

# **Training Manual**

## on Climate Change Adaptation in Agri Value Chain





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# Abbreviations and Acronyms

CSA	Climate-Smart Agriculture
EWS	Early Warning System
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IARI	Indian Agricultural Research Institute
IGP	Indo Gangetic Plain
IPCC	Intergovernmental Panel on Climate Change
KVK	Krishi Vigyan Kendra
NRLM	National Rural Livelihoods Mission
UN	United Nations
UNDP	United Nations Development Programme





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# Training Module 1 Government Officials on Climate Change and Adaptations by Agri Value Chains



# Session 1

## Introduction of the Facilitator, Workshop and Participants

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### Desired Outcome

Participants are familiar with each other and the facilitator of the workshop. An informal tone is set for the workshop.

### Duration

60 minutes

### Method

- Introduction
- Presentation
- Discussion

### Material

30 chits, sketch pens

### Instructions for Trainer

Explain the objective of the workshop to the participants.

Participants' expectation from the workshop to be written on a drawing sheet and to be placed for display. Formation of ground rules. Participants are encouraged to come up with the ideas to make the workshop effective such as use of mobile phones during the workshop, participation protocol within the participants and with the facilitator, punctuality, etc.

### Resources

**Icebreaking Tips:** There are many ways of making the participants feel comfortable and make the entire ambience more informal. It's important that the trainer and participants know each other well. The process/games could be place/participants-specific yet there should be some unique ways of getting to know the participants, such as the following.

There are some games in the reference material which could be adapted to make more relevant examples (<http://reprolineplus.org/system/files/resources/icebreak2.pdf>)



# Session 2

## Introduction to Climate Change and its Impact on Agriculture

### Desired Outcome

Participants are able to define basic concepts related to climate change and understand the reasons for climate change.

### Duration

2 small sessions of 1 hour each with smaller breaks in between

### Method

- Brainstorming
- Presentation
- Question and answer session

### Material

PPT, white board and marker, audio-visual system

### Instructions for Trainer

This session is to be built on the group presentations made on understanding of climate change by the participants. At the end of the exercise, participants should be able to understand the reasons and consequences of climate change. In addition to this, participants should also be able to understand the basic terms associated with climate change.

### Resources

The following textual and audio-visual resource material to be referred to in the session in addition to the key points shared below.

<https://unfccc.int/process-and-meetings/the-convention/glossary-of-climate-change-acronyms-and-terms>

<https://climatechange.ucdavis.edu/science/climate-change-definitions/>

<https://www.ipcc.ch/sr15/chapter/glossary/>

[https://www.undp.org/content/dam/india/docs/undp\\_climate\\_change.pdf](https://www.undp.org/content/dam/india/docs/undp_climate_change.pdf)

<https://climate.nasa.gov/images-of-change?id=699#699-icelands-ok-glacier-melts-away>

[https://calp2016.sites.olt.ubc.ca/files/2019/05/Introduction-to-Climate-Change\\_CALP-UBC.pdf](https://calp2016.sites.olt.ubc.ca/files/2019/05/Introduction-to-Climate-Change_CALP-UBC.pdf)

<https://youtu.be/XMf-flqNqgw>

<https://youtu.be/OHnrBUoD4S0>

<https://royalsociety.org/topics-policy/projects/climate-change-evidence-causes/basics-of-climate-change/>

### Subtopics to Cover

Under this topic, which is going to form a basis for further sessions, we are going to look at the basic concepts of climate and climate change.

**Introduction to climate and climate change, key terms used in climate change discussions, causes of climate change and impact of climate change on agriculture.**

#### Difference between Weather and Climate

Weather refers to atmospheric conditions in the short term, including changes in temperature, humidity, precipitation, cloudiness, brightness, wind, and visibility. While the weather is always changing, especially over the short term, climate is the average of weather patterns over a longer period (may be more than 30 years).

Climate can be understood as the average of weather over time and across large regions. (The classic period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.)

#### Key terms to be focused during discussions:

- Long-term verses short-term;
- Small geographical areas verses large geographic regions; and
- Small variability verses long-term trends.

Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or variability of its properties and that persists for an extended period, typically decades or longer.

**The Framework Convention on Climate Change in its Article 1, defines climate change as: a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.** This variation may be caused by both natural processes and human activity. Global warming is one of the aspects of climate change.

Climate variability refers to variations in the mean state and other statistics of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may occur due to natural internal processes within the climate system (internal variability) or to variations in natural or anthropogenic external forcing (external variability).

#### **Other important terms used in climate change discussions<sup>28,29,30,31</sup>**

**Participants need to be provided a brief on sustainable development and Sustainable Development Goals. (This will help in developing a broader perspective on climate change and other aspects of human development–maximum 15 minutes can be devoted for this exercise.)**

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs and balances social, economic and environmental concerns. The 17 global goals for development for all countries established by the United Nations through a participatory process and elaborated in the 2030 Agenda for Sustainable Development, including ending poverty and hunger; ensuring health and well-being, education, gender equality, clean water and energy, and decent work; building and ensuring resilient and sustainable infrastructure, cities and consumption; reducing inequalities; protecting land and water ecosystems; promoting peace, justice and partnerships; and taking urgent action on climate change.

**This exercise should be done in a participative manner with participants being requested to share their understanding of sustainable development and if they are aware of one or many of the Sustainable Development Goals being prescribed.**

#### **Intergovernmental Panel on Climate Change**

The United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) is a scientific body established by the United Nations Environment Programme and the World Meteorological Organization. It reviews and assesses the most recent scientific, technical and socio-economic work relevant to climate change but does not

carry out its own research. The IPCC was honoured with the 2007 Nobel Peace Prize.

A small 10-minute tea break may be provided and after that participants should be made aware of key terms associated with climate change.

This session should be made participative with participants being asked to share their understanding of key words which can be written on white board/ chart papers/flip charts. Once participants are through with their understanding, the Trainer can share her/his definition or understanding.

#### **1. Vulnerability**

It is the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

It is basically the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change. Vulnerability is a function of the character, magnitude and rate of climate change, and variation to which a system is exposed, and its sensitivity and adaptive capacity.

It is usually described as a condition of susceptibility shaped by exposure sensitivity and resilience. It refers to the (in)ability of people to avoid, cope with or recover from the harmful impacts of factors that disrupt their lives and that are beyond their immediate control. This includes both shocks and trends.

(Shocks are sudden changes such as natural hazards, war or collapsing market prices) and trends (for example, gradual environmental degradation, oppressive political systems or deteriorating terms of trade).

**In relation to climate change, vulnerability relates to direct effects such as more storms, lower rainfall or sea level rises that lead to displacement and to indirect effects such as lower productivity from changing ecosystems or disruption to economic systems.**

#### **2. Resilience**

Resilience is the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning. It is the capacity of self-organization, and the capacity to adapt to stress and change.

In other words, it is the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also

<sup>28</sup> <https://www.climaterealityproject.org/blog/key-terms-you-need-understand-climate-change>

<sup>29</sup> [https://www.agmrc.org/media/cms/Glossary\\_of\\_Global\\_Warming\\_and\\_Clim\\_4314FBAC16B15.pdf](https://www.agmrc.org/media/cms/Glossary_of_Global_Warming_and_Clim_4314FBAC16B15.pdf)

<sup>30</sup> <https://climatechange.ucdavis.edu/science/climate-change-definitions/>

<sup>31</sup> [http://www.fao.org/fileadmin/user\\_upload/rome2007/docs/1\\_Climate%20Change%20and%20Agr.pdf](http://www.fao.org/fileadmin/user_upload/rome2007/docs/1_Climate%20Change%20and%20Agr.pdf)



maintaining the capacity for adaptation, learning and transformation.

In the context of people, it represents their ability to withstand the impact of the trends and shocks described above, absorbing them while maintaining function. It is determined by two characteristics of people's livelihoods: the assets they possess and services provided by external infrastructure and institutions. Taken together, the reduction of vulnerabilities and improvement of resilience of poor people to withstand the impacts of climate change will improve their security: that is, the extent to which they can live their lives and conduct their livelihoods free from threats.

### 3. Adaptation

The process of adjustment to actual or expected climate and its effects, to moderate harm or exploit beneficial opportunities. These are the actions that help to cope with the effects of climate change.

It is the ability to respond and adjust to actual or potential impacts of changing climate conditions in ways that moderate harm or takes advantage of any positive opportunities that the climate may afford. It includes policies and measures to reduce exposure to climate variability and extremes, and the strengthening of adaptive capacity.

For example, construction of barriers to protect against rising sea levels, or adoption of crops capable of surviving high temperatures and drought or a change in the package of practices which includes change in inputs as well as in processes or technology.

**Climate change adaptation** refers to the adjustments societies or ecosystems make to limit the negative effects of climate change or to take advantage of opportunities provided by a changing climate. Adaptation can range from farmers planting more **drought-resistant crops** to coastal communities evaluating how best to protect themselves from sea level.

### 4. Adaptive Capacity

The ability of a system (e.g., ecosystem) to adapt to climate change or other environmental disturbances.

It is the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences. This may mean moderating potential damage, taking advantage of opportunities or coping with the consequences. In discussions on global warming, adaptive capacity often refers to a country. In this case, it is currently much lower in developing countries, consequential to poverty.

**Anticipatory adaptation** that takes place before the impacts of climate change are observed. **Incremental adaptations** are those that maintain the essence and integrity of a system or process at a given scale while **transformational adaptation** changes the

fundamental attributes of a socio-ecological system in anticipation of climate change and its impacts.

Trainers need to place emphasis on why it is important to build on adaptive capacity and the importance of anticipatory adaptation. It is also important to explain the merits of incremental adaptation.

**Participants may be asked to share some examples of adaptations from their experience. They can share their examples from various sectors/sub-sectors.**

**Sharing of examples with technologies such as smart phone/computers/digital process/finance and payments will make the process of understanding much easier.**

### 5. Extreme Weather Events

An extreme weather event is an event that is rare at a place and time of year. Definitions of rare vary but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. The characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season).

### 6. Global Warming

The estimated increase in global mean surface temperature averaged over a 30-year period, or the 30-year period centred on a particular year or decade, expressed relative to pre-industrial levels unless otherwise specified. For 30-year periods that span past and future years, the current multi-decadal warming trend is assumed to continue. The steady rise in global average temperature in recent decades, which experts believe is largely caused by man-made greenhouse gas (GHG) emissions. The long-term trends continue upwards, they suggest, even though the warmest year on record, according to the UK's Met Office, is 1998.

### 7. Enabling Conditions (Participative Exercise) (15 minutes)

**(Participants may be asked to define enabling conditions with examples and how their department/s can participate in the process of developing enabling conditions).**

Conditions that affect the feasibility of adaptation and mitigation options and can accelerate and scale-up systemic transitions that would limit temperature increase and enhance capacities of systems and societies to adapt to the associated climate change, while achieving sustainable development, eradicating poverty and reducing inequalities. Enabling conditions include finance, technological innovation, strengthening policy instruments, institutional

capacity, multilevel governance, and changes in human behaviour and lifestyles.

**As participants are from the government, they may be asked to define and share examples on how enabling conditions can be developed.**

#### **8. Feasibility (Needs to be explained along with Feasible Solutions)**

The degree to which climate goals and response options are considered possible and/or desirable. Feasibility depends on geophysical, ecological, technological, economic, social and institutional conditions for change. Conditions underpinning feasibility are dynamic, spatially variable, and may vary between different groups.

**This discussion is important so that participants can focus on the importance of practical and doable solutions.**

#### **9. Equity**

It is the principle of fairness in burden-sharing and is a basis for understanding how the impacts and responses to climate change, including costs and benefits, are distributed in and by society in equal ways. It is often aligned with ideas of equality, fairness and justice and applied with respect to equity in the responsibility for, and distribution of, climate impacts and policies across society, generations and gender, and in the sense of who participates and controls the processes of decision-making.

**The discussion on equity is important to sensitize government officials so that they can understand the importance of safeguarding interests of the small and marginal farmers who are the most vulnerable to climate change impacts.**

#### **10. Climate Smart Agriculture**

Climate-smart agriculture (CSA) is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. CSA aims to tackle three main objectives:

- Sustainably increasing agricultural productivity and incomes;
- Adapting and building resilience to climate change; and

- Reducing/removing GHG emissions, wherever possible.

#### **11. Early Warning Systems**

The set of technical, financial and institutional capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare to act promptly and appropriately to reduce the possibility of harm or loss. Dependent upon context, Early Warning Systems (EWS) may draw upon scientific and/or indigenous knowledge. EWS are also considered for ecological applications, e.g., conservation, where the organization itself is not threatened by hazard but the ecosystem under conservation is (an example is coral bleaching alerts), in agriculture (for example, warnings of ground frost, hailstorms) and in fisheries (storm and tsunami warnings).

#### **What Causes Climate Change (5 Minutes)?**

**Participative exercise with participants who are asked to share/discuss the contributing factors leading to climate change. This exercise can be the last exercise before lunch break**

Discussion Points: Travel & transportation, industrialization, deforestation, livestock production, farming, consumerism, overuse of electricity, aerosols, inability to change, etc.

#### **Concluding Points**

Even if we addressed every single other issue on this list today, the impact of human-caused global warming will remain for decades, if not centuries.

The magnitude of the issue is, quite simply, too difficult for many of us to comprehend. So, many of us wonder if we can't truly fix this issue, what's the point of even trying? After all, it's our very inaction that has caused or worsened many of these issues.

But humans are capable of change, as shown by the reduction in fuel combustion emissions seen in many countries since the early 2000s, including the United States, and by evolving public attitudes toward climate change and our role in it.

# Session 3

## Impact of Climate Change on Agriculture and Select Crops in Context of the Indo-Gangetic Plain

### Desired Outcome

Participants need to be made aware of the importance of the Indo-Gangetic Plain (IGP) and its contribution to food security in India. They are also introduced to the key crops grown in the IGP region. They are able to identify and understand the impact of climate change on these key crops.

### Duration

45 minutes +15 minutes

### Method

- Presentation (audio-visual)
- Question and answer session

### Material

White board and marker, projector

### Instructions for Trainer

This session is very important and will provide the base for sharing the findings of the study undertaken by the United Nations Development Programme (UNDP). Participants will be able to understand IGP, its importance and how climate change affects agriculture in the IGP.

### Resources

<http://admin.indiaenvironmentportal.org.in/files/Soils%20of%20the%20Indo-Gangetic%20Plains.pdf>,  
<https://www.jstor.org/stable/pdf/24107215.pdf>

### Subtopics to Cover

At the beginning of the exercise, participants may be asked to share their understanding of:

- (i) **Climate change impacts on agriculture (production, productivity, cost, quality, sustainability) key discussion points**
- (ii) **Understanding of IGP (geography, states, and which zone respective states such as Bihar and Uttar Pradesh are located)**

- The Planning Commission, as per its division of the region into various agro-climatic zones, has divided this area into four major sub-regions which are: 1) Trans Gangetic Plain; 2) Upper Gangetic Plain; 3) Middle Gangetic Plain; and 4) Lower Gangetic Plain. IGP covers five states (Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal) that occupy nearly 15 percent of the total geographical area and house approximately 38 percent of the population of the country. It is one of the most intensely farmed areas also and is popularly known as the food bowl of India due to its high contribution in production of cereal crops, especially rice and wheat.

Major crops grown in this area are rice, wheat, maize, chickpea, lentil, mustard, potato, sugarcane and vegetables. Rice- and wheat-based cropping systems cover most of the area from these two regions which can be attributed to its climate suitability, better adaptability, availability of high yielding varieties and increasing mechanization of both the crops.

- The productivity of most crops in this region is near their yield potential due to the presence of **favourable agro-climatic conditions** which are productive **alluvial soil, maximum irrigated land, sub-tropical climate**, etc.
- Agricultural practices adopted by farmers are **highly input intensive** with higher usage of resources such as fertilizer and water.
- The region contributes immensely to the national production of wheat and rice. The production of rice and wheat together in the IGP region contributes around 70 percent of the total production.
- The sector has been facing adverse climatic conditions such as **erratic insufficient, intense, untimely rainfall, rising temperature, floods, prolonged dry periods, droughts**, etc., in various degrees.

- In addition to the natural reasons that are causing problems to the overall natural resource availability and quality, there are human factors as well that are aggravating the situation and increasing vulnerability. The man-made factors consist of large-scale residue burning, physical, chemical and biological degradation of soil due to inappropriate crop rotation, unsustainable irrigation management practices and overuse of pesticides that are causing problems. As per some estimates around, 90-140 MT per year of crop residues are burnt to clear the fields. This is emerging as a major concern for air quality in the region.
- In India, agriculture contributes around 16-17 percent to Gross Domestic Product (GDP). However, climate change might impact the overall GDP by 1.5 percent<sup>32</sup>. By 2030, rice and wheat production is likely to decrease by 6-10 percent. Even the production of maize and sorghum would be impacted negatively due to climate change.
- Climate change impacts are likely to be more pronounced for rain-fed agriculture due to the absence of coping mechanisms to face rainfall variability<sup>33</sup>. There could be a serious impact on livelihoods related to agriculture with increasing frequency of extreme events such as drought and flood.
- In recent year, the region is increasingly experiencing floods, heavy and intense rainfall, prolong periods of dry and drought-like situations, increased humidity and associated increase in plant diseases. Such extreme climatic conditions are impacting agriculture in the region.

### Impact of climate change on agriculture in IGP

**The incidence of weather extremes, duration and frequencies of drought and floods are becoming/will become more frequent which may significantly impact the yields of rice in the region.**

### Drought

A period of abnormally dry weather long enough to cause a serious hydrological imbalance. For example, shortage of precipitation during the growing season impinges on crop production or ecosystem function in general (due to soil moisture drought, also termed agricultural drought) and, during the runoff and percolation season, primarily affects water supplies (hydrological drought). Storage changes in soil moisture and groundwater are also affected by increases in actual evapotranspiration in addition to reductions in precipitation. A period with an abnormal precipitation deficit is defined as a meteorological drought.

### Flood

The overflowing of the normal confines of a stream or other bodies of water, or the accumulation of water over areas that are not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods. Events such as floods lead to complete failure of existing crops. Water logging also affects the cropping timing of the next crop.

There are broadly three types of impacts of climate change:

- Production and productivity;
- Quality of produce; and
- Increased cost of production to minimize the impact of climate change.

In an extreme situation (flood/severe drought) there is also risk of complete loss of production.

The Indian Agricultural Research Institute (IARI) examined the vulnerability of agricultural production to climate change, with the objective of determining differences in climate change impacts on agriculture. Overall, temperature increases are predicted to reduce yields of cereal crops such as paddy and wheat. An increase of 2-4°C of temperature is predicted to result in a significant reduction in yield of paddy. The study also found that, for wheat crop, increases in temperature (by about 2°C) will lead to a reduction in yield<sup>34</sup>. Increased temperatures and decreased radiation will result in relatively fewer grains, smaller grain size and shorter grain filling durations<sup>35</sup> (Key sheet 6-Climate Change Impacts on Agriculture in India, Indian Agriculture Research Institute).

***The Ministry of Agriculture, in a written response to the parliamentary committee, said that crops such as wheat, paddy, maize, potato, cotton, sorghum, mustard and coconut are likely to be badly affected by climate change. The ministry informed the parliamentary committee, presided over by Bhartiya Janta Party leader Murli Manohar Joshi, that production of wheat would decline by 6 to 23 percent by 2050 if proper steps were not taken in a timely manner. The production of wheat could reduce by 6,000 kg for every 1°C rise in the temperature<sup>36</sup>. This parliamentary committee has made the 30th report on 'Demonstrating National Action Plan on Climate Change'.***

Climate change adaptation involves taking action to adjust to, or respond to, the effects of changes in climate. Adaptations to climate change exist at various levels during the growth cycle of crops. Types of adaptation ranges from change in variety, more application of inputs, change in planting and harvest dates, tillage and rotation practices, substitution of crop varieties, increased fertilizer or pesticide applications, and improved irrigation and drainage systems.

<sup>32</sup> <https://www.downtoearth.org.in/news/agriculture/climate-change-causes-about-1-5-per-cent-loss-in-india-s-gdp-57883>

<sup>33</sup> <http://www.indiaenvironmentportal.org.in/files/Defra-india-cc-agri.pdf>

<sup>34</sup> <http://www.indiaenvironmentportal.org.in/files/Defra-india-cc-agri.pdf>

<sup>35</sup> <http://www.indiaenvironmentportal.org.in/files/Defra-india-cc-agri.pdf>

<sup>36</sup> <http://krishijagran.com/news/climate-change-affecting-agriculture-wheat-production-in-india-could-drop-by-23-agri-ministry/>



# Session 4 and 5

## Understanding Small and Marginal Holders' Climate Change Impacts and Adaptations in IGP

### Desired Outcome

Participants may be asked to identify top five to six most important crops grown in the region and may be asked to share their basis of selection of crops.

Participants may be explained that this session will focus on five crops which we felt are important from the perspective of:

- (i) Number of households that grow these crops;
- (ii) Their importance for small and marginal land holder farmers; and
- (iii) Potential of value addition and scope of participation of farmers in the value chain and value transfer.

### Duration

3 hour session with 30 minutes break after 1 hour  
15 minutes

### Method

Discussion

### Material

White board, multi-colour markers, duster, drawing sheets, multicolour sketch pens

### Instructions for Trainer

The Trainer is expected to first introduce the topic and encourage participants to share more. A cropping calendar is to be designed with the help of participants. General as well as crop specific climate vulnerabilities are identified. Participants are asked to share their understanding of climate change impacts and adaptation methods. It is to be noted that, as far as possible, all participants are involved in discussions. The group can be identified as per crops and various crop-specific adaptation measures shared by participants in that crop-group are noted and presented to all.

### Resources

<https://nidm.gov.in/PDF/pubs/Adaptation%20to%20Climate%20Change.pdf>

[https://www.undp.org/content/dam/india/docs/climate\\_change\\_adaptation\\_activities\\_in\\_india\\_part\\_i.pdf](https://www.undp.org/content/dam/india/docs/climate_change_adaptation_activities_in_india_part_i.pdf)

### Sub-topics to cover Impact of Climate Change on Various Crops

***At the beginning of the session, participants may be asked to share their understanding/observations of climate change on various crops. Crops can be taken up one after one, starting with paddy and wheat in Session 4 and maize and horticulture in Session 5.***

***One crop may be taken up for discussion at a time and participants should be asked to explain the impact of climate change on that particular crop and the adaptations that they have observed.***

***(The focus should on making the session as interactive as possible)***

#### 1 Paddy/Rice

**Key discussion points for paddy:**

- Paddy, being a water dependent crop, is prone to extreme weather conditions.
- Excessive heat, humidity, erratic rainfall affects the growth of paddy and incidences of pest infestation.
- Increase in temperature leads to reduction in crop growth duration, increase in pollen sterility, reduced seed set and number of grains, and reduced grain weight which cause yield reduction.
- Farmers reported that, in recent years, climatic conditions have been very unpredictable. Unexplainable delays in rains, insufficient and untimely rains resulting in excessive humidity and prolong periods of high temperature are

resulting in increased incidences of pest attacks on paddy crop.

and the immunity level is reducing, making the crops more susceptible to diseases.

- Due to the prolonged period of heat, the moisture level in the soil has been decreasing

Perceived Impact of Climate Change	Frequency of Occurrence and Perceived Impact on Production
Loss of Crops due to Flood/Flood-like Situations	The frequency of occurrence of such events is low but whenever they happen there is complete loss of crops <b>(production loss)</b>
Loss of Crops due to Drought/Long Period of no Rains	The frequency of occurrence of drought or long period of no rains is frequent. If such a period occurs during the initial month, farmers shift the transplantation activities. If it happens at a later stage, farmers try to manage with additional irrigations <b>(productivity loss)</b>
Late Rainfall Affecting Nursery Preparation	The availability of short duration varieties of paddy compensates for the delay in nursery preparation. Farmers now prepare the nursery in phases to minimize the risks <b>(increased cost of production)</b>
Long Drought Periods leading to Increase in Weed/Pest Infestation	Increase in pest/insect infestation is leading to more usage of pesticides. Pest attacks at times lead to significant loss of yield <b>(increased cost of production)</b>
Quality Reduction of Paddy	Moisture, presence of empty shells and grain discoloration are some of the quality indicators that farmers notice <b>(quality loss)</b>

- The crop sometimes loses its natural shine and the weight of grain is also affected. Frequency of un-ripe paddy is also on the rise.
- Seed companies have introduced short varieties with shorter duration which has helped in mitigating climate change impact to some extent. Farmers have observed that these new varieties are more prone to diseases and therefore they are constantly under pressure to match the production by increasing doses of inputs to maintain production and to avoid incidences of pest attack.

Adaptation Measures	Reasons for Adaptation
Change in Seed Variety	<ul style="list-style-type: none"> <li>• New varieties are perceived to have higher resistance against drought and flood</li> <li>• Short duration varieties minimize the exposure risks to climatic variations</li> <li>• Short duration varieties provide flexibility to late transplantation due to delay in monsoon</li> <li>• Adoption of high yielding/hybrid varieties also compensate for yield loss</li> </ul>
Nursery Preparation in a Phased Manner	<ul style="list-style-type: none"> <li>• Nursery preparation is done in a phased manner and in surplus so that whenever there are rains, farmers have seedlings to transplant</li> </ul>
Increased Intercultural Operations	<ul style="list-style-type: none"> <li>• Long durations of dry period lead to more weeds. More intercultural operations help in improved soil and root zone aeration</li> <li>• Retains the moisture in the soil and promotes growth</li> </ul>
More Usage of Fertilizer	<ul style="list-style-type: none"> <li>• Usage of fertilizer is increasing continuously, and farmers believe that there is no other alternative</li> </ul>
More Usage of Insecticides/Pesticides/Herbicides	<ul style="list-style-type: none"> <li>• Pest infestation is increasing due to long durations of dry spells</li> <li>• Prevalence of disease is also increasing</li> </ul>

## 2 Wheat

### Key Discussion Points for Wheat

- Due to favourable climatic conditions, most major wheat growing states in India are located within IGP which includes states such as Uttar Pradesh, Punjab Haryana, Bihar, etc.
- The region provides favourable conditions with cool and moist weather during the winter which facilitates the growth of the plant and dry and warm weather from late February onwards that enables the grain to ripen properly.
- It is expected that climate change will lead to a rise in maximum temperatures in winter as well as reduction in number of days with low temperatures. This may affect the wheat grown especially in the middle part of IGP.
- Wheat is sensitive to high temperatures, especially during the reproductive stage as it increases the levels of water stress in the plant cell. Temperatures rising towards the end of its growth, especially during the grain-filling stage of development (early arrival of summer), affect the yield of wheat.
- Late sown wheat exposes pre-anthesis phenological events to high temperature which influence grain development and ultimately the yield.
- Rainfall or cloudy weather may lead to a rust attack in the wheat crop. Higher temperature at the time of maturity also leads to forced maturity resulting in yield loss.
- Farmers also reported that, during the ripening season, the fear of having rains or unfavourable conditions forces them to opt for harvesting, even when the crop grains haven't fully matured. This early harvesting leads to low recovery of grain with a higher proportion of immature seeds, broken and poor-quality grains. Such grains are more susceptible to disease during storage.

Climate Change as Perceived by Farmers	Impact
Late Arrival of Winter	Farmers have started shifting their cropping calendar. Modern seed varieties which generally take less time compensate for the delay in sowing
Less than Expected Decline in Temperature	It affects both the number of grains as well as the size of the grains
Unseasonal Rain in Winter	Other than rains which happen after the ripening of crops, it helps the crop
Early Arrival of Summer	It affects the grain quality and appearance
Increase in Pest Infestation	Pest and insects attacks are increasing and are also developing resistance against pesticides
Quality of Grains	Proportion of unusually small grains is increasing
Increase Presence of Foreign Matter	Farmers believe that it happens only when there is rainfall/hailstorm, etc., during the harvesting phase

*One of the most common adaptations taking place at the farmer level is experimenting with sowing dates to minimize the effect of temperature or residual moisture. Farmers also reported that the frequency of seed replacement has also increased. If sowing is delayed due to climatic variations, farmers also increase the seed rate by reducing the spacing between the plants.*

Adaptation Measures	Reasons
Change in Seed Variety	<ul style="list-style-type: none"> <li>Seed replacement has increased but not with change in variety</li> <li>Seed company/seed shops influence the decision making of farmers</li> <li>Shift towards 120-day variety</li> </ul>
Change in Sowing Time	<ul style="list-style-type: none"> <li>Farmers now advance/delay sowing as per the existing climatic conditions</li> <li>The window of sowing has also narrowed down</li> </ul>
Increased Intercultural Operations	<ul style="list-style-type: none"> <li>Use of herbicide has increased</li> </ul>
More Usage of Fertilizer	<ul style="list-style-type: none"> <li>Usage of fertilizer is increasing continuously and there is no other alternative</li> </ul>
More Usage of Pesticides/Herbicides	<ul style="list-style-type: none"> <li>Cost of using herbicides is lower than the earlier method of using labour</li> </ul>
Increased Mechanization	<ul style="list-style-type: none"> <li>In the harvesting phase, mechanization is increasing but it has more to do with labour shortage</li> </ul>
Post-harvest Measures	<ul style="list-style-type: none"> <li>Small farmers don't store wheat for long durations</li> <li>Local traders/aggregators don't pay much attention to quality</li> <li>Everyone in the channel believes that, in the value chain of wheat, quality is not given that much importance</li> </ul>

*Usage of better quality seeds, application of agro-chemicals and increased usage of fertilizer are helping farmers to mitigate the risks of climate change to a certain extent. Increased mechanization during the harvesting period has been one of the greatest adaptation strategies undertaken by farmers. Though used increasingly to overcome labour shortage, combine harvesters are also helping to reduce climatic risks by shortening the harvesting window after ripening of wheat. Though their use is helping farmers in reducing exposure of crops, it is leading to events such as residual burning which is a contributor of adverse climatic conditions.*

### 3 Maize

#### Key Discussion Points for Maize

- In comparison to other competing cereals, maize, due to its photo-insensitive nature has wider adaptability and can be grown in all cropping seasons. Kharif or early summer season maize is of short duration, while rabi season maize is of a little longer duration.
- Rabi maize is also considered to have superior transpiration efficiency, lesser usage of water per unit of production and high versatile usage which makes it easily marketable.
- Favourable agro-climatic conditions, low infestation of insect, pest and diseases, slow growth of weeds and almost no risks from extreme events such as flood or drought makes

maize an attractive crop in the rabi season. Cultivation of maize is also less resource (water, fertilizer, etc.) intensive, when compared to paddy or wheat IGP.

In comparison to rice and wheat, maize is less impacted by climatic vagaries. Prolonged high temperature and moisture affect the yield of maize due to hastened crop phenology, reduced photosynthesis, increased pollen sterility and poor grain filling with decreasing grain number. Kharif maize-growing farmers also recognize that erratic rainfall has high potential to damage pre-flowering stalks. Additionally, increased temperature and humidity raises the level of infection or infestation of various diseases and insect pests resulting in lower yields.



Climate Change Impact as Perceived by Farmers	Reasons
Loss of Crops due to Flood/Flood-like Situation	Rabi maize is cultivated in controlled irrigation and kharif maize is generally grown in uplands in the flood-prone regions
Loss of Crops due to Drought/Long Period of no Rains	Erratic rainfall influences maize growth in kharif as it affects soil moisture. The impact on rabi maize is negligible as it is cultivated in an irrigated environment
Unseasonal Rain in Rabi	Unseasonal rains and water logging affect the yield, both during harvesting as well immediately after harvesting. Uneven drying and unseasonal rains increase contamination in maize
Increase in Temperature	Increase in temperature affects yield of both kharif and rabi maize. It hastens the flowering season as well the grain filling process. Variability in the day and night temperature also affects the yield
Increase in Pest/Weed Infestation	Weeds pose a major problem in kharif maize and its effect is partial in winter maize

The inability of farmers to decide the right adaptation strategy makes them very vulnerable. Change in sowing dates and variety of seeds has been the key adaptation practice reported by farmers. Delay in sowing provides the opportunity for the crop to experience relatively lower temperatures during the grain filling period. Across the region, preference for short duration varieties of seeds is increasing.

Adaptation Measures	Reasons
Change in Seed Varieties	<ul style="list-style-type: none"> <li>New varieties are perceived to have higher resistance against drought and flood</li> </ul>
Shift in Sowing Time	<ul style="list-style-type: none"> <li>Late sowing by 15-20 days in the kharif season and 10-15 days in rabi</li> </ul>
Increased Intercultural Operations	<ul style="list-style-type: none"> <li>Long durations of dry period lead to more weeds. More intercultural operations help in improved soil and rootzone aeration</li> <li>Retains the moisture in the soil</li> </ul>
More Usage of Insecticides/Pesticides/Herbicides	<ul style="list-style-type: none"> <li>Increase in spray for insect/pest control. Frequency of spraying is increasing</li> </ul>

**Tea break/small break of 20 minutes**

#### 4 Potato

##### Key Discussion Points for Potato

- The Indian potato belt stretches from Punjab (North West) to West Bengal in East India. Uttar Pradesh, West Bengal, Bihar and Punjab together account for about 86 percent of India's potato production. Uttar Pradesh is the largest producer of potatoes in India.
- Potato is a cool season crop and tolerates frost moderately. The ideal temperature for its growth during the initial stage is around 25°C. Deep, well-drained and friable soils having good organic matter are ideal for its cultivation.
- Potato is highly susceptible to climate change in comparison to other crops and adverse climatic situations can affect productivity, quality (size and appearance), cost of production and storage.
- Potato is best adapted to cool climates with

temperatures in the range of 15 to 25°C.

Temperature higher than this range retards tuberization. Additionally, heat stress also leads to a higher proportion of smaller tubers with paler skin colour of the tubers. Temperature above 25-30°C shortens the growing period of potatoes and reduces tuber yield.

- During the winter longer-than-usual periods of frost and dew cause the foliage to remain wet for prolonged periods during the day which also affects crop growth.
- The crop is also sensitive to water and yield is reduced in drought as well in waterlogged conditions. Drought events occurring early in the growing season reduce the number of tubers per plant and even a single, short-term drought during tuber bulking decreases potato quality (i.e., tuber size and appearance) along with the overall yield.

- Unseasonal rains around harvest lead to high soil moisture conditions which result in rotting of crops and make produce extremely vulnerable to disease/pest infestation even after harvesting.
- Variations in irrigation and temperatures also cause the harvested produce to be of smaller size substantially increasing the on and off farm grading and sorting costs.

Climate Change Impact as Perceived by Farmers	Reasons
Late Arrival of Winter	Farmers adjust the sowing window to minimize the impact
Lower Duration of Winter	Size of tuber gets affected due to early maturing
High Frost and Dew Conditions	Plant growth gets affected
Less than Expected Decline in Temperature	Both quality and yield get affected as it directly affects both the number and size of tuber
Unseasonal Rain in Winter	Leads to rotting and pest infestation
High Temperature and Humidity at the Time/After Harvesting	Farmers feel that the quality of harvested potato deteriorates very fast due to high temperature and humidity  Apart from climatic change, they also attribute this to high usage of chemical fertilizers and pesticides

Potato growers' adaptation strategies range from usage of newer seeds, more application of inputs, change in planting and harvest dates, and increased applications of fertilizers or pesticides. The most common adaptation happening at the potato growers' level is experimentation with sowing and harvesting dates which helps them to minimize the effect of temperature or residual moisture. In order to adapt to frequent

temperature variations, small and marginal farmers have reported using shorter duration varieties that mature much earlier than the traditional varieties. These varieties can be harvested in 70-90 days which not only helps the farmers in avoiding high stress periods by strategically sowing the crop but also generates higher income as early harvested potato fetches a higher price in the market.

Adaptation Measures	Reasons
Change in Sowing Time	10 to 15 days shifting is common
Increased Intercultural Operations	Frequent earthing up and mulching of ridges helps in better soil and water management. It also leads to better germination
Adoption of Alternate Crops/ Intercropping	Even though potato is considered ideal for intercropping, farmers are not very keen on cultivating potato with other crops
More Usage of Fertilizer	Nitrogen-based fertilizer usage is increasing
More Usage of Insecticides/Pesticides/ Herbicides	Usage of herbicides and insecticides has increased due to more incidences of weeds and insects
More Irrigation	Light but regular irrigation is helpful especially in critical stages during crop development, tuber initiation and tuber development; 15-20 days before harvesting, farmers stop irrigation
Selling Immediately after Harvest	Small and marginal farmers prefer to sell the produce immediately to minimize the rotting

## 5 Tomato

### Key Discussion Points for Tomato

- Tomato is the second most grown vegetable in the districts of IGP after potato. It is grown as a winter as well as a summer crop.
- Complete failure of crops, shortage of yields, reduction in quality and increasing pestilence and disease are some of the key challenges faced by the farmers due to climatic variations.
- Since the crop is most vulnerable to climate change, adverse climatic conditions cause severe damage to the tomato crop. The crop is highly susceptible to increased temperature and drought-like conditions.
- The crop needs a controlled supply of water throughout the growing period to maintain quality and productivity. As the crop is sensitive to water deficits, in phases such as post transplantation, flowering and fruit development regular water supply needs to be ensured.
- Long periods of heat stress also have very adverse effect on crop production as they affect the vegetative and reproductive processes of tomato leading to a reduction in yield and fruit quality.
- Rains with high intensity can cause severe damage to plants both during nursery as well in the initial days after transplantation.
- During the ripening season, high rainfalls significantly damage both quality and quantity of tomato produced. Incidence of water logging causes serious damage to tomato.
- Attacks of disease have increased significantly with high incidence of cases of complete burning of flowers and curling of leaves.
- Climatic variations also affect post-harvest quality and cause severe losses further in the value chain. Variations in temperature, rainfall, humidity and dew affect the growth and spread of fungi and bacteria which affects the fruit's colour and appearance as well as shelf life after harvesting.
- If temperature is high, despite good vegetative growth of the crop, there may be a lower number of fruits as high temperature causes more production of male flowers while low temperature leads to production of more female flower.
- Continuous exposure to high temperatures also reduces the number of pollen grains in the flower. High temperature also affects the shine and size of tomato.

Climate Change Impact as Perceived by Farmers	Reasons
High Temperature	Increase in temperature affects quantity and quality of the produce both in rabi as well as in the summer crop
Erratic Rainfall	Erratic rains affect at the time of nursery preparation, early days of transplantation and ripening
Increased Frequency of Pest Attack	Increased attacks of pests and insects are the biggest climate change threat
Reduced Production	The effect of climate change in production is limited
Quality of Yield	Both appearance and size of tomato are affected due to adverse climatic conditions during the growing period.

# Session 6 and 7

## Capturing Participants' Understanding about Agriculture Value Chains and Value Chain Actors in IGP Region

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### Desired Outcome

1. Warming up session. Participants get the opportunity to share their understanding of agri value chains.
2. Participants identify the key agri value chains operating in the IGP region, value chain agents, value addition and interdependence among value chain agents. Impact of climate change on these value chains and adaptation measures undertaken by value chain agents across value chain.

### Duration

30 minutes + 10 minutes break + 45 minutes

### Method

- Brainstorming
- Presentation
- Question and answer session

### Material

One drawing sheet per group, sketch pen box, colour sticky notes.

### Instructions for Trainer

A short introduction of value chains and agri value chains is given to participants. Post this, groups of four or five participants are formed and asked to identify agri value chains of key crops from IGP. Each group may then present the findings.

The Trainer must remember that she/he is more of a facilitator who should focus on drawing ideas out of participants' minds rather than dominating the entire discussion with her/his own ideas.

### Sub Topics to Cover

A value chain is simply defined as the path or system which adds value to the product or service offered. In the case of agri value chains, this path has different actors and varying value contribution takes place at different levels. Value contribution is a function of relationships between these actors, information sharing and use, and handling of processes efficiently. Value chain actors are a set of actors that are involved in a value chain and who collectively add value. These actors could be identified as the growers, those involved in aggregation and collection, transporters and warehouse agents and food processors. These value chain actors add value through different sets of activities.

### Instructions for the Trainer

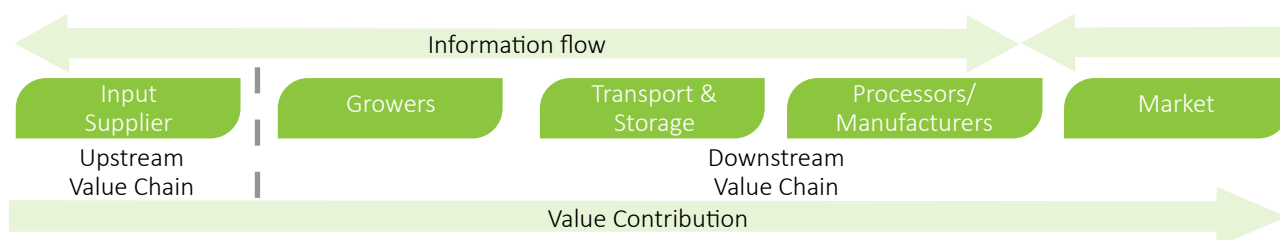
This session should be built on group presentations and understanding of agriculture value chains in the IGP region.

### Sub-topics to Cover

**Value Chains of Major Crops in IGP and Impact of Climate Change:** Growth and development of agricultural value chains is a powerful medium of economic empowerment particularly for small and marginal farmers. The value chain is a sequence of value addition activities, from production of agriculture produce to making it fit for consumption in various forms, through activities such as transportation, storage and processing.

The Trainer can show the following diagram to the participants.





### Key Discussion Points

- Climate change impacts value chains in many ways. It affects the quality and yield of agriculture commodities and hence, to maintain the quality of final products, value chain agents need to adapt by making changes in their supply chains and production systems which require additional resources.
- Climate change sometimes adversely impacts production in their procurement areas and they need to make alternative arrangements for procurement leading to higher procurement and transportation costs.
- Climate change can also have impact the quality of final products as well their shelf life.
- The impact of climate change is also leading to an increased tendency on the part of value chain agents to relax the quality norms for procuring paddy/wheat from farmers due to their long-term relations and interdependency.
- A change in climatic conditions increases the cost of operations for warehouse/cold storage owners due to an increase in electricity charges and fumigation expenses and a decrease in capacity utilization.
- The impact of climate change is felt by small businesses more than big businesses as small businesses lack resources for adequate planning and preparedness. The vulnerability of small businesses also increases due to a lack of financial resources to endure even a small rupture in the supply chain which may be caused, for instance, due to an extreme weather event.
- As flow of raw material starts from the farmers' end and affects all actors in the value chain. The adoption of short duration high yielding varieties by farmers as an adaptation in monsoon crops affects the business of traders, warehouse owners, transporters as well the final processors. Similarly, an increase in moisture content of the raw material affects the conversion ratio during processing, increases the cost of production and leads to higher investments in new equipment and machines.

The following image can be used for starting the discussion and participants may be asked to share live examples.



#### Impact on Raw Material Supply

- Supply of farm produce not meeting quality specification
- Inadequate supply from regular procurement area/ fluctuating supply
- Working capital management issues due to disruptive procurement (credit/payments/ cash purchase, etc.)



#### Impact on Supply Chain

- High cost of storage in warehouses due to increased expense in fumigation expense, capacity underutilization
- Quality deterioration risks of both raw material as well as finished products



#### Impact on Logistics

- Increased cost of transportation due to production loss in the natural procurement area
- Higher cost in transportation to maintain quality standards
- Increased risk in supplying finished products



#### Impact on Production/ Processing

- Quality of final product
- Low shelf life of final product
- Additional investment machineries

- One of the impacts with respect to storage of paddy is retention of moisture level at the warehouse. It needs to constantly be maintained below 14 percent and proper safeguards need to be undertaken to ensure that it doesn't imbibe moisture from the surrounding air.
- Increased temperature and humidity are considered to be favourable for growth of storage insect pests as they can multiply faster in these conditions. To maintain the quality, grain stacked in gunny bags needs to be periodically fumigated; warehouses therefore need to go in for more cycles of fumigation which results in increased cost of warehouse maintenance.
- The impact of climate change is felt in decreased grain weight, reduced grain filling, and a higher percentage of white chalky and milky white rice are common effects of high temperature during the ripening stage. Regular increases in temperature, prolonged periods of drought-like situations amid the rainy season affect the moisture content of paddy which leads to a higher percentage of broken rice.
- In recent years the percentage of broken rice has increased by 2 to 3 percent. Short duration paddy has lower conversion rates to the extent of 1 to 2 percent than the traditional variety. The short duration variety paddy is relatively more brittle and so the percentage of broken rice is high.
- Processors reported that, in recent years, due to changing climate conditions, incidences of high moisture in rice, higher percentage of broken and black rice and impurities are affecting the quality and cost of processing. This leads to 2 to 3 percent of loss of the finished product leading to a production loss of INR 90-100 per quintal of puffed rice produced.

#### **Impact of Climate Change on Wheat Value Chain**

- Around 30 to 35 percent of the wheat produced by the farmers is used for self-consumption, around 5 percent is retained for seed while the remaining produce is marketable surplus.
- Sudden rain, hailstorm, heavy winds sometimes destroy or damage the wheat crop so much that such crop is used for animal feed purposes only.
- The arrival for wheat into warehouses, in both Bihar and Uttar Pradesh, starts in the month of April and continues till early June. The primary aim of storage activity is to prevent deterioration of the quality of grain. This is done through control of moisture and

aeration and by saving the wheat grains from the attack of microorganisms, insects and rodents.

- The storage of wheat starts in early summer and it continues till the rainy season. During this storage period, both temperature and humidity increases which is favourable for proliferation of storage insect pests. Under the hot and humid climate, they can multiply faster.
- Sometimes due to the early harvest, wheat grains have higher moisture content which increases the risk of quality deterioration. To maintain the quality, grain stacked in gunny bags needs to be periodically fumigated. In such circumstances, warehouses must apply more cycles of fumigation which results in increased cost of storage.
- Early onset of summer affects the quality of wheat grain. This effect is magnified at the grain filling stage which leads to reduced grain size. Untimely rains before/at time of the harvest result in discoloured wheat. The recent experience of untimely rain during harvest months compelled farmers to harvest crop produce before maturity in haste.
- Millers reported that wheat with higher moisture content tends to consume more energy during processing. Although it is difficult to quantify the exact correlation, a pattern of higher energy consumption is being observed. Millers also stated that use of drying units was not very common earlier. Now as it becomes common, electricity consumption has risen by roughly 10-15 percent.
- Roller millers stated that the extraction proportion for different products such as *maida/sooji* also depends upon the moisture content of wheat. The quality of *maida* is affected by the high moisture content in wheat. The cost of processing has increased to match the quality requirement due to investment in advanced machines such as sievers, grinders and driers.

#### **Impact of Climate Change on Maize Value Chain**

Adverse climatic conditions affect the quantity and quality of maize and have a cascading effect on the entire value chain albeit with varying degrees. Most value chain agents use maize grain rather than its by-products. This peculiarity of the maize value chain makes it susceptible to any adverse impact on quantity and quality of maize production.

- The risk of incidences of storage pest/fungus on the stored grain has increased which is attributed to climate change by warehouse owners. This affects

the extraction percentage and quality of different derivatives of maize.

- Slightly increased occurrence of mycotoxin and aflatoxin levels in the stored maize has been observed in recent years which can be attributed to increased humidity levels.
- Maize forms 50-60 percent of the input required for broiler feed and 25-35 percent of the input required for layer feed. In general, raw materials used as ingredients for preparing feeds include maize, bajra, soybean oil cakes, rice-bran groundnut, other oilseed cake, etc.
- For both broilers and layers, two to three types of feed are used (starter, finisher, etc., for broilers and chick mash, grower mash, layer mash, etc., for layers). In terms of production, 80 percent of poultry feed is produced in pellet form and the balance 20 percent in mash form. Maize is the main source of energy in poultry feeds and soybean contributes to the protein element.
- Feed industries hire the services of drying units to reduce the moisture level in maize from 15-16 percent to 12-13 percent by using drying units to meet the feed industry's requirement. Cattle feed manufacturers also reported that, despite using dryers, a minimum of 2 percentage of maize procured by them goes into wastage as it is beyond the acceptable limit of quality standards at the time of processing.

#### **Impact of Climate Change on the Potato Value Chain**

- Potato is considered a staple crop and is used in three ways: 60 to 65 percent is utilized as vegetable for domestic table consumption while another 18 to 20 percent is used as seed. Roughly 8 to 10 percent of the produce is used for higher value-added potato products.
- Potato-processing is split into organized and unorganized sectors. The organized sector is under the control of large manufacturers with a presence across the country while the unorganized sector comprises small manufacturers with less-known or no brand names operating at the regional level.
- Potato chips are the most common product across both sectors. The processing industry in the IGP region is restricted to the unorganized sector and small players. The suitability of the variety grown in both Bihar and Uttar Pradesh is the key hindrance in development of large potato processing units.

- The impacts of climate change on cold storage are two-fold: higher electricity charges due to a rise in temperatures; and humidity management. The longer summer season and delayed monsoons also affect the operations of cold storages by raising the operational costs of running cold storages as they require larger amounts of electricity to maintain optimal levels of temperature and humidity. As reported by cold storage owners, their electricity consumption units have increased by about 10-12 percent in the last few years.
- The highest climate change impact faced by potato processors is in terms of the quality of the potato. Increased temperatures often lead to smaller size of the potato which increase wastage during peeling due to higher amount of peeling losses as a higher proportion of potatoes have diameters of less than 40 mm.
- Farmers in the IGP region prefer early maturing varieties while late maturing varieties contain high dry matter as required for processing industries. High usage of fertilizers also reduces the dry matter presence in potatoes. Potatoes with lower dry matter increase the energy cost as well quantum of cooking oil required to fry it. Additionally, during storage of potato the proportion of sugar increases which leads to change in colour to brown/black.

#### **Impact of Climate Change on the Tomato Value Chain**

- Due to high perishability and shorter shelf-life of the product, transportation is one of the most critical factors in the value chain of tomato. The quality of tomatoes is affected at every level during the transportation, starting from the farms to end consumers. Supply chain bottlenecks and quality of yield which are highly vulnerable consequently result in poor price realization for producers. In between, there are very high losses in the value chain. The biggest challenge with transportation and storage is the lack of cold chains in the tomato value chain. In the districts of IGP, there is a scarcity of storage facilities around the production centres.
- The very nature of the processing of tomato by processing units reduces the impact of climate-related quality changes in tomato. Due to decreasing shelf life, in recent years, the supply of tomato is, in fact, growing for processors as traders consider these units as the last resort to minimize their losses. On the other hand, processors are matching shortfall in supply due to adverse climatic conditions from distant regions and sometimes even importing.

# Session 8 and 9

## Desired Outcome

This session will be the concluding session. Before starting the session, there should be a small discussion on enabling conditions and how they can be developed and who will develop them.

## Duration

45 minutes + 15 minutes + 45 minutes

## Method

Discussion, presentation

## Material

White board, multi-colour markers, duster, laptop/desktop projector.

## Instructions for Trainer

The Trainer is expected to introduce key findings of the study undertaken with the participants.

## Sub Topics to Cover

### Key Information Gap Existing

This can be achieved through a participatory planning process which involves all key stakeholders (farmers,

Information Gap Themes	Key Areas for Capacity Building
Production and Productivity	Varietal knowledge which includes awareness on flood- and drought-resistant/tolerant varieties, staggered cropping planning, shift in sowing/transplantation and harvesting dates, community nurseries, weed and pest management, intercropping and crop rotation, etc.
Harvesting, Post-harvest and Value Chain	Grain maturity and harvesting, drying, in-house storage, moisture management, orientation on commercial warehouse functioning, transportation, cold storage, seasonal fluctuation of prices, shelf-life management, etc.
Sustainability Enhancement	Nutrient management, soil moisture management, water management, rainwater conservation, natural farming, system of crop intensification, agriculture residue disposal (stubble burning), etc.
Financial Linkage, Insurance and Leveraging Government Support	Crop insurance, farm credit, warehouse financing, agriculture credit (Kisan Credit Card), community institutions (Self-help groups and federations, producer groups and companies), micro financial institutions, Primary Agricultural Credit Society, credit cooperatives, National Bank for Agriculture and Rural Development (NABARD) schemes, etc.
Technological/Mechanization	Usage of commercial driers, moisture management, combine threshers, and other implements, custom hiring centre concepts, etc.
Weather and Climate	Crop advisory, weather advisory, and predictions, other sources of weather-related information (mass media, print media), etc.





women, collectives, extension services, research institutions, the government, etc.) and is targeted specifically to reach the small and marginal farming households which are most vulnerable to climate change events.

It will require work on enabling services to communities through partnerships with research institutions or resource organizations.

- Weather-based, agri-advisory services can help farmers make climate-smart decisions. Government and private sector agencies such as Skymet/ meteorological departments, etc., can help in designing and customizing early warning systems for one time/seasonal forecasts as well as non-disaster forecasts.
- Participatory/communitized information-sharing mechanisms can be developed through the concept of farmer schools or other institutional mechanisms through convergence with the Gram Panchayat, Village Organizations, and other government departments. These village-level demonstration centres can be managed through institutional collaboration with research institutions/resource organizations (National Rural Livelihoods Mission (NRLM), Kisan Vigyan Kendra (KVKs) etc).
- Making changes in the package of practices can help farmers in reducing the impact of climate change. This becomes even more relevant as input-driven production increase has reached the level of stagnation for most of the crops. Capacity building needs to be undertaken to improve the resilience of farmers through adaptation measures.
- Farmers also need to be trained in better water management agriculture practises (System of Rice/Wheat Intensification). Agricultural research institutions and agriculture extension services can work on the development of experimental model fields.
- Improved coordination and deeper integration, across the existing supply chain, will be the key to

mitigating climate change impact by processors. Key steps would likely include implementing successful models of contract farming between processors (as well as traders) and farmers, integrating inputs, technical services to improve farming practices.

- Agriculture research institutes also need to work on developing traits such as multiple insect resistance and herbicide tolerance in the seeds being promoted so that the use of chemical pesticides may be reduced. Most seeds used are already of hybrid varieties in maize; the choice of seed is influenced by seed shops/marketing agents from seed companies. Agriculture research and agriculture extension should work to ensure the availability of such seeds to farmers.
- Another area of support required is in terms of better crop insurance products and assessment of losses as incidents such as flood and drought impact paddy cultivation.
- There is a need to align traditional methods of weather projections with climate-smart methods of EWS.
- The location of warehouses is the most important factor. The small or marginal producer, with meagre marketable surplus, will not find it convenient to carry his produce all the way from his farm to the warehousing point. During the study, it was also realized that many warehouses are underutilized. The government may need to support construction of small and decentralized warehouses through the right policy initiatives.
- Most units in the identified value chain belong to micro and small-scale industries, undertake limited value addition activities and do not deal with high-end processing or processing of high-end varieties. Such industries may need support through specific schemes for additional investments in plant and machinery or purchase of new machines/ replacement of old units.

- To increase the participation of farmers in the value chain, decentralization of storage facilities needs to be explored. The government may need to work closely with entrepreneurs to facilitate/support construction of small and micro warehouses (Gram Panchayat level) which should be located near the production centres.

Manual handling and poor storage infrastructure lead to an increase in moisture content of maize of up to 20 percent, which should ideally be up to 13 percent. Maize with a moisture level of more than 15 percent is not considered suitable for the feed industry. This affects the farmer's share in the maize value chain. One

of the areas of intervention could be to increase the establishment of dryer units near production locations. State governments may also plan to subsidize portable maize dryers.

- Perishable crops such as tomato require immediate cold storage to maintain their freshness for longer periods. Even though large numbers of cold storages have been developed in the IGP region, they are designed for storage of a single commodity which is mostly potato. The development of small cold storages which are suitable for the storage of multiple crops is required.

Area	Activity	Requisite Skills of Government/ Research Institutions
Phase-wise Nursery/ Plantation Planning	<ul style="list-style-type: none"> <li>Member-wise crop planning</li> <li>Placing order with seed companies</li> <li>Bidding by members for planting nurseries</li> <li>Pricing mechanism for nursery delivery</li> </ul>	<ul style="list-style-type: none"> <li>Fair, transparent and consistent price discovery mechanism</li> </ul>
Enhanced Information Dissemination Mechanism	<ul style="list-style-type: none"> <li>Dedicated cadre for weather and crop advisory-related information dissemination</li> <li>Skill development of information warriors</li> <li>Recorded voice calls with actionable advisory</li> </ul>	<ul style="list-style-type: none"> <li>Ability to communicate actionable advices</li> <li>Understanding of ever-evolving technology landscape</li> </ul>
Improved Weather Insurance Cover	<ul style="list-style-type: none"> <li>Localized weather stations</li> <li>Enhanced use of technology in production loss assessment</li> <li>Adherence to turnaround time in claim settlement</li> <li>Import duty cut on localized weather stations</li> <li>Viability gap funding for insurance companies using collectives in insurance ecosystem</li> </ul>	<ul style="list-style-type: none"> <li>Understanding of trade policies</li> <li>Negotiations</li> <li>Monitoring</li> <li>Big data analysis</li> </ul>
Enhanced Irrigation Facilities	<ul style="list-style-type: none"> <li>Tax incentives for collectives running irrigation as service</li> </ul>	<ul style="list-style-type: none"> <li>Big data analysis</li> <li>Negotiation skills</li> </ul>
Weather-resistant Crops	<ul style="list-style-type: none"> <li>Corporate incentives for research into weather resistant varieties</li> <li>Strong intellectual property regulation regime</li> <li>Time-bound dispute resolution mechanism through arbitration</li> <li>Incentives for government funded research institutes for monetization of researches</li> <li>Dissemination through collectives</li> </ul>	<ul style="list-style-type: none"> <li>Trade relationship with research institutions</li> <li>Big data analysis</li> </ul>
Decentralized Warehousing	<ul style="list-style-type: none"> <li>Incentives for collectives to run small warehouses</li> <li>Mechanism similar to the Insolvency and Bankruptcy Code for collectives to deal with business failures in timely manner</li> </ul>	<ul style="list-style-type: none"> <li>Big data analysis</li> <li>Financial systems understanding</li> </ul>
Grading of Output and Lower Level of Value Addition	<ul style="list-style-type: none"> <li>Collectives to get their members skilled on grading/ value addition through Pradhan Mantri Krishi Sinchayee Yojana (PMSKY)</li> </ul>	<ul style="list-style-type: none"> <li>Not applicable</li> </ul>

A photograph of a middle-aged man with grey hair and a beard, wearing a light-colored striped shirt, standing in a green field under a blue sky. The number '2' is overlaid on the left side of the image.

# 2

## Training Module 2 For Farmers/Collective Institutions on Climate Change and Adaptations by Agri Value Chains



# Session 1

## Introduction of the Facilitator, Workshop and Participants

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### Desired Outcome

Participants are familiar with each other and the facilitator of the workshop. An informal tone is set for the workshop.

### Duration

60 minutes

### Method

- Introduction
- Presentation
- Discussion

### Material

30 chits, sketch pens

### Instructions for Trainer

Explain the objective of the workshop to the participants.

Participants' expectation from the workshop to be written on a drawing sheet and to be placed on display. Formation of ground rules. Participants are encouraged to come up with the ideas to make the workshop effective such as use of mobile phones during the workshop, participation protocol within the participants and with the facilitator, punctuality, etc.

### Resources

**Icebreaking Tips:** There are many ways of making the participants feel comfortable and make the entire ambience more informal. It's important that the trainer and participants know each other well. The process/games could be place/participants-specific yet there should be some unique ways of getting to know the participants, such as the following.

There are some games in the reference material which could be adapted to make more relevant examples (<http://reprolineplus.org/system/files/resources/icebreak2.pdf>)

# Session 2

## Introduction to Climate Change and its impact on Agriculture

### Desired Outcome

Participants are able to define basic concepts related to climate change and understand the reasons for climate change.

### Duration

2 small sessions of 1 hour each with smaller breaks in between

### Method

- Brainstorming
- Presentation
- Question and answer session

### Material

PPT, white board and marker, audio-visual system

### Instructions for Trainer

This session is to be built on the group presentations on understanding of climate change by the participants. At the end of the exercise, participants should be able to understand the reasons and consequences of climate change. In addition to this, participants should also be able to understand the basic terms associated with climate change.

### Resources

The following textual and audio-visual resource material to be referred to in the session in addition to the key points shared below.

<https://unfccc.int/process-and-meetings/the-convention/glossary-of-climate-change-acronyms-and-terms>

<https://climatechange.ucdavis.edu/science/climate-change-definitions/>

<https://www.ipcc.ch/sr15/chapter/glossary/>

[https://www.undp.org/content/dam/india/docs/undp\\_climate\\_change.pdf](https://www.undp.org/content/dam/india/docs/undp_climate_change.pdf)

<https://climate.nasa.gov/images-of-change?id=699#699-icelands-ok-glacier-melts-away>

[https://calp2016.sites.olt.ubc.ca/files/2019/05/Introduction-to-Climate-Change\\_CALP-UBC.pdf](https://calp2016.sites.olt.ubc.ca/files/2019/05/Introduction-to-Climate-Change_CALP-UBC.pdf)

<https://youtu.be/XMf-flqNqgw>

<https://youtu.be/OHnrBUoD4S0>

<https://royalsociety.org/topics-policy/projects/climate-change-evidence-causes/basics-of-climate-change/>

### Sub Topics to Cover

Under this topic, which is going to form a basis for further sessions, we are going to look at the basic concepts of climate and climate change.

**Introduction to climate and climate change, key terms used in climate change discussions, causes of climate change and impact of climate change on agriculture.**

#### Difference between Weather and Climate

Weather refers to atmospheric conditions in the short term, including changes in temperature, humidity, precipitation, cloudiness, brightness, wind, and visibility. While the weather is always changing, especially over the short term, climate is the average of weather patterns over a longer period (may be more than 30 years).

Climate can be understood as the average of weather over time and across large regions. (The classic period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.)



### Key terms to be focused during discussions:

- Long-term verses short-term;
- Small geographical areas verses large geographic regions; and
- Small variability verses long-term trends.

Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. **The Framework Convention on Climate Change, in its Article 1, defines climate change as: a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.** This variation may be caused by both natural processes and human activity. Global warming is one of the aspects of climate change.

Climate variability refers to variations in the mean state and other statistics of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability) or to variations in natural or anthropogenic external forcing (external variability).

### Other important terms used in climate change discussions<sup>37,38,39,40</sup>

#### Participants need to be provided a brief on sustainable development and Sustainable Development Goals.

- Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs and balances social, economic and environmental concerns.  
(Optional Discussion: If participants are interested, a quick list of Sustainable Development Goals, it may be shared/discussed. Else this can be skipped).
- The 17 global goals for development for all countries established by the United Nations through a participatory process and elaborated in the 2030 Agenda for Sustainable Development, including ending poverty and hunger; ensuring health and well-being, education, gender equality, clean water and energy, and decent work; building and ensuring resilient and sustainable infrastructure, cities and consumption; reducing inequalities; protecting land

and water ecosystems; promoting peace, justice and partnerships; and taking urgent action on climate change.

**A short 10-minute tea break may be provided and after that participants should be made aware of key terms associated with climate change. This session should be made participative with participants be asked to share their understanding of key words and key words can be written on white board/chart papers/flip charts. Once participants are through with their understanding, the Trainer can share his definition or understanding.**

#### 1 Vulnerability

It is the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

It is basically the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change. Vulnerability is a function of the character, magnitude and rate of climate change, and variation to which a system is exposed, and its sensitivity and adaptive capacity.

It is usually described as a condition of susceptibility shaped by exposure sensitivity and resilience. It refers to the (in)ability of people to avoid, cope with or recover from the harmful impacts of factors that disrupt their lives and that are beyond their immediate control. This includes both shocks and trends.

(Shocks are sudden changes such as natural hazards, war or collapsing market prices) and trends (for example, gradual environmental degradation, oppressive political systems or deteriorating terms of trade).

**In relation to climate change, vulnerability relates to direct effects such as more storms, lower rainfall or sea level rises that lead to displacement and to indirect effects such as lower productivity from changing ecosystems or disruption to economic systems.**

**It is also important for farmers to understand the vulnerabilities of their cropping system at different stages of growth (nursery vis-à-vis mature plant). Other examples can be the vulnerability of small**

<sup>37</sup> <https://www.climaterealityproject.org/blog/key-terms-you-need-understand-climate-change>

<sup>38</sup> [https://www.agmrc.org/media/cms/Glossary\\_of\\_Global\\_Warming\\_and\\_Clim\\_4314FBAC16B15.pdf](https://www.agmrc.org/media/cms/Glossary_of_Global_Warming_and_Clim_4314FBAC16B15.pdf)

<sup>39</sup> <https://climatechange.ucdavis.edu/science/climate-change-definitions/>

<sup>40</sup> [http://www.fao.org/fileadmin/user\\_upload/rome2007/docs/1\\_Climate%20Change%20and%20Agr.pdf](http://www.fao.org/fileadmin/user_upload/rome2007/docs/1_Climate%20Change%20and%20Agr.pdf)

**child vis-à-vis adult.**

### Participative Exercises

- (i) Farmers may be encouraged to arrange the crops with respect to their vulnerabilities at different stages of growth.
- (ii) Farmers should be encouraged to identify the factors which increase/decrease their vulnerability

## 2 Resilience

Resilience is the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning. It is the capacity of self-organization, and the capacity to adapt to stress and change.

In other words, it is the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation.

In the context of people, it represents their ability to withstand the impact of the trends and shocks described above, absorbing them while maintaining function. It is determined by two characteristics of people's livelihoods: the assets they possess and services provided by external infrastructure and institutions. Taken together, the reduction of vulnerabilities and improvement of resilience of poor people to withstand the impacts of climate change will improve their *security*: that is, the extent to which they can live their lives and conduct their livelihoods free from threats.

### Participative Exercise

- (i) Identify the measures which farmers are undertaking to reduce their vulnerabilities and increase their resilience
- (ii) How are resilience and vulnerabilities interlinked?

## 3 Adaptation

The process of adjustment to actual or expected climate and its effects, to moderate harm or exploit beneficial opportunities. These are the actions that help to cope with the effects of climate change.

It is the ability to respond and adjust to actual or potential impacts of changing climate conditions in ways that moderate harm or takes advantage of any positive opportunities that the climate may

afford. It includes policies and measures to reduce exposure to climate variability and extremes, and the strengthening of adaptive capacity.

For example, construction of barriers to protect against rising sea levels, or adoption of crops capable of surviving high temperatures and drought or a change in the package of practices which includes change in inputs as well as in processes or technology.

**Climate change adaptation** refers to the adjustments societies or ecosystems make to limit the negative effects of climate change or to take advantage of opportunities provided by a changing climate. Adaptation can range from farmers planting more **drought-resistant crops** to coastal communities evaluating how best to protect themselves from sea level.

## 4 Adaptive Capacity

The ability of a system (e.g., ecosystem) to adapt to climate change or other environmental disturbances.

It is the ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences. This may mean moderating potential damage, taking advantage of opportunities or coping with the consequences. In discussions on global warming, adaptive capacity often refers to a country. In this case, it is currently much lower in developing countries, consequential to poverty.

**Anticipatory adaptation** that takes place before the impacts of climate change are observed. **Incremental adaptations** are those that maintain the essence and integrity of a system or process at a given scale while **transformational adaptation** changes the fundamental attributes of a socio-ecological system in anticipation of climate change and its impacts.

Trainers need to place emphasis on why it is important to build on adaptive capacity and the importance of anticipatory adaptation. It is also important to explain the merits of incremental adaptation.

**Participants may be asked to share some examples of adaptations from their experience. They can share their examples from various sectors/sub-sectors.**

**Sharing of examples from use of technologies such as smart phone/computers/digital process/finance and payments will make the process of understanding much easier.**

## 5 Extreme Weather Events

An extreme weather event is an event that is rare at a place and time of year. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season).

## 6 Enabling Conditions (Participative Exercise) (15 minutes)

Conditions that affect the feasibility of adaptation and mitigation options and can accelerate and scale up systemic transitions that would limit temperature increase and enhance capacities of systems and societies to adapt to the associated climate change, while achieving sustainable development, eradicating poverty and reducing inequalities. Enabling conditions include finance, technological innovation, strengthening policy instruments, institutional capacity, multilevel governance, and changes in human behaviour and lifestyles.

**Farmers may be asked to list down the existing and potential enabling conditions which will reduce their vulnerabilities and increase their resilience in the context of climate change. This will also help in mapping the expectations of farmers/stakeholders from different stakeholders.**

## 7 Livelihood

Livelihood is a means of making a living. It encompasses people's capabilities, assets, income and activities required to secure the necessities of life. A livelihood is sustainable when it enables people to cope with and recover from shocks and stresses (such as natural disasters and economic or social upheavals) and enhance their well-being and that of future generations without undermining the natural environment or resource base.

In the context of the discussion, participants should focus on the following points

- (i) The assets people draw upon;
- (ii) The strategies they develop to make a living;
- (iii) The context within which a livelihood is developed; and
- (iv) Factors that make a livelihood more or less vulnerable to shocks and stresses.

## 8 Diversification

Livelihood diversification is the set of activities undertaken by households to find new ways to raise incomes and reduce their risks and vulnerabilities. It includes a range of activities which are undertaken to generate income additional to that from the main

household activity. Households adopt diversification to construct a diverse range of livelihood portfolios either in expectation of increasing their income or in anticipation of some expected risks/unforeseen loss.

### Relevant Examples of Diversification

In the IGP region, where farm-based livelihood predominates, diversification strategies range from a change in farming practices to extreme cases where households completely abandon their existing livelihood and shift to some new work.

Due to extreme climate change events such as drought and floods many of the poor and vulnerable households from IGP (both Uttar Pradesh and Bihar) abandon their farm-based livelihoods and shift to non-farm sectors. This often leads to large-scale migration from their native places to urban centres and work as skill/unskilled worker.

This shift is also affecting the off-farm sector as this sector is closely linked with the farm sector. Many of the small households shift from farm-based to non-farm-based livelihoods when the availability of field-based fodder reduces.

## 9 Climate Smart Agriculture

CSA is an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. CSA aims to tackle three main objectives:

- Sustainably increasing agricultural productivity and incomes;
- Adapting and building resilience to climate change; and
- Reducing or removing GHG emissions, wherever possible.

Some of the elements of CSA may be shared with the participants:

- (i) Management of farms, crops, livestock, to balance near-term food security and livelihoods needs with priorities for adaptation and mitigation;
- (ii) Ecosystem and landscape management to conserve ecosystem services that are important for food security, agricultural development, adaptation and mitigation;
- (iii) Services for farmers and other stakeholders to enable better management of climate risks/impacts and mitigation actions; and
- (iv) Changes in the wider food system including

demand-side measures and value chain interventions that enhance the benefits of CSA.

## 10 Early Warning Systems (EWS)

The set of technical, financial and institutional capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare to act promptly and appropriately to reduce the possibility of harm or loss.

Dependent upon context, EWS may draw upon scientific and/or Indigenous knowledge. In agriculture (for example, warnings of ground frost, hailstorms) and in fisheries (storm and tsunami warnings).

### What Causes Climate Change (5 Minutes)?

**Participative exercise with participants being asked to share and discuss contributing factors leading to climate change. This exercise can be the**

### last exercise before lunch break

Discussion Points: Travel and transportation, industrialization, deforestation, livestock production, farming, consumerism, overuse of electricity, aerosols, inability to change, etc.

### Concluding Points

*Even if we addressed every single other issue on this list today, the impact of human-caused global warming will remain for decades, if not centuries. The magnitude of the issue is, quite simply, too difficult for many of us to comprehend. So, many of us think, if we can't truly fix this issue, what's the point of even trying? After all, it's our very inaction that has caused or worsened many of these issues. But humans are capable of change, as shown by the reduction in fuel combustion emissions seen in many countries since the early 2000s, including the United States, and by evolving public attitudes toward climate change and our role in it.*

# Session 3

## Impact of Climate Change on Agriculture and Select Crops in Context of IGP

### Desired Outcome

Participants need to be made aware of the importance of IGP and its contribution to food security in India. They are also introduced to the key crops grown in the IGP region. They are able to identify and understand the impact of climate change on these key crops.

### Duration

45 minutes +15 minutes

### Methodology

- Presentation (audio-visual)
- Question and answer session

### Material

White board and marker, projector

### Instructions for Trainer

This session is very important and will provide the base for sharing the findings of the study undertaken by UNDP. Participants will be able to understand IGP, its importance and how climate change affects agriculture in the IGP.

### Resources

<http://admin.indiaenvironmentportal.org.in/files/Soils%20of%20the%20Indo-Gangetic%20Plains.pdf>,  
<https://www.jstor.org/stable/pdf/24107215.pdf>

### Sub Topics to Cover

**At the beginning of the exercise, participants may be asked to share their understanding of:**

- (i) **Climate change impacts on agriculture (production, productivity, cost, quality, sustainability)**

#### Key discussion points

- (ii) **Understanding of IGP (geography, states, and in which zone respective states such as Bihar and Uttar Pradesh are located)**

- The Planning Commission, as per its division of the region into various agro-climatic zones, has divided this area into four major sub-regions which are: 1) Trans Gangetic Plain; 2) Upper Gangetic Plain; 3) Middle Gangetic Plain; and 4) Lower Gangetic Plain. IGP covers five states (Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal) that occupy nearly 15 percent of the total geographical area and house approximately 38 percent of the population of the country. It is one of the most intensely farmed areas also and is popularly known as the food bowl of India due to its high contribution in production of cereal crops, especially rice and wheat.
- Major crops grown in this area are rice, wheat, maize, chickpea, lentil, mustard, potato, sugarcane and vegetables. Rice- and wheat-based cropping systems cover most of the area from these two regions which can be attributed to its climate suitability, better adaptability, availability of high yielding varieties and increasing mechanization of both the crops.
- The productivity of most crops in this region is near their yield potential due to the presence of **favourable agro-climatic conditions** which are productive **alluvial soil, maximum irrigated land, sub-tropical climate**, etc.
- Agricultural practices adopted by farmers are **highly input intensive** with higher usage of resources such as fertilizer and water.
- The region contributes immensely to the national production of wheat and rice. The production



of rice and wheat together in the IGP region contributes around 70 percent of the total production.

- The sector has been facing adverse climatic conditions such as **erratic insufficient, intense, untimely rainfall, rising temperature, floods, prolonged dry periods, droughts**, etc., in various degrees.
- In addition to the natural reasons that are causing problems to the overall natural resource availability and quality, there are human factors as well that are aggravating the situation and increasing vulnerability. The man-made factors consist of large-scale residue burning, physical, chemical and biological degradation of soil due to inappropriate crop rotation, unsustainable irrigation management practices and overuse of pesticides that are causing problems. As per some estimates around, 90-140 MT per year of crop residues are burnt to clear the fields. This is emerging as a major concern for air quality in the region.

### Threats from Climate Change

- India is among the most climate-vulnerable countries in the world. The following projections on key parameters highlight this vulnerability.<sup>41</sup> Unusual and unprecedented spells of hot weather are expected to occur far more frequently and cover much larger areas. In warming of 4°C, the west coast and southern India are projected to shift to new, high-temperature climatic regimes with significant impact on agriculture.
- A 2°C rise in the world's average temperatures will make India's summer monsoon highly unpredictable. At 4°C warming, an extremely wet monsoon that currently has a chance of occurring only once in 100 years is projected to occur every 10 years by the end of the century. An abrupt change in the monsoon could precipitate a major crisis, triggering more frequent droughts as well as greater flooding in large parts of India.
- Droughts are expected to be more frequent in some areas, especially in north-western India, Jharkhand, Odisha and Chhattisgarh. Crop yields

are expected to fall significantly because of extreme heat by the 2040s.

- Climate change impacts will be more pronounced for rain-fed agriculture due to the absence of coping mechanisms for rainfall variability.<sup>42</sup> There could be serious impact on livelihoods related to agriculture with increasing frequency of extreme events such as drought and flood.
- In recent year, the region is increasingly experiencing floods, heavy and intense rainfall, prolonged periods of dry and drought-like situations, increased humidity and associated increase in plant diseases. Such extreme climatic conditions are impacting agriculture in the region.
- Seasonal water scarcity, rising temperatures, and intrusion of sea water would threaten crop yields, jeopardizing the country's food security. Should current trends persist, substantial yield reductions in both rice and wheat can be expected in the near and medium term. At 2°C warming by the 2050s, the country may need to import more than twice the amount of food grain than would be required without climate change.

### **The incidence of weather extremes, duration and frequencies of drought and floods are becoming/ will become more frequent which may significantly impact the yields of rice in the region.**

There are broadly three types of impact of climate change on agriculture related to:

- Production and productivity;
- Quality of produce; and
- Increased cost of production to minimize the impact of climate change.

IARI examined the vulnerability of agricultural production to climate change with the objective of determining differences in climate change impacts on agriculture. Overall, temperature increases are predicted to reduce yields of cereal crops such as paddy and wheat. An increase of 2-4°C of temperature is predicted to result in a significant reduction in yield of paddy. The study also found that for wheat crop, increases in temperature (by about 2°C) will lead to a reduction in yield.<sup>43</sup> Increased temperatures and decreased radiation will result in relatively fewer grains, smaller grain size and shorter grain

<sup>41</sup> <https://www.worldbank.org/en/news/feature/2013/06/19/india-climate-change-impacts>

<sup>42</sup> <http://www.indiaenvironmentportal.org.in/files/Defra-india-cc-agri.pdf>

<sup>43</sup> <http://www.indiaenvironmentportal.org.in/files/Defra-india-cc-agri.pdf>

filling durations<sup>44</sup> (Key sheet 6-Climate Change Impacts on Agriculture in India, Indian Agriculture Research Institute).

***The Ministry of Agriculture, in a written response to the parliamentary committee, said that crops such as wheat, paddy, maize, potato, cotton, sorghum, mustard and coconut are likely to be badly affected by climate change. The ministry informed the parliamentary committee presided over by Bhartiya Janta Party leader Murli Manohar Joshi that production of wheat will decline by 6 to 23 percent by 2050 if proper steps were not taken in a timely manner. The production of wheat could reduce by 6,000 for every 1°C rise in***

***temperature<sup>45</sup>. This parliamentary committee has made the 30th report on 'Demonstrating National Action Plan on Climate Change'.***

*Climate change adaptation involves taking action to adjust to, or respond to, the effects of changes in climate. Adaptations to climate change exist at various levels during the growth cycle of the crops. Types of adaptation ranges from a change in variety, more application of inputs, change in planting and harvest dates, tillage and rotation practices, substitution of crop varieties, increased fertilizer or pesticide applications, and improved irrigation and drainage systems.*

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<sup>44</sup> <http://www.indiaenvironmentportal.org.in/files/Defra-india-cc-agri.pdf>

<sup>45</sup> <http://krishijagran.com/news/climate-change-affecting-agriculture-wheat-production-in-india-could-drop-by-23-agri-ministry/>

# Session 4 and 5

## Understanding Small and Marginal Holders' Climate Change Impacts and Adaptations in IGP

### Desired Outcome

Participants may be asked to identify top five to six most important crops grown in the region and may be asked to share their basis of selection of crops.

Participants may be explained that this session will focus on five crops which we felt are important from the perspective of:

- (i) Number of households that grow these crops;
- (ii) Their importance for small and marginal land holder farmers; and
- (iii) Potential of value addition and scope of participation of farmers in the value chain and value transfer.

### Duration

3 hour session with 30 minutes break after 1 hour  
15 minutes

### Method

Discussion

### Material

White board, multi-colour markers, duster, drawing sheets, multicolour sketch pens

### Instructions for Trainer

The Trainer is expected to first introduce the topic and encourage participants to share more. A cropping calendar is to be designed with the help of participants. General as well as crop specific climate vulnerabilities are identified. Participants are asked to share their understanding of climate change impacts and adaptation methods. It is to be noted that, as far as possible, all participants are involved in discussions. The group can

be identified as per crops and various crop-specific adaptation measures shared by participants in that crop-group are noted and presented to all. If required, farmers may also be asked to select the five most important crops from their region before start of the season.

### Resources

<https://nidm.gov.in/PDF/pubs/Adaptation%20to%20Climate%20Change.pdf>

[https://www.undp.org/content/dam/india/docs/climate\\_change\\_adaptation\\_activities\\_in\\_india\\_part\\_i.pdf](https://www.undp.org/content/dam/india/docs/climate_change_adaptation_activities_in_india_part_i.pdf)

### Sub-topics to cover Impact of Climate Change on Various Crops

***At the beginning of the session, participants may be asked to share their understanding/observations of climate change on various crops. Crops can be taken up one after one, starting with paddy and wheat in Session 4 and maize and horticulture in Session 5.***

***One crop may be taken up for discussion at a time and participants should be asked to explain the impact of climate change on that particular crop and the adaptations that they have observed.***

***(The focus should on making the session as interactive as possible)***

#### 1 Paddy/Rice

Key discussion points for paddy:

- Paddy, being a water dependent crop, is prone to extreme weather conditions.
- Excessive heat, humidity, erratic rainfall affects the growth of paddy and incidences of pest infestation.
- Increase in temperature leads to reduction in crop growth duration, increase in pollen sterility, reduced seed set and number of grains,

and reduced grain weight which cause yield reduction.

- Farmers reported that, in recent years, climatic conditions have been very unpredictable. Unexplainable delays in rains, insufficient and untimely rains resulting in excessive humidity and prolong periods of high temperature are

resulting in increased incidences of pest attacks on paddy crop.

- Due to the prolonged period of heat, the moisture level in the soil has been decreasing and the immunity level is reducing, making the crops more susceptible to diseases.

Perceived Impact of Climate Change	Frequency of Occurrence and Perceived Impact on Production
Loss of Crops due to Flood/Flood-like Situation	The frequency of occurrence of such events is low but whenever they happen there is complete loss of crops <b>(production loss)</b>
Loss of Crops due to Drought/Long Period of no Rains	The frequency of occurrence of drought or long period of no rains is frequent. If such as period occurs during the initial month, farmers shift the transplantation activities. If it happens at a later stage, farmers try to manage with additional irrigations <b>(productivity loss)</b>
Late Rainfall Affecting Nursery Preparation	The availability of short duration varieties of paddy compensates for the delay in nursery preparation. Farmers now prepare the nursery in phases to minimize the risks <b>(increased cost of production)</b>
Long Drought Periods Lead to Increase in Weed/Pest Infestation	Increase in pest/insect infestation is leading to more usage of pesticides. Pest attacks at times lead to significant loss of yield <b>(increased cost of production)</b>
Quality Reduction of Paddy	Moisture, presence of empty shells and grain discoloration are some of the quality indicators that farmers notice <b>(quality loss)</b>

- The crop sometimes loses its natural shine and the weight of grain is also affected. Frequency of un-ripe paddy is also on the rise.
- Seed companies have introduced short varieties with shorter duration which has helped in mitigating climate change impact to some extent.

Farmers have observed that these new varieties are more prone to diseases and therefore they are constantly under pressure to match the production by increasing doses of inputs to maintain production and to avoid incidences of pest attack.

Adaptation Measures	Reasons for Adaptation
Change in Seed Variety	<ul style="list-style-type: none"> <li>• New varieties are perceived to have higher resistance against drought and flood</li> <li>• Short duration varieties minimize the exposure risks to climatic variations</li> <li>• Short duration varieties provide flexibility to late transplantation due to delay in monsoon</li> <li>• Adoption of high yielding/hybrid varieties also compensate for yield loss</li> </ul>
Nursery Preparation in a Phased Manner	<ul style="list-style-type: none"> <li>• Nursery preparation is done in a phased manner and in surplus so that whenever there are rains, farmers have seedlings to transplant</li> </ul>
Increased Intercultural Operations	<ul style="list-style-type: none"> <li>• Long durations of dry period lead to more weeds. More intercultural operations help in improved soil and root zone aeration</li> <li>• Retains the moisture in the soil and promotes growth</li> </ul>
More Usage of Fertilizer	<ul style="list-style-type: none"> <li>• Usage of fertilizer is increasing continuously, and farmers believe that there is no other alternative</li> </ul>
More Usage of Insecticides/Pesticides/Herbicides	<ul style="list-style-type: none"> <li>• Pest infestation is increasing due to long durations of dry spells</li> <li>• Prevalence of disease is also increasing</li> </ul>

## 2 Wheat

### Key Discussion Points for Wheat

- Due to favourable climatic conditions, most major wheat growing states in India are located within IGP which includes states such as Uttar Pradesh, Punjab Haryana, Bihar, etc.
- The region provides favourable conditions with cool and moist weather during the winter which facilitates the growth of the plant and dry and warm weather from late February onwards that enables the grain to ripen properly.
- It is expected that climate change will lead to a rise in maximum temperatures in winter as well as reduction in number of days with low temperatures. This may affect the wheat grown especially in the middle part of IGP.
- Wheat is sensitive to high temperatures, especially during the reproductive stage as it increases the levels of water stress in the plant cell. Temperatures rising towards the end of its growth, especially during the grain-filling stage of development (early arrival of summer), affect the yield of wheat.
- Late sown wheat exposes pre-anthesis phenological events to high temperature which influence grain development and ultimately the yield.
- Rainfall or cloudy weather may lead to a rust attack in the wheat crop. Higher temperature at the time of maturity also leads to forced maturity resulting in yield loss.
- Farmers also reported that, during the ripening season, the fear of having rains or unfavourable conditions forces them to opt for harvesting, even when the crop grains haven't fully matured. This early harvesting leads to low recovery of grain with a higher proportion of immature seeds, broken and poor-quality grains. Such grains are more susceptible to disease during storage.

Climate Change as Perceived by Farmers	Impact
Late Arrival of Winter	Farmers have started shifting their cropping calendar. Modern seed varieties which generally take less time compensate for the delay in sowing
Less than Expected Decline in Temperature	It affects both the number of grains as well as the size of the grains
Unseasonal Rain in Winter	Other than rains which happen after the ripening of crops, it helps the crop
Early Arrival of Summer	It affects the grain quality and appearance
Increase in Pest Infestation	Pest and insects attacks are increasing and are also developing resistance against pesticides
Quality of Grains	Proportion of unusually small grains is increasing
Increase Presence of Foreign Matter	Farmers believe that it happens only when there is rainfall/hailstorm, etc., during the harvesting phase

*One of the most common adaptations taking place at the farmer level is experimenting with sowing dates to minimize the effect of temperature or residual moisture. Farmers also reported that the frequency of seed replacement has also increased. If sowing is delayed due to climatic variations, farmers also increase the seed rate by reducing the spacing between the plants.*



Adaptation Measures	Reasons
Change in Seed Variety	<ul style="list-style-type: none"> <li>Seed replacement has increased but not with change in variety</li> <li>Seed company/seed shops influence the decision making of farmers</li> <li>Shift towards 120-day variety</li> </ul>
Change in Sowing Time	<ul style="list-style-type: none"> <li>Farmers now advance/delay sowing as per the existing climatic conditions</li> <li>The window of sowing has also narrowed down</li> </ul>
Increased Intercultural Operations	<ul style="list-style-type: none"> <li>Use of herbicide has increased</li> </ul>
More Usage of Fertilizer	<ul style="list-style-type: none"> <li>Usage of fertilizer is increasing continuously and there is no other alternative</li> </ul>
More Usage of Pesticides/Herbicides	<ul style="list-style-type: none"> <li>Cost of using herbicides is lower than the earlier method of using labour</li> </ul>
Increased Mechanization	<ul style="list-style-type: none"> <li>In the harvesting phase, mechanization is increasing but it has more to do with labour shortage</li> </ul>
Post-harvest Measures	<ul style="list-style-type: none"> <li>Small farmers don't store wheat for long durations</li> <li>Local traders/aggregators don't pay much attention to quality</li> <li>Everyone in the channel believes that, in the value chain of wheat, quality is not given that much importance</li> </ul>

*Usage of better quality seeds, application of agro-chemicals and increased usage of fertilizer are helping farmers to mitigate the risks of climate change to a certain extent. Increased mechanization during the harvesting period has been one of the greatest adaptation strategies undertaken by farmers. Though used increasingly to overcome labour shortage, combine harvesters are also helping to reduce climatic risks by shortening the harvesting window after ripening of wheat. Though their use is helping farmers in reducing exposure of crops, it is leading to events such as residual burning which is a contributor of adverse climatic conditions.*

### 3 Maize

#### Key Discussion Points for Maize

- In comparison to other competing cereals, maize, due to its photo-insensitive nature has wider adaptability and can be grown in all cropping seasons. Kharif or early summer season maize is of short duration, while rabi season maize is of a little longer duration.
- Rabi maize is also considered to have superior transpiration efficiency, lesser usage of water per unit of production and high versatile usage which makes it easily marketable.
- Favourable agro-climatic conditions, low infestation of insect, pest and diseases, slow growth of weeds and almost no risks from extreme events such as

flood or drought makes maize an attractive crop in the rabi season. Cultivation of maize is also less resource (water, fertilizer, etc.) intensive, when compared to paddy or wheat IGP.

In comparison to rice and wheat, maize is less impacted by climatic vagaries. Prolonged high temperature and moisture affect the yield of maize due to hastened crop phenology, reduced photosynthesis, increased pollen sterility and poor grain filling with decreasing grain number. Kharif maize-growing farmers also recognize that erratic rainfall has high potential to damage pre-flowering stalks. Additionally, increased temperature and humidity raises the level of infection or infestation of various diseases and insect pests resulting in lower yields.

Climate Change Impact as Perceived by Farmers	Reasons
Loss of Crops due to Flood/Flood-like Situation	Rabi maize is cultivated in controlled irrigation and kharif maize is generally grown in uplands in the flood-prone regions
Loss of Crops due to Drought/Long Period of no Rains	Erratic rainfall influences maize growth in kharif as it affects soil moisture. The impact on rabi maize is negligible as it is cultivated in an irrigated environment
Unseasonal Rain in Rabi	Unseasonal rains and water logging affect the yield, both during harvesting as well immediately after harvesting. Uneven drying and unseasonal rains increase contamination in maize
Increase in Temperature	Increase in temperature affects yield of both kharif and rabi maize. It hastens the flowering season as well the grain filling process. Variability in the day and night temperature also affects the yield
Increase in Pest/Weed Infestation	Weeds pose a major problem in kharif maize and its effect is partial in winter maize

The inability of farmers to decide the right adaptation strategy makes them very vulnerable. Change in sowing dates and variety of seeds has been the key adaptation practice reported by farmers. Delay in sowing provides the

opportunity for the crop to experience relatively lower temperatures during the grain filling period. Across the region, preference for short duration varieties of seeds is increasing.

Adaptation Measures	Reasons
Change in Seed Varieties	<ul style="list-style-type: none"> <li>New varieties are perceived to have higher resistance against drought and flood</li> </ul>
Shift in Sowing Time	<ul style="list-style-type: none"> <li>Late sowing by 15-20 days in the kharif season and 10-15 days in rabi</li> </ul>
Increased Intercultural Operations	<ul style="list-style-type: none"> <li>Long durations of dry period lead to more weeds. More intercultural operations help in improved soil and rootzone aeration</li> <li>Retains the moisture in the soil</li> </ul>
More Usage of Insecticides/Pesticides/Herbicides	<ul style="list-style-type: none"> <li>Increase in spray for insect/pest control. Frequency of spraying is increasing</li> </ul>

**Tea break/small break of 20 minutes**

#### 4 Potato

##### Key Discussion Points for Potato

- The Indian potato belt stretches from Punjab (North West) to West Bengal in East India. Uttar Pradesh, West Bengal, Bihar and Punjab together account for about 86 percent of India's potato production. Uttar Pradesh is the largest producer of potatoes in India.
- Potato is a cool season crop and tolerates frost moderately. The ideal temperature for its growth during the initial stage is around 25°C. Deep, well-drained and friable soils having good organic matter are ideal for its cultivation.
- Potato is highly susceptible to climate change in comparison to other crops and adverse climatic situations can affect productivity, quality (size and appearance), cost of production and storage.
- Potato is best adapted to cool climates with temperatures in the range of 15 to 25°C. Temperature higher than this range retards tuberization. Additionally, heat stress also leads to a higher proportion of smaller tubers with paler skin colour of the tubers. Temperature above 25-30°C shortens the growing period of potatoes and reduces tuber yield.
- During the winter longer-than-usual periods of frost and dew cause the foliage to remain wet

for prolonged periods during the day which also affects crop growth.

- The crop is also sensitive to water and yield is reduced in drought as well in waterlogged conditions. Drought events occurring early in the growing season reduce the number of tubers per plant and even a single, short-term drought during tuber bulking decreases potato quality (i.e., tuber size and appearance) along with the overall yield.
- Unseasonal rains around harvest lead to high soil moisture conditions which result in rotting of crops and make produce extremely vulnerable to disease/pest infestation even after harvesting.
- Variations in irrigation and temperatures also cause the harvested produce to be of smaller size substantially increasing the on and off farm grading and sorting costs.

Climate Change Impact as Perceived by Farmers	Reasons
Late Arrival of Winter	Farmers adjust the sowing window to minimize the impact
Lower Duration of Winter	Size of tuber gets affected due to early maturing
High Frost and Dew Conditions	Plant growth gets affected
Less than Expected Decline in Temperature	Both quality and yield get affected as it directly affects both the number and size of tuber
Unseasonal Rain in Winter	Leads to rotting and pest infestation
High Temperature and Humidity at the Time/After harvesting.	Farmers feel that the quality of harvested potato deteriorates very fast due to high temperature and humidity  Apart from climatic change, they also attribute this to high usage of chemical fertilizers and pesticides

Potato growers' adaptation strategies range from usage of newer seeds, more application of inputs, change in planting and harvest dates, and increased applications of fertilizers or pesticides. The most common adaptation happening at the potato growers' level is experimentation with sowing and harvesting dates which helps them to minimize the effect of temperature or residual moisture. In order to adapt to frequent

temperature variations, small and marginal farmers have reported using shorter duration varieties that mature much earlier than the traditional varieties. These varieties can be harvested in 70-90 days which not only helps the farmers in avoiding high stress periods by strategically sowing the crop but also generates higher income as early harvested potato fetches a higher price in the market.

Adaptation Measures	Reasons
Change in Sowing Time	10 to 15 days shifting is common
Increased Intercultural Operations	Frequent earthing up and mulching of ridges helps in better soil and water management. It also leads to better germination
Adoption of Alternate Crops/ Intercropping	Even though potato is considered ideal for intercropping, farmers are not very keen on cultivating potato with other crops
More Usage of Fertilizer	Nitrogen-based fertilizer usage is increasing
More Usage of Insecticides/ Pesticides/Herbicides	Usage of herbicides and insecticides has increased due to more incidences of weeds and insects
More Irrigation	Light but regular irrigation is helpful especially in critical stages during crop development, tuber initiation and tuber development; 15-20 days before harvesting, farmers stop irrigation
Selling Immediately after Harvest	Small and marginal farmers prefer to sell the produce immediately to minimize the rotting

## 5 Tomato

### Key Discussion Points for Tomato

- Tomato is the second most grown vegetable in the districts of IGP after potato. It is grown as a winter as well as a summer crop.
- Complete failure of crops, shortage of yields, reduction in quality and increasing pestilence and disease are some of the key challenges faced by the farmers due to climatic variations.
- Since it is a crop most vulnerable to climate change, adverse climatic conditions cause severe damage to the tomato crop. The crop is highly susceptible to increased temperature and drought-like conditions.
- The crop needs a controlled supply of water throughout the growing period to maintain quality and productivity. As the crop is sensitive to water deficits, in phases such as post transplantation, flowering and fruit development regular water supply needs to be ensured.
- Long periods of heat stress also have very adverse effect on crop production as they affect the vegetative and reproductive processes of tomato leading to a reduction in yield and fruit quality.
- Rains with high intensity can cause severe damage to plants both during nursery as well in the initial days after transplantation.
- During the ripening season, high rainfalls significantly damage both quality and quantity of tomato produced. Incidence of water logging causes serious damage to tomato.
- Attacks of disease have increased significantly with high incidence of cases of complete burning of flowers and curling of leaves.
- Climatic variations also affect post-harvest quality and cause severe losses further in the value chain. Variations in temperature, rainfall, humidity and dew affect the growth and spread of fungi and bacteria which affects the fruit's colour and appearance as well as shelf life after harvesting.
- If temperature is high, despite good vegetative growth of the crop, there may be a lower number of fruits as high temperature causes more production of male flowers while low temperature leads to production of more female flower.
- Continuous exposure to high temperatures also reduces the number of pollen grains in the flower. High temperature also affects the shine and size of tomato.

Climate Change Impact as perceived by Farmers	Reasons
High Temperature	Increase in temperature affects quantity and quality of the produce both in rabi as well as in the summer crop
Erratic Rainfall	Erratic rains affect at the time of nursery preparation, early days of transplantation and ripening
Increased Frequency of Pest Attack	Increased attacks of pests and insects are the biggest climate change threat
Reduced Production	The effect of climate change in production is limited
Quality of Yield	Both appearance and size of tomato are affected due to adverse climatic conditions during the growing period.

In comparison to cereal crops, horticulture crops such as tomato are much more vulnerable to the consequence of climate change. Even minor climatic variations have the potential to destroy the crops.

The other challenge is with the quality of produce as minor climatic variations affect the appearance of the produce. Heavy irrigation provided after a long spell of drought causes cracking of the fruits. Based on their past cropping experience and suggestions from fellow

farmers and input supplier, farmers adapt one or other strategy to minimize the impact of adverse climate stresses. Some adaptations are in terms of changing the processes while others have been with respect to change in quantity and types of inputs. Unlike paddy and wheat where farmers necessarily grow paddy or wheat, tomato farmers also adopt strategies related to crop diversification or changing the cropping calendar.

Adaptation Measures	Reasons
Change in Seed Variety	<ul style="list-style-type: none"> <li>Farmers keep experimenting with seeds as per feedback from fellow farmers and local input suppliers</li> <li>Farmers believe that newer varieties of seeds are more productive and resistance to pest attack</li> </ul>
Change in Agricultural Practices	<ul style="list-style-type: none"> <li>Raised nursery beds prevent the problem of water logging during the nursery phase</li> <li>Better plant spacing</li> <li>Staking</li> </ul>
More Usage of Insecticides/ Pesticides/Herbicides	<ul style="list-style-type: none"> <li>Pest infestation is increasing both in rabi and summer tomato</li> <li>Prevalence of disease is increasing, and many previously used pesticides are rarely effective in the following years</li> </ul>



# Session 6 and 7

## Capturing Participants' Understanding about Agriculture Value Chains and Value Chain Actors in IGP Region

### Desired Outcome

- 1 Warming up session. Participants get the opportunity to share their understanding of agri value chains.
- 2 Participants identify the key agri value chains operating in the IGP region, value chain agents, value addition and interdependence among value chain agents. Impact of climate change on these value chains and adaptation measures undertaken by value chain agents across value chain.

### Duration

30 minutes + 10 minutes break + 45 minutes

### Method

- Brainstorming
- Presentation
- Question and answer session

### Material

One drawing sheet per group, sketch pen box, colour sticky notes.

### Instructions for Trainer

A short introduction of value chains and agri value chains is given to participants. Post this, groups of four or five participants are formed and asked to identify agri value chains of key crops from IGP. Each group may then present the findings.

The Trainer must remember that she/he is more of a facilitator who should focus on drawing ideas out of participants' minds rather than dominating the entire discussion with her/his own ideas.

### Instructions for the Trainer

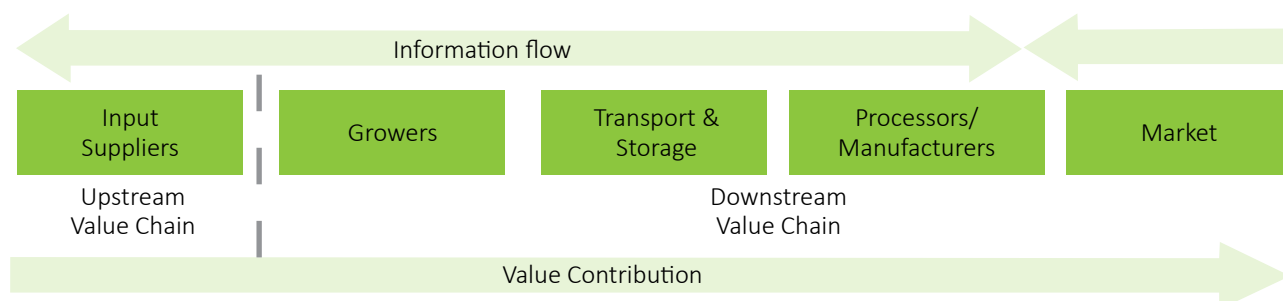
This session should built on group presentations and understanding of agriculture value chains in the IGP region.

### Sub Topics to Cover

#### Value Chains of Major Crops in IGP and Impact of Climate Change:

Growth and development of agricultural value chains is a powerful medium of economic empowerment particularly for small and marginal farmers. The value chain is a sequence of value addition activities, from production of agriculture produce to making it fit for consumption in various forms, through activities such as transportation, storage and processing.

The Trainer can show the following diagram to the participants.



## Key Discussion Points

- Climate change impacts value chains in many ways. It affects the quality and yield of agriculture commodities and, hence, to maintain the quality of final products, value chain agents need to adapt by making changes in their supply chains and production systems which require additional resources.
- Climate change sometimes adversely impacts production in their procurement areas and they need to make alternative arrangements for procurement leading to higher procurement and transportation costs.
- Climate change can also have impact the quality of final products as well their shelf life.
- The impact of climate change is also leading to an increased tendency on the part of value chain agents to relax the quality norms for procuring paddy/wheat from farmers due to their long-term relations and interdependency.
- A change in climatic conditions increases the cost of operations for warehouse/cold storage owners due to an increase in electricity charges and

fumigation expenses and a decrease in capacity utilization.

- The impact of climate change is felt by small businesses more than big businesses as small businesses lack resources for adequate planning and preparedness. The vulnerability of small businesses also increases due to a lack of financial resources to endure even a small rupture in the supply chain which may be caused, for instance, due to an extreme weather event.
- As flow of raw material starts from the farmers' end and affects all actors in the value chain. The adoption of short duration high yielding varieties by farmers as an adaptation in monsoon crops affects the business of traders, warehouse owners, transporters as well the final processors. Similarly, an increase in moisture content of the raw material affects the conversion ratio during processing, increases the cost of production and leads to higher investments in new equipment and machines.

The following image can be used for starting the discussion and participants may be asked to share live examples.



### Impact on Raw Material Supply

- Supply of farm produce not meeting quality specification
- Inadequate supply from regular procurement area/ fluctuating supply
- Working capital management issues due to disruptive procurement (credit/payments/ cash purchase etc.)



### Impact on Supply Chain

- High cost of storage in warehouses due to increased expense in fumigation expense, capacity underutilization
- Quality deterioration risks of both raw material as well finished products



### Impact on Logistics

- Increased cost of transportation due to production loss in the natural procurement area
- Higher cost in transportation to maintain quality standards
- Increased risk in supplying finished products



### Impact on Production/ Processing

- Quality of final product
- Low shelf life of final product
- Additional investment machineries

- The impact of climate change is also leading to increased tendency on the part of value chain agents to relax the quality norms for procuring paddy/ wheat from farmers due to their long-term relations and interdependency.
- The impact of climate change affects small businesses more than big businesses as the former lack resources for adequate planning and preparedness. The vulnerability of small businesses also increases due to the lack of financial resources to endure even a small rupture in the supply chain which may be caused, for instance, by an extreme weather event.

### Impact of Climate Change on the Paddy Value Chain

The following table may be shared with the farmers to make them understand the different products/by-products in the paddy value chain.

- One of the impacts with respect to storage of paddy is retention of moisture level at the warehouse. It needs to constantly be maintained below 14 percent and proper safeguards needs to be undertaken to ensure that it doesn't imbibe moisture from the surrounding air.
- Increased temperature and humidity are considered to be favourable for growth of storage insect pests as they can multiply faster in these conditions. To

maintain the quality, grain stacked in gunny bags needs to be periodically fumigated; warehouses therefore need to go in for more cycles of fumigation which results in increased cost of warehouse maintenance.

- The impact of climate change is felt in decreased grain weight, reduced grain filling, and a higher percentage of white chalky and milky white rice are common effects of high temperature during the ripening stage. Regular increases in temperature, prolonged periods of drought-like situations amid the rainy season affect the moisture content of paddy which leads to a higher percentage of broken rice.
  - In recent years the percentage of broken rice has increased by 2 to 3 percent. Short duration paddy has lower conversion rates to the extent of 1 to 2 percent than the traditional variety. The short duration variety paddy is relatively more brittle and so the percentage of broken rice is high.
  - Due to changing climate conditions, there are incidences of high moisture in paddy, increasing the percentage of broken and black rice and impurities in rice. This leads to a 2 to 3 percent of loss of finished product leading to production loss

### Impact of Climate Change on Wheat Value Chain

Channels		Proportion of wheat	Final Product/ By-product
Under MSP			
Regulated value chain	Farmers- (Food Corporation of India, state government agencies)-public distribution system-customer	30 to 35%	Wheat flour ( <i>atta</i> )
	Farmers- (Food Corporation of India, state government agencies)-traders/ processors (Open Market Sale Scheme)		
Private trade			
Organized value chain	Farmer – aggregator – wholesaler- roller miller – retailer- consumer	10-15%	<i>Maida</i> (fine flour), rawa ( <i>sooji</i> ), wheat bran ( <i>choker</i> ), etc.
	Farmer – aggregator – wholesaler- <i>chakki</i> mill – retailer- consumer	4-5%	<i>Atta</i>
Unorganized value chain	Unorganized value chain (processed through <i>chakki</i> mills)	45-50%	<i>Atta</i> and wheat bran

- Around 30 to 35 percent of the wheat produced by the farmers is used for self-consumption, around 5 percent is retained for seed while the remaining produce is marketable surplus.
- Sudden rain, hailstorm, heavy winds sometimes destroy or damage the wheat crop so much that such crop is used for animal feed purposes only.
- The arrival for wheat into warehouses, in both Bihar and Uttar Pradesh, starts in the month of April and continues till early June. The primary aim of storage activity is to prevent deterioration of the quality of grain. This is done through control of moisture and aeration and by saving the wheat grains from the attack of microorganisms, insects and rodents.
- The storage of wheat starts in early summer and it continues till the rainy season. During this storage period, both temperature and humidity increases which is favourable for proliferation of storage insect pests. Under the hot and humid climate, they can multiply faster.
- Sometimes due to the early harvest, wheat grains have higher moisture content which increases the risk of quality deterioration. To maintain the quality, grain stacked in gunny bags needs to be periodically fumigated. In such circumstances, warehouses must apply more cycles of fumigation which results in increased cost of storage.
- Early onset of summer affects the quality of wheat grain. This effect is magnified at the grain filling stage which leads to reduced grain size. Untimely rains before/at time of the harvest result in discoloured wheat. The recent experience of untimely rains during harvest months compelled farmers to harvest crop produce before maturity in haste.
- Millers reported that wheat with higher moisture content tends to consume more energy during processing. Although it is difficult to quantify the exact correlation, a pattern of higher energy consumption is being observed. Millers also stated that use of drying units was not very common earlier. Now as it becomes common, electricity consumption has risen by roughly 10-15 percent.
- Roller millers stated that the extraction proportion for different products such as *maida/sooji* also depends upon the moisture content of wheat. The quality of *maida* is affected by the high moisture content in wheat. The cost of processing has increased to match the quality requirement due to investment in advanced machines such as sievers, grinders and driers.

#### Impact of Climate Change on Maize Value Chain

**(Before starting the discussions, the following table may be shared with the farmers to make them understand the usage of maize)**

Products	Percentage Usage	Processing Point	End Consumer
Self-consumption	12-15%		
Poultry	45-50%	Poultry feed industry	Poultry industry
Cattle feed	10-13%	Cattle feed industry	Consumer
Starch	12-14%	Starch industry	Processing units
Food processed industry	6-10%	Food processing industry	

- Around 85 to 90 percent of the maize produced in both Bihar and Uttar Pradesh is marketable surplus. In general, maize is known to have around 67-72 percent of starch, 12-15 percent of moisture, 8-12 percent of protein, 2-4 percent of fat, 2-3 percent of fibre and around 1.5 percent minerals. Due to its wide usage in other industries, maize has a long value chain. It is in high demand from the feed industries.
- About 45-50 percent of the total maize production is used by the poultry feed industry. Around 14-15 percent goes into manufacturing of cattle feed and, 10-15 percent is used by the starch industry where it is processed further to produce key ingredients for confectionery, toothpaste and pharmaceutical industries. Around, 6-10 percent of the maize is also used by food processing/brewery industries.
- Maize forms 50-60 percent of the input required for broiler feed and 25-35 per cent of the input required for layer feed. In general, the major raw materials used as ingredients for preparing feeds include maize, bajra, soybean oil cakes, rice-bran groundnut, other oilseed cake, etc.

- For both broilers and layers, two to three types of feed are used (starter, finisher, etc., in broilers and chick mash, grower mash, layer mash, etc., for layers). In terms of production, 80 percent of poultry feed is produced in pellet form and balance 20 percent in mash form. Maize is the main source of energy in poultry feeds and soybean contributes to the protein element.
- The risk of incidences of storage pest/ fungus on stored grain has increased which is attributed to climate change by warehouse owners. This affects the extraction percentage and quality of different derivatives of maize. Slightly increased occurrence of mycotoxin and aflatoxin levels in stored maize has been observed in recent years which can also be attributed to increased humidity level.
- Feed industries hire the services of drying units to reduce the moisture level in maize. Moisture levels are brought down from 15- 16 percent to 12-13 percent by drying units to meet feed industries requirement. Cattle feed manufacturers also reported that, despite using dryers, a minimum of 2 percentage of maize procured by them is wasted as it is beyond the acceptable limit of quality standards at the time of processing.

#### **Impact of Climate Change on Potato Value Chain**

- About 60 to 65 percent of the potato grown is utilized as vegetable for domestic table consumption while another 18 to 20 percent is used as seed. Roughly 8 to 10 percent of the produce is used for higher value-added potato products. The potato-processing sector is split into the organized and unorganized sectors. The organized sector is under the control of large manufacturers with a presence across the country while the unorganized sector comprises small manufacturers with less-known or no brand names operating at the regional level. The processing industry in the IGP region is restricted to the unorganized sector and small players. The suitability of the variety grown in both Bihar and Uttar Pradesh is the key hindrance in development of large potato processing units.
- The impacts of climate change on cold storage are two-fold: higher electricity charges due to a rise in temperatures; and humidity management. The longer summer season and delayed monsoons also affect the operations of

cold storages by raising the operational costs of running cold storages as they require larger amounts of electricity to maintain optimal levels of temperature and humidity. As reported by cold storage owners, their electricity consumption units have increased by about 10-12 percent in the last few years.

- The highest climate change impact faced by potato processors is in terms of the quality of the potato. Increased temperatures often lead to smaller size of the potato which increase wastage during peeling due to higher amount of peeling losses as a higher proportion of potatoes have diameters of less than 40 mm.
- Farmers in the IGP region prefer early maturing varieties while late maturing varieties contain high dry matter as required for processing industries. High usage of fertilizers also reduces the dry matter presence in potatoes. Potatoes with lower dry matter increase the energy cost as well quantum of cooking oil required to fry it. Additionally, during storage of potato the proportion of sugar increases which leads to change in colour to brown/black.

#### **Impact of Climate Change on the Tomato Value Chain**

- Due to high perishability and shorter shelf-life of the product, transportation is one of the most critical factors in the value chain of tomato. The quality of tomatoes is affected at every level during the transportation, starting from the farms to end consumers. Supply chain bottlenecks and quality of yield which are highly vulnerable consequently result in poor price realization for producers. In between, there are very high losses in the value chain. The biggest challenge with transportation and storage is the lack of cold chains in the tomato value chain. In the districts of IGP, there is a scarcity of storage facilities around the production centres.
- The very nature of the processing of tomato by processing units reduces the impact of climate-related quality changes in tomato. Due to decreasing shelf life, in recent years, the supply of tomato is, in fact, growing for processors as traders consider these units as the last resort to minimize their losses. On the other hand, processors are matching shortfall in supply due to adverse climatic conditions from distant regions and sometimes even importing.

# Session 8 and 9

## Desired Outcome

This session will be the concluding session. Before starting the session, there should be a small discussion on enabling conditions and how they can be developed and who will develop them.

## Duration

45 minutes + 15 minutes + 45 minutes

## Method

Discussion, presentation

## Material

White board, multi-colour markers, duster, laptop/desktop projector.

## Instructions for the Trainer

The Trainer is expected to introduce key findings of the study undertaken with the participants

## Subtopics to cover (Information and Capacity Building)

**Convergence support area where farmers can benefit from collective actions**

Type of Value Chain Agent	Climate Change Impact	Crops Impacted	Mitigation Strategy	Responsibility
Small and marginal farmer	No rains at sowing time	Paddy	Better irrigation and shorter duration crops	Individual farmers through collectives
	Excessive rains during germination/transplantation phase	Paddy, maize	Phase-wise nursery/plantation	Individual farmers through collectives
	Storm/hailstorm during harvest time	Wheat/paddy	Localized weather stations and enhanced weather insurance	Collectives, private players and government
Warehouse	Increased susceptibility to fungus and deterioration in quality	All	Aggressive fumigation/decentralized warehousing	Collectives and government
Unorganized processing units such as <i>chakki</i> , chips and ketchup manufacturing	Increased percentage of stones, soil, and leftover of other crops	All	Grade-based pricing	Collectives, private players and government



- Weather-based, agri-advisory services can help farmers make climate-smart decisions. The government and private sector agencies such as Skymet/meteorological departments, etc., can help in designing and customizing EWS for one time/seasonal forecasts as well as non-disaster forecasts.
- Participatory/communitized information-sharing mechanisms can be developed through the concept of farmer schools or another institutional mechanism through convergence with Gram Panchayats, Village Organizations, and other government departments. These village-level demonstration centres can be managed through institutional collaboration through research institutions/resource organizations (NRLM, KVKs, etc.).

Key Focus area to work through collectives/individually

### Areas where Farmers can Work Collectively to Mitigate the Impacts

Area	Activity
Phase-wise Nursery/Plantation Planning	<ul style="list-style-type: none"> <li>Crop planning both at individual level as well as through collectives</li> <li>Working closely with seed companies/government agriculture/seed development departments/research and extension departments</li> </ul>
Enhanced Information Dissemination Mechanism	<ul style="list-style-type: none"> <li>Dedicated cadre for weather and crops advisory-related information dissemination</li> <li>Skill development of information warriors</li> <li>Recorded voice calls with actionable advisory</li> </ul>
Improved Weather Insurance Covers	<ul style="list-style-type: none"> <li>Localized weather stations</li> <li>Enhanced use of technology in production loss assessment</li> <li>Adherence to turnaround time in claim settlement</li> <li>Import duty cut on localized weather stations</li> <li>Viability gap funding for insurance companies using collectives in insurance ecosystem</li> </ul>
Weather Resistant Crops	<ul style="list-style-type: none"> <li>Corporate incentives for research into weather resistant varieties</li> <li>Strong intellectual property regulation regime</li> <li>Time-bound dispute resolution mechanism through arbitration</li> <li>Incentives for government funded research institutes for monetization of researches</li> <li>Dissemination through collectives</li> </ul>
Decentralized Warehousing	<ul style="list-style-type: none"> <li>Incentives for collectives to run small warehouses</li> <li>Big farmers can diversify into warehousing</li> </ul>
Grading of Output and Lower Level of Value Addition	<ul style="list-style-type: none"> <li>Collectives to negotiate with fast moving consumer goods companies to understand and deliver on grading using manual labour and low-level machines</li> <li>Collectives to get their members skilled on grading/value addition through Pradhan Mantri Kaushal Vikas Yojana</li> </ul>

### Summing up of Two-day Workshop/Training Programme and Feedback from Participants

Desired Outcome	The key highlights of the workshops are revised, and participants are able to recall the key points of these important issues. Participants also share honest and detailed feedback on the sessions conducted
Duration	15 minutes
Method	Discussion. Feedback Formats
Material	None





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