat, mung bean and mustard. However, there is no evidence that farmers have significantly changed the kind of crops that they grow as a result of climate change. There was an awareness that this might become necessary in time, but to date there has been no significant shift in crop type.

A large majority of farmers (67%) grow hybrid rice varieties in the Central Plains. Higher proportions of growers use local desi varieties (15%) on the Bastar Plateau and Northern Hills, with some also using a mix of hybrid and desi (18%).

Local coping strategies evident from key informant discussions and stakeholder consultation also indicated that the farmers increasingly adopt shorter-duration, hybrid varieties to deal with reduced monsoon duration. Increasingly, farmers also resort to planting or mixing high yielding varieties with desi varieties, which may show more resilience to drought. This evidence was anecdotal and requires further research.

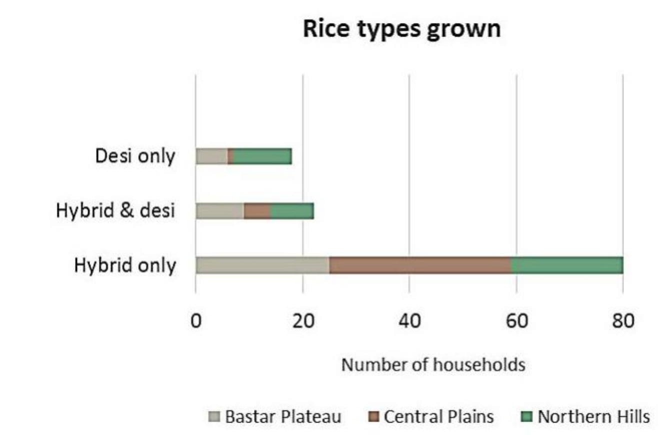

Figure 23: Rice types grown

There is also a trend towards delayed planting of kharif crops. Previously monsoon rains started dependably and consistently on 12-15th June and ended 15th September, but now rains begin later and end earlier, as reported in Section 5. Whilst previously famers would always sow in June, now there is a tendency to sow in July, and an overwhelming majority of farmers (93%) recognized the need to shift sowing dates.

This has implications for the rice crop, where long-duration varieties may no longer have sufficient time to reach maturity. There is an increasing trend in the consumption of pesticides, and this was observed across all the ACZs. 85% of the respondents confirmed pesticide application in their fields.

Unique Coping Strategies

- In Bastar District, where 7% of farmers, encouraged by government, had planted an increased area of bananas. However, this change is more likely to be because of subsidies than a response to climate change.
- In rice fields, the old system of under sowing the paddy crop with 'kesiri' dhal (Lathyrus; which produced a crop on residual moisture) is dying out, partly because free-grazing cattle populations are now too high, but partly also as a result of early cessation of the monsoon and reduced residual groundwater. This was mentioned by 18% respondents.

Livestock Production Management

The number of cattle owned by households was greatest on the Bastar Plateau, with an average herd size of 5, against 3.5 in the Central Plains and 2.6 only in the Northern Hills. The numbers of households owning no cattle was similar across the ACZs, with 28% of the total sample having no animals. The average herd size on the Bastar Plateau was 4-5 animals, compared to 2-3 in the Central Plains and Northern Hills. Local desi breeds predominate in all ACZs. There was some anecdotal evidence that farmers feel that desi breeds are more resilient that improved hybrids, and that in the face of a more difficult environment brought about by climate change, that they would prefer the local types. Farmers aspire to having high yielding milch animals, as this provides them with a reliable and growing asset base that can be used through sales in times of emergency.

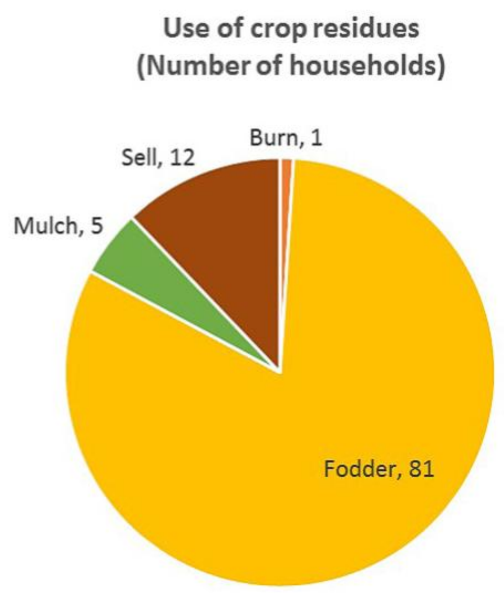

Figure 24: Use of crop residues

69% of the sampled farmers used grazing under contract

71% of the sampled farmers adopted free grazing

81% of the households used crop residues as fodder

Hybrid Napier cultivation is increasingly adopted by farmers

Migration

There were incidences of distress migration in all ACZs, and from four districts out of the six. The worst was from Bastar District, and Bastar Plateau among the ACZs was worst hit. The level of youth migration to urban centres was extremely low, with two instances only reported, both from Janjgir-Champa. FGDs with women in the ACZs reveal an increasing trend in migration of men. Migration has increased in 4-5 years due to high risk and losses in agriculture. With men mostly gone to cities for labour work women bear additional responsibility of household, field and cattle protection.

Table 4: Incidence of Distress migration

ACZ/District	Migrate	None	Total
Bastar	4	16	20
Bijapur	3	17	20
Bastar Plateau	**7**	**33**	**40**
Janjgir-Champa		20	20
Mahasamund	1	19	20
Central Plains	**1**	**39**	**40**
Balrampur		20	20
Sarguja	2	18	20
Northern Hills	**2**	**38**	**40**
Total	**10**	**110**	**120**

Other Adaptation Strategies

Households were asked whether they had managed to find alternative sources of income and livelihood, other off-farm or non-farm income generating activities. The figure shows that the predominance of off-farm work was as a daily wage labourer, and this was mostly with the MNREGA scheme. There are no major differences noted between districts or ACZs.

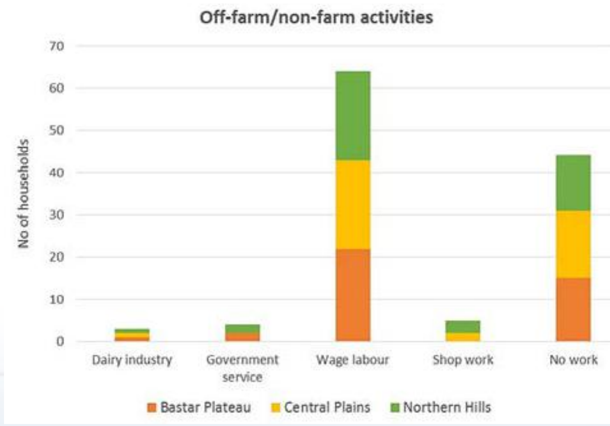

Figure 25: Off-farm and non-farm activities

Households were also asked whether they had taken the option of investing in crop insurance. More farmers (28%) had taken this option than bank loans, 15% with Kisan Credit Card (Bank of India) and just less than this (14%) with the new Pradhan Mantri Fasal Bima Yojana (PMFBY) a crop insurance scheme announced by Government in 2016, whereby farmers pay a very low premium to insure their crops, only 2% of the sum insured for Kharif crops, 1.5% for Rabi crops and 5% for horticulture and cash crops.

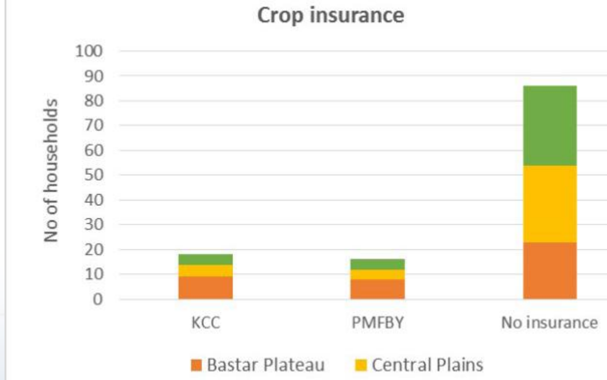

Figure 26: Crop insurance

Government Support for Climate Adaptation

Table 5: Farmers in receipt of government subsidies

ACZ/District	Seed subsidy		Fertilizer subsidy		Price subsidy	
	No	% tot	No	% tot	No	% tot
Bastar	10	8	16	13	15	13
Bijapur	7	6	13	11	15	13
Bastar Plateau	**17**	14	**29**	24	**30**	25
Janjgir-Champa	6	5	6	5	18	15
Mahasamund	8	7	10	8	9	8
Central Plains	**14**	12	**16**	13	**27**	23
Balrampur	6	5	7	6	16	13
Sarguja	5	4	7	6	9	8
Northern Hills	**11**	9	**14**	12	**25**	21
Total	**42**	**35**	**59**	**49**	**82**	**68**

A higher number of households availed price support subsidies in comparison to input subsidies in the study area. The lower penetration of seed subsidies among the respondents could also indicate stagnant seed replacement ratios.

Key Informant and Stakeholder Perspectives on Local Coping Strategies

Key informant and stakeholder perspectives were further grouped into research, crop-weather information, policy and training interventions and agronomic/crop-livestock management practices. The illustration summarizes the coping strategies supported by stakeholders in all ACZs:

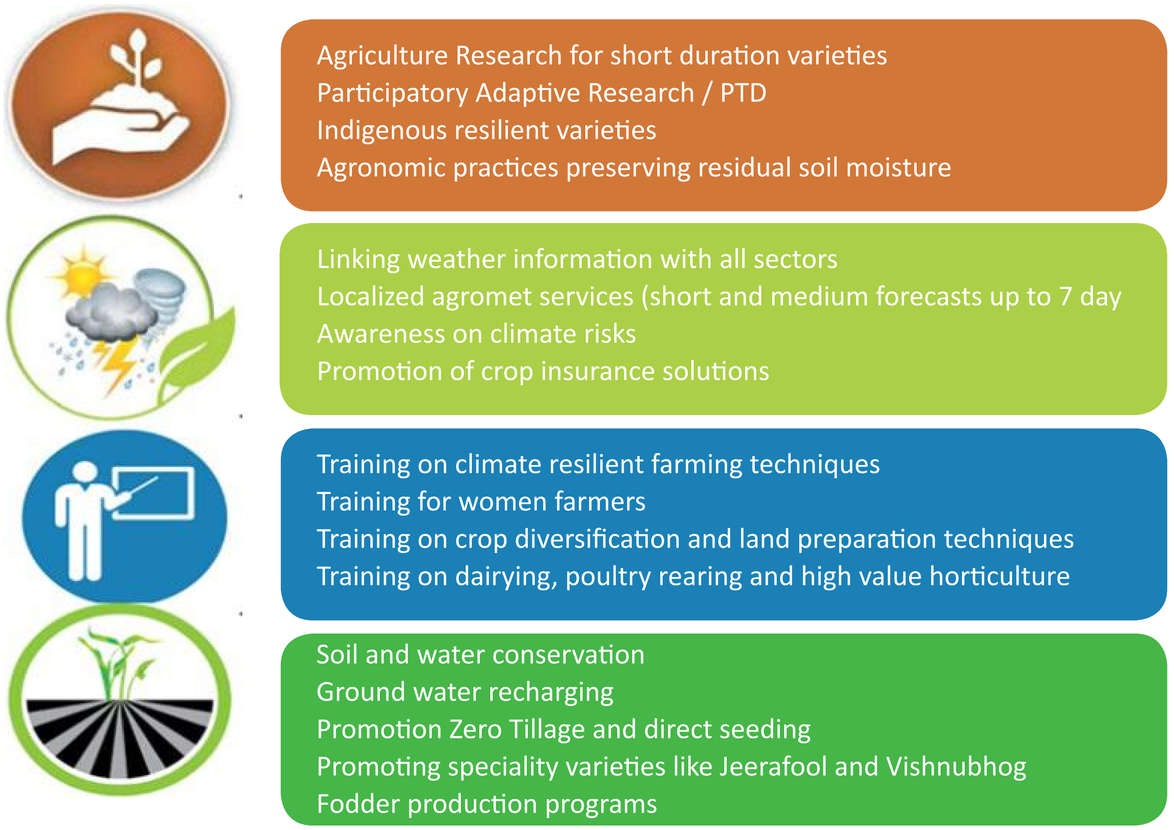

Figure 27: Coping strategies

Community-level Adaptation Strategies

Of the sampled households, 92% had taken part in no community-led response to the changing climate, despite an increasing awareness among the community on climate change impacts. The remaining 8% respondents participated in the construction of a community grain bank. All respondents felt the need for an early warning system that would permit them to make allowances for unfavourable changes in weather, and to adjust their livelihoods accordingly. A large majority (76%) recognized that community-owned lands were being overgrazed and felt the need to conserve them. Villages were accessing a few government support schemes to provide themselves with short-term financial support. Of these MNREGA was the most used (80%), followed by National Bank for Agriculture and Rural Development-funded programs (8%).

Access to Agro-met Services

As a part of the field survey, participants were asked a series of questions about how they access information regarding the weather and agro-met services. Results are shown below in table 6.

The highest proportion of farmers (79 per cent) received the agro-met information through print media channels, and electronic media; only 17 per cent had received this through mobile phones. Central Plains offered better access to information and communication resources, including information about erratic rainfall and disasters such as floods and cyclones, compared to the Northern Hills and Bastar Plateau Zones.

Table 6: Access to agro-met services

Respective responses in Per cent to the total		No	Yes	Not accurate	Less Accurate	Partly Correct	Mostly Correct
Mode of receipt	a) Electronic media (TV / radio/...)	21.7	78.3				
	b) Print media: News paper	20.8	79.2				
	c) Mobile phone service	82.5	17.5				
Information sources	a) IMD / RMC	20.8	79.2	20.0	5.0	53.3	21.7
	b) State Agricultural University	82.5	17.5	82.5	0.0	12.5	5.0
	c) State agricultural extension services	84.2	15.8				
	d) NGO	100.0	0.0				
	e) Co-operative/ Producers' association	99.2	0.8				
	f) Neighbour / Relative	74.2	25.8	74.2	14.2	11.7	0.0
Type of information received by the farmers	a) Date of onset of the rainy season	9.2	90.8	12.5	20.0	60.0	7.5
	b) Probability of expected rainfall quantum in the season	12.5	87.5	12.5	15.0	55.8	16.7
	c) Possibility for rainfall in 3-5 days	25.8	74.2	25.8	13.3	45.8	15.0
	d) Expected increase or decrease in day and night temperature in next 3-5 days	80.8	19.2	80.8	0.8	13.3	5.0
	e) Expected wind speed in next 3-5 days	82.5	17.5	82.5	1.7	11.7	4.2
	f) Expected wind direction in next 3-5 days	85.0	15.0				

Source: Field survey

Section 9: Conclusions

What has Changed?

Our analysis shows that farmers have observed profound changes in the weather that supports their livelihoods. All farmers interviewed felt that overall changes in the climate were happening, and many of them felt this was severe. The changes are more acute in the Northern Hills ACZ. Several factors are contributing to these changes. The most dramatic effects are taking place with regard to rainfall. The monsoons are more erratic and unpredictable, and are starting some 15 days later and ending sooner. All farmers reported an overall reduction in the overall amount of rain, with nearly 60% responding that this reduction was severe. There are indications again that the Northern Hill Zone is more vulnerable. Drought is becoming more common across all districts and ACZs, with dry periods of up to 21 days during the monsoon being reported now as frequent. Intense rainfall events and flooding are more frequent, with the 2016 floods in Bastar and Balrampur still very fresh in the memory. Soil erosion as a result of floods was reported in these locations also. Farmers reported more days when temperatures are very high, with temperatures above 40 degrees now common in summer months, whereas previously this was a rare event. The occurrence of wind storms has also been noticed, and people from the Northern Hills have observed this more than other areas.

Livelihoods assets, and levels of household income, are being eroded. In particular natural livelihoods assets – among these animal and crop production, NTFPs, and soil fertility - are becoming depleted. With both crop and horticultural production, the impacts of reduced and erratic rainfall mean that people are planting a reduced area, that yields are falling, and that the quality of produce is compromised. Pests and diseases are on the increase with the changes, and this affects crops, horticulture and livestock production. The incidence of food shortage periods is on the increase. For livestock producers, access to quality fodder is getting increasingly difficult, with both fodder areas and quality falling because of unfavourable weather and inadequate rainfall. This leads to reduced numbers of animals, less consumption per animal and hence to reduced yields and quality.

Yields for all crops in the region will experience large declines, particularly in rainfed situations, and Chhattisgarh is no exception. In many developing countries, climate change will cause yield declines for the most important crops, and South Asia will be particularly hard hit. India is very much within this frame, as is Chhattisgarh, and this report adds weight to this. To address the impending crisis, the National Initiative on Climate Resilient Agriculture (NICRA) was constituted in 2011. NICRA actions are multi-stage and strategic in addressing climate risks. There are several government programmes, plus a large volume of multilateral, bilateral, non-government and increasingly private sector initiatives that are facing up to the challenges presented. Chhattisgarh needs to be in the forefront of national activities addressing climate change.

Rice yields are highly dependent on rainfall. This threat is more acute in the Northern Hills and Bastar Plateau ACZs, where most of the crop is rainfed. Yields of rice are totally dependent on a good monsoon, and this report demonstrates that this is no longer guaranteed, and is increasingly uncertain. Rice growers are thus vulnerable, and resilience through drought resistance will need to be introduced into new varieties. The minor millets are much more resistant to drought periods, and need to be further encouraged.

There is a dramatic shortage of fodder for livestock. Climate change has impacted fodder production both directly (reduced fodder crop yields in both field and forest) and indirectly (less area to fodder, more to agriculture). Farmers are reacting to this by reducing the numbers of animals they hold. Livestock productivity is falling. Larger producers are reported to be using greater levels of concentrates to boost milk yields.

The insect pest, disease and weed spectrum is changing. For example, sucking pests such as aphids on rice were previously seen in the dry season, but these now can survive and cause damage in the rainy season. The incidence of smuts, rusts, and blights is on the increase. As a result of this, the use of pesticides is increasing, and this was observed across all the ACZs. This trend towards an increasing reliance on chemical control as a result of climate change is alarming. There is a strong need to introduce a programme which encourages other more ecologically friendly means of control.

Water shortage is going to become one of the state's main production constraints. There is a strong requirement for improved water management. One of the clear effects of climate change in Chhattisgarh is declining and more erratic rainfall. Managing water for agricultural use is vital, and is going to become even more crucial. Increased reliance on boreholes will not provide a sustainable way forward, and government policies which encourage this will be helping to deplete increasingly scarce groundwater supplies. Technology solutions including drip irrigation, sprinklers, water management practices such as; alternate wetting and drying (AWD) and System of Rice Intensification (SRI) in paddy and land levelling/mulching should offer a better solution, and in particular may be recommended where water intensive crops like sugarcane are being promoted. Harvesting rainwater, especially in the Bastar Plateau and Northern Hills Zones, should also be encouraged. A village level Water Budgeting Manual has been prepared under the ACT program in Maharashtra. The tool could be modified as per local context and used in the state. This will help farmers and Gram Panchayats take appropriate measures for water conservation including regulatory measures to take decisions such as selection of crops based on rainfall etc. in a more scientific manner.

Who is Most Affected by these Changes?

The survey has demonstrated that the effects of climate change on the lives and livelihoods of rural people in Chhattisgarh are both wide-ranging and potentially overwhelming. There is scarcely an element of their livelihood and farming systems that remains untouched either directly or indirectly by the climate changes observed and reported here. The growing impact of climate change on livelihoods that were in the first place highly vulnerable is going to be devastating in the worst cases, tipping the poorest further into poverty and destitution.

The role of women in agriculture activities is very crucial especially in context of the state of Chhattisgarh where land holding size is low and a large proportion of men migrate to other cities for labour work. Women are engaged in various activities of agriculture, animal husbandry and collection of NTFPs but have limited decision making space. Their vulnerability to climate change is exposed to various structural imbalances and inadequate opportunities due to lack of mobility, responsibility of children, social prohibitions, low nutrition etc.

The most vulnerable people are those who rely on agriculture only, and where the large part, or all, of household income comes from farming. This includes those farmers in ACZ 2 - the Central Plains – who rely on rice cultivation only. In addition to being dependent on a single crop they also rely heavily on costly external inputs such as improved seeds, fertilisers and pesticides; this group are arguably the most vulnerable of all. Our field analyses suggest that those households with diversified livelihoods have a greater level of resilience from a variety of sources, and are less vulnerable. This includes the large populations of forest-dwellers in ACZs 1 & 3, who firstly have a wide range of crops under cultivation in traditional mixed farming situations, secondly have livelihoods that are more diversified in nature, and thirdly who are much less reliant on external inputs – where these are used at all. In addition, some local (desi) varieties may show greater levels of resilience than improved varieties.

Forest dwellers face multiple threats to their livelihoods. Tribal communities rely on more diversified sources of livelihood. This includes agriculture, often as tenant farmers under increasingly unfavourable terms, and the productivity of their farming will be adversely affected by climate change. In addition, these households rely also on non-timber forest produce (NTFPs) which they collect from forest areas around them. NTFPs – and in particular Mahua flower, tendu leaf and sal - are also being adversely affected by more erratic rainfall and temperature rises, and thus more than a single livelihood source is being threatened; although they may be more resilient than mono-cropping households they are still likely to be increasingly vulnerable. These forest-dependent communities contain the poorest of the poor, and are often landless, and in addition to livelihoods from forest and agriculture also sell their daily wage labour; given declining productivity, employment as well will be adversely affected.

How Can People Cope with the Changes?

There are some agronomic management practices being undertaken by farmers in response to climate change. This includes a trend towards delayed planting of kharif crops. Previously monsoon rains started dependably and consistently on 15th June and ended 15th September, but now rains begin later and end earlier. Whilst previously famers would always plant in June, now there is a tendency to plant in July, and an overwhelming majority of farmers recognized the need to shift planting dates. This has implications for the rice crop, where long-duration varieties may no longer have sufficient time to reach maturity.

Over three-quarters of all cattle owned by the survey sample are desi types, which are more resilient. Farmers and many others working in animal husbandry believe that local desi cattle are more resilient than improved hybrids, and have qualities well suited to a changing climate. They are small and well adapted, but not very productive in terms of milk yield. Indian breeds are certainly to be preferred, and among the high quality and well adapted national breeds are Gir, Sahiwal, and Red Sindhi. Kosali is a recognized local breed, and may be used to improve the unrecognized local desi types.

Migration to urban centres for employment has been occurring for many years, and climate change is contributing to this movement. Households and individuals were asked if there had been any change in the patterns of migration because of climate change, and many felt that this was a growing trend. There were incidences of distress migration in all ACZs.

There were very few examples of community-led response to the changing climate, despite households were being very clear about the nature and severity of these changes. The exception was where a community had constructed a community grain bank. All respondents felt the need for an early warning system that would permit them to make allowances for unfavourable changes in weather, and to adjust their livelihoods accordingly. A large majority recognized that community-owned lands were being overused for grazing purposes, and that this was becoming worse with the impacts of changing climate. Villages were accessing government employment schemes to provide themselves with short-term financial support. Of these MNREGA was the most used (80%), and the overall reliance on this as a source of income and livelihoods was very high. This demonstrates that government programs that build household-level resilience through improved incomes, employment opportunities or creation of farm assets are key to achieving climate resilience. Although the scope for community level actions have a huge potential impact such interventions are currently minimal and need to be encouraged and supported.

Some positive aspects to climate change. New opportunities exist if farmers can adapt and make things work to their advantage, but they have not started to do so yet. Agricultural research has many potential answers, such as drought resistant crops, but take-up has been slow and farmers are not yet using these widely. There is a need to find the early adapters/adopters and work with them, firstly to validate their ideas through on-farm testing, and then replicating and taking these ideas to scale. There is a strong need for some participatory adaptive research, and piloting new ideas should become an investment priority.

Aware of the existence of climate change is widespread, but knowledge of the science behind it, and an understanding of how it may be dealt with through adaptation, are at a very low level. People can recall accurately how the climate is changing and how this has affected them. However, few have given any thought to the growing and accumulating impact of these changes, and how they might change their lives and livelihoods to adapt to these.

The need for crop diversification and integrated farming systems and cropping models. The threats identified through this survey will require that agricultural research and development in Chhattisgarh adopt a change of approach. Approximately 10 lakh hectares of cultivable area is found in an upland situation where rice cultivation is currently not economical, and where it is likely to become less so. The hilly area of Bastar Plateau and Northern Hill zone where rice cultivation will become increasingly marginal will need to be replaced by suitable alternate crop. This situation suggests that a move towards crop diversification would be beneficial. Across the three agro-climatic zones, integrated farming is already being practiced, but this will need some adjustment to take into consideration the technological interventions and advancements which are going on in the field of agriculture.

Some Policy Implications

The Chhattisgarh State Agriculture Policy would do well to focus more directly on climate change, and address associated risks. Chhattisgarh State developed a draft State Agriculture Policy in 2012 with a view to revitalising the agriculture sector. Sustainable agriculture is a key theme running through the SAP, but climate change risks and their possible impacts are not properly addressed. The future vision of the agriculture sector needs to adapt to the reality of water scarcity and higher temperatures. The concept of climate resilient agriculture is yet to be integrated into the department's annual action plans and therefore there is need to align the department's planning and decision-making process, and policies, institutions and processes need to be restructured to meet new challenges. Principle points of contact for climate change within the key departments (agriculture, animal husbandry and horticulture) have been nominated, but progress has been slow.

From an agricultural research perspective, there is a need to adapt technologies for an uncertain future, and a need to involve farmer innovations in the research. There exists a wide range of crops that may be grown to offer more diversity to livelihoods, and yield increases should be pursued. Beneficial crop diversification may become easier, such as the opportunity to grow soybean, maize, and sunflower on vertisols which were formerly too wet. Irrigated areas may be extended to increase resilience, using water-saving technologies such as drip-feeding. Rain harvesting opportunities can be exploited. SRI (System of Rice Intensification) farming systems may be increased. The promotion of minor millets in rainfed zones, using germplasm from local varieties shows promise; drought resistance needs to be bred into improved lines. Involving farmers at all stages will ensure the relevance of research.

There is a need to move towards the CRA practices being recommended by IGKV in the state. Crop diversification, integrated farming systems and cropping models, rain water conservation, and improved land and water management are among these. The threats identified through this survey will require that agricultural research and development in Chhattisgarh adopt a change of approach. For example, approximately 10 lakh hectares of cultivable area is found in an upland situation where rice cultivation is currently not economical, and where it is likely to become less so. The hilly areas of Bastar Plateau and Northern Hill zone where rice cultivation will become increasingly marginal will need to be replaced by suitable alternate crops, and a move towards crop diversification would be beneficial. Across the three agro-climatic zones, integrated farming is already being practiced, but this will need some adjustment to take into consideration the technological interventions and advancements which are current in the field of agriculture. Recommended practices from IGKV, by ACZ, are in Annex 12.

The Climate Resilient Agriculture approach is an entirely appropriate one for Chhattisgarh. Climate Smart Agriculture (CSA) and Climate Resilient Agriculture (CRA) are approaches with a very recent history, the term CSA being coined by FAO only in 2011. It has accumulated a growing list of success stories and an increasingly confident catalogue of lessons and best practice around its three pillars of productivity, adaptation and mitigation. It involves developing technologies, policies and institutions, and mobilising investments. One or two of a growing list of lessons stand out that are relevant for the state. One is the need to adopt an integrated approach, as understanding vulnerabilities and impacts of climate change on local livelihoods calls for a combination of various methodologies, including microclimatic variations, farming systems and socio-economics, combined with findings from downscaled climate models to inform development planning and policy processes. Another is the need for information and data, which must be collated if it is not currently accessible, as without this the analysis to inform decision-making cannot be made.

ACT is in a good position to continue to support government in adopting a CRA approach, and in institutionalizing this. There is a need for capacity building, systems improvement and program design through mainstreaming climate information, and ACT is in a good position to transfer lessons from other Indian states and build on good practices in adaptation, economic growth and climate financing. ACT itself has several CRA/CSA interventions on-going in a number of states in India, and is learning fast about how best to address the associated risks, and to bolster resilience. It has current work on CRA in Assam, Bihar, and Odisha, where many of the same challenges faced by Chhattisgarh are being addressed. It also has an intervention in Maharashtra where the private sector is partnering with government to increase climate resilience among poor rural communities through agriculture.

Section 10: Recommendations for Further Action

The The study aims to inform and offer specific options or recommendations to the Departments of Agriculture, Horticulture and allied sector, and aid the design of appropriate short (1-3 years), medium (3-5 years) and long term (>5 years) CRA interventions in the state. A prioritization of the recommendations is offered using an adapted priority matrix.[36]

In terms of their impacts and ability to influence changes in key areas, these recommendations have been drawn from the key conclusions outlined in Section 9. The study has aimed to produce a set of politically acceptable, technologically feasible, financially viable, and administratively actionable recommendations that are mapped against the following impact areas:

- The urgent priorities;
- Improved Practices, Knowledge and Technology;
- Inclusive Markets and Institutions; and
- Good Policies.

The Urgent Priorities

Based on the priority matrix at the end of this section, the three following recommendations are put forward f**or immediate adoption**.

1. **Integrate CRA into the State Agriculture Policy (SAP).** As a first step, efforts towards integration of CRA into the State Agriculture Policy needs to be taken up. Based on the policy directives, a roadmap for CRA implementation should be developed, and work on this should begin immediately which would include aligning schemes and action plans accordingly. It is recommended that GoC adopts a Climate Resilient Agriculture approach, and that the Department of Agriculture, including all its Directorates, should fully incorporate this into its policies, plans and processes. After the roadmap, a revision of the draft State Agriculture Plan can be conducted. The development of the CRA-focussed SAP would be supported by the new Resource Centre.
2. **Constitute an inter-departmental CRA Resource Centre in Raipur.** CRA calls for coordination and complementary roles with line departments of the state. An appropriate institutional model that coordinates with key departments is required. Draft TOR already exist with IGKV; these should be finalised. A final, detailed ToR and panel can be drawn upon consultation with the government and senior officers.
3. **Capacity building.** Current levels of capacity to address CRA are minimal. Awareness and motivation need to be addressed within all levels of government, from field staff through to senior government officials. This is particularly relevant in the development

36 www.gartner.com/pages/docs/gartner/hc/priorityMatrix.html

ministries (environment, agriculture, livestock and animal husbandry, etc), but also crucially in the Department of Finance and Department of Planning where decisions are made regarding resource allocation. Capacity building should be addressed in an ACZ-centric manner, driven through the KVKs. Draft plans to implement a programme along these lines are already in draft, and these should be implemented. Women farmers and farmers with marginal landholding especially from Scheduled Tribal could be given priority for training and capacity building by:

- Ensure coverage of women farmers in all training programs of KVKs including long term training programs such as Farmer Field Schools.
- Special focus of training and capacity building and efforts towards other institutional linkages to include women from scheduled tribal groups.

Improved Practices, Knowledge and Technology

This includes activities that facilitate incorporation of climate resilient practices observed in the farmers' fields into the technology guidelines and management practices recommended by the Department of Agriculture. This includes among others:

1. **ACZ-centric research and extension support.** Findings show that the effects of climate change are localized and crop-specific, and are already affecting Chhattisgarh's 3 ACZs in marked and different ways. The CRA agenda in these zones, implemented through the KVKs, must reflect local circumstances, developing technologies that are locally specific. Annual Plans and Contingency Plans can be developed jointly with inputs from ACZ-level, nodal institutions (KVKs). Extension services need change from the conventional top-down, production-focused approach currently in use, to a customized strategy based on a CRA-based agenda (irrigation, crop management, marketing, diversification).

2. **Adaptive on-farm research.** To address locally-specific climate-related problems, Department of Agriculture researchers must work closely with farmers to maximise synergies and establish best practices. New varieties should be developed using Participatory Adaptive Research (PAR) and Participatory Technology Development (PTD) techniques. It is recommended that the Department of Agriculture increases its investment in establishing a wide network of adaptive on-farm, demonstration plots in all ACZs. This must also incorporate integrated approaches. Examples of this are:

   a. **Integrated weed, pest and disease management strategies** to counteract the effects of a much wider range of weeds, pests and diseases that are already threatening productivity with the changing climate. Unseasonal rains, and fluctuating temperatures have led to pest/disease flare ups that require sustained but integrated controls.

   b. **Integrated water and nutrient management strategies** focusing on water harvesting, conservation, use efficiency and optimal nutrient consumption (based on Soil Health Cards) are recommended. Capacity building on alternative management techniques such as Alternate Wetting and Drying (AWD), System of Rice Intensification (SRI), mulching and adoption of micro irrigation are to be prioritized.

3. **Embedding drought resistance into local cropping systems.** With the frequency of drought events on the rise in Chhattisgarh, the threshold of drought tolerance in the existing cropping system of three ACZs should be increased. An optimal mix of drought tolerant varieties in current cropping systems will optimize drought response and minimize economic losses. This should include:

   a. **Rice** is by far the most important crop in Chhattisgarh, but shows little drought tolerance, and is very dependent on a good monsoon. Agricultural research must build in drought resistance to new varieties, using PTD. Traditional varieties are very likely to have genetic material to offer in breeding programmes, and the large collection of local types held by IGKV (over 200 lines) should be put to full use;

   b. **Fodder production** has been badly hit by climate change, and as a result animal numbers and livestock productivity are falling. There is a need for agricultural research to develop new species and varieties of fodder that are drought resistant; IGKV has several lines of fodder research located across all ACZs, and these must be accorded high priority status;

4. **Promotion of minor millets.** Kodo millet and finger millet in kharif season and Kutki in mid-season have strong drought tolerant characteristics, and provide a highly nutritious and protein rich diet. These crops offer a high level of resilience, and should be promoted wherever possible. Overall contribution of small millets to the food basket of the state is currently minimal. A total of 15,000 hectares were, for example, grown in Chhattisgarh State in 20014, against over 4 million hectares of rice. Traditionally farmers were cultivating minor millets largely for household consumptive use in marginal landholding in absence of adequate marketing opportunities. Of late there has been efforts undertaken by the government to ensure marketability of minor millets. This needs more support and impetus from the government. IGKV conducts a large research programme on small millets from its centre in Jagdalpur, and this work should become focussed less on general agronomy, and increasingly on marketing and value chains. Continuing work should seek to develop markets and explore organic outlets both nationally and overseas.

5. **Promoting livelihood diversification.** The more diverse the source, the greater the resilience livelihoods will exhibit. A reliance on mono-cropped rice-based agriculture creates the highest levels of vulnerability to climate change. This survey has demonstrated the necessity of incorporating mixed farming models into current small holder systems for the three ACZs. For example, IGKV and the KVKs have 'ready-to-roll-out' models for livestock-poultry-fodder production (e.g. Azolla, Hybrid Napier); these systems can be integrated into the rice-maize based farming system that is widely used by farmers.

6. **Promoting Community-based Adaptation (CBA) opportunities.** Improved awareness levels and community actions must be promoted by DOA. A notable gap in community-driven initiatives was observed in field surveys, FGDs and Key Informant Interviews. CBA can be introduced to DOA field staff through training. Since forests have a large role to play in shaping the lives, livelihoods and environments of Chhattisgarh, an immediate opportunity to initiate and foster community action may lie in the improvement of forest quality by identifying native tree species to mitigate the losses resulting from flora or habitat level changes in the forests of Chhattisgarh. The Department of Forests already uses Joint Forest Management (JFM) to underpin its community-based work, and this approach should be intensified, with resources to match.

7. **Full adoption of the CRA practices being recommended by IGKV in the state.** Crop diversification, integrated farming systems and cropping models, rain water conservation, and improved land and water management are among these. Location specific integration of crops needs to be promoted, at block level. Different models for different kinds of farms have been developed by IGKV and are being promoted by KVKs. Different cropping models need to be promoted at the Gram Panchayat level in planned manner. For this large-scale training of Gram Panchayats need to be undertaken on incorporating Climate Resilient Agriculture in their annual and long-term planning. Recommended practices from IGKV, by ACZ, are in Annex 12.

Inclusive Markets and Institutions

Access to markets and services is one of the main constraints for farmers when it comes to livelihoods development. Service provision and extension packages from the DOA must adapt to meet the demands of a changing climate. Key Informant Interviews with all concerned line departments, IGKV, Raipur and domain experts from KVKs indicate that a responsive, and strong institutional coordination mechanism, a needs-based capacity building strategy and participation of line departments holds the key to building resilience in the agricultural sector of the state. To this end, the following actionable recommendations are presented:

1. **Constitute an inter-departmental CRA Resource Centre in Raipur.** CRA calls for coordination and complementary roles with line departments of the state such as; agriculture, horticulture, water resources, veterinary and

animal husbandry, dairying and soil and land use departments. There are different elements of CRA that will require the operational support of these line departments; hence an appropriate institutional model that coordinates with key departments is required. Drawing from the experience of other states (Karnataka, Andhra Pradesh and Assam), it is recommended that a CRA Resource Centre is convened with the following constitution:

- **Chair:** Additional Chief Secretary and Development Commissioner
- **Secretary:** Principal Secretary (Agriculture) and Agricultural Production Commissioner
- **Members:** Secretaries of Agriculture, Horticulture, Environment and Forests, Climate Change Cell, Water Resources, Animal Husbandry and Livestock, Revenue departments
- **Expert Members:** Vice Chancellor or nominees from IGKV, Directors/JDs of line depts., KVK Zonal Heads, private sector actors
- **Special Invitees:** Eminent National/ International Subject Experts, private sector specialists.

IGKV has already drafted some TOR for the Resource Centre. These require further work by a cross-departmental team. A final, detailed ToR and panel can be drawn upon consultation with senior government officers. The Resource Centre, when operational, can drive the overall CRA process. In the interim there will be a need to commence the following tasks:

a. **Integrate CRA into the State Agriculture Policy (SAP).** A roadmap for CRA implementation should be developed, and work on this should begin immediately. It is recommended that GoC adopts a Climate Resilient Agriculture approach, and that the Government of Chhattisgarh's Department of Agriculture, including all its Directorates, should fully incorporate this into its policies, plans and processes. After the roadmap, a revision of the draft State Agriculture Plan can be conducted. The development of the CRA-focussed SAP would be supported by the new Resource Centre.

b. **Capacity building.** Current levels of capacity to address CRA are minimal. Awareness and motivation need to be addressed within all levels of government, from field staff through to senior government officials. This is particularly relevant in the development ministries (environment, agriculture, livestock and animal husbandry, etc), but also crucially in the Ministries of Finance and Planning where decisions are made regarding resource allocation. Capacity building should be addressed in an ACZ-centric manner, driven through the KVKs. Draft plans to implement a programme along these lines are already in draft, and these should be implemented.

c. **Integrate the CRA approach into the State Action Plan on Climate Change (SAPCC).** This will directly contribute to the effort to meet development goals such as SDGs and Climate action targets of the state. This will open up new avenues for financing climate actions from external and domestic sources.

2. **Adopt a Value Chain Analysis (VCA) framework for comprehensive crop improvement.** VCA allows to examine the roles of multiple actors, institutions and knowledge-information systems for crop production, value addition, and marketing. It will also help enable a better understanding of the barriers, transaction costs and opportunities at each stage of the value chain from pre-production to retail marketing/consumption. VCA insights of climate resilient crops such as minor millets and legumes from neighbouring Bihar, Assam and Odisha point to the ability of the analysis to solve constraints and realize policy opportunities quickly aiding decisions on diversification.

3. **Freeing up NTFP markets.** Chhattisgarh Government has declared the state as "Herbal state" with an objective to conserve plant resource in natural form. Cultivation of medicinal plants in and outside the forest, non-destructive harvesting, promotion of organized trade and promotion of Minor Forest Products (MFP) based industries for processing of MFP to generate the additional employment opportunities in the state, improve socio-economic status of rural communities and provide health cover are the main activities taken up by the MFP Federation. Opportunities to explore capacity building, value addition, and fair-trade certification must be realized for sustainable economic development of NTFP markets in the state.

Good Policies for Climate Resilient Agriculture

During the course of the study, several examples of well-intentioned sectoral policies resulting maladaptation came to light. This highlights that CRA objectives cannot be met in isolation and need to be conceived as a part of an integrated framework aligning sectoral goals with CRA outcomes. A review of key policies and program goals is required to identify maladaptation triggers and also to highlight opportunities for evidence-based-policies in supporting CRA implementation in the state. This will include among a list of others; review of subsidization of concentrates fed to cattle that is widely acknowledged as resulting in higher emissions, subsidy policies for micro irrigation technologies, artificial insemination policies for breed stabilization etc. The roadmap for CRA implementation should be able to identify synergistic and maladaptation triggers that will enable the achievement of CRA objectives. A series of success stories of climate smart agriculture in action, has been released by the Technical Centre for Agricultural and Rural Cooperation (CTA) and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) to demonstrate the varied ways climate smart agriculture can take shape. These experiences from the across the globe on CRA as well success stories and initiatives on sustainable agriculture from across India including the Value Chain Analysis work done in Maharashtra, Odisha and Assam under the ACT program could be referred to.

Phasing CRA Interventions in Chhattisgarh

Further prioritizing the recommendations using an adapted Gartner's priority matrix. The opportunities identified through field surveys, analyses, FGDs and KIIs are filtered through a dual-optic of impacts and benefits versus implementation time required. A final list of opportunities will be produced on consultation with the government and stakeholders.

Potential Impacts	Years to Mainstream			
	<1 year	1-3 years	3-5 years	>5 years
Transformational	1. CRA Roadmap and Policy adoption. 2. CRA Resource Centre	1. ACZ-level Livelihood diversification strategies 2. Early Warning Sys for Agriculture	1. Stabilization of crossbreds 2. Community-driven Forest Quality Improvement Program using identified, native spp.	1. 3 ACZ-level seed banks for native, climate resilient crop varieties identified by the communities
High Impact	1. Capacity building of staff 2. Subsidy policy review of livestock feeds 3. Mainstreaming agro-met services by service providers	1. Integrate CRA in SAPCC 2. Comm. Based Adaptation 3. VC approach for CR crops 4. IWRM (On-farm water conservation techniques)	1. ACZ-focused res/policies 2. ACZ-specific DR crops 3. Standardization of ACZ-level mixed farming models	1. Expand coverage of Soil Health Cards and promotion of a state-wide, ACZ-specific Micronutrient Mission
Moderate Impact	1. Department-level nodal officers/ tech experts for state-level community of practice on CRA	1. Intg. Water Management 2. IPM - Biocontrol 3. Nutritional Mission with Minor Millets in Schools	1. Investments in post harvest handling and procurement/processing	
Low Impact		1. CGMFP corporation-led Fair-Trade certification for MFPs 2. Promotion of Farmer Producer Organizations with government support	1. Small scale Fish feed units 2. Establishment of laboratories @ state level for water quality and fish health studies	

For more information, please contact:

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