

Estimating crop water requirement

CROPWAT (FAO model)

- CROPWAT is a decision support tool developed by the Land and Water Development Division of FAO
- CROPWAT 8.0 for Windows is a computer program for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data
- The program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns
- Model can also be used to evaluate farmers' irrigation practices and to estimate crop performance under both rainfed and irrigated conditions.

Software

<http://www.fao.org/land-water/databases-and-software/cropwat/en/>

<http://www.fao.org/3/X0490E/X0490E00.htm>

CLIMWAT

CROPWAT

Impact of CC on CWR

- Saudi Arabia (Chowdhury et al., 2016): CWR might be increased in the range of 5.3–9.6% from 2011 to 2050 for the same level of crop productions. The increase in CWR was mainly due to the increase in temperature

Maize: 1.5%

Barley: 0.2%

Vegetables: 3.9%

Citrus: 1.5%

Grapes: 2%

- Thailand (Boonwichai et al., 2018): Temperature rises could increase crop water usage and higher rainfall alone may not be sufficient
- IWR is expected to increase in the future
- Rain fed rice yield may reduce by 14% under RCP4.5 scenario, and 10% under RCP-8.5 scenario by 2080s
- Due to the increment of crop water use and decrease in rice yield, CWP could reduce by 32% under RCP4.5 scenario, and 29% under RCP8.5 scenario by 2080s

- Iraq (Salman et al., 2020): The comparison of CWD revealed an increase in agricultural water needs in the late period (1984–2013) compared to the early period (1961–1990) by 1.0–8.0, 1.0–14, 15–30, 14–27 and 0.0–10 mm for wheat, barley, millet, sorghum and potato, respectively

- USA (CA)-Hopmans and Maurer, 2008: Significant uncertainty in projected precipitation translates into uncertainty of future water supply, ranging from an increase of 10% to a decrease of 30% in 2100

- Gujarat, India (Parekh and Prajapati, 2013): Crop water requirement of all Hot Weather crops (Millet, Ground nut, Maize, Small vegetables and Tomato) in all future periods is increasing as compared to base period 2003-2009.
- Crop water requirement of Rabi crops (Wheat, Sorghum, Maize, Small Vegetables, Tomato, Gram and Cowpeas) shows negligible decrease in crop water requirement in the period 2011-2020 but all crops shows considerable increasing water requirement in the period 2021-2030 including the periods 2046-2065 and 2080-2099 as compared to base period 2003-2009.

2. Phenological shifts

- Phenology, or the timing of the annual cycles of plants and animals, is extremely sensitive to changes in climate
- Plants and animals may adjust the timing of certain phenological events, such as tree flowering or migration, based on changes in weather

- The majority of previous phenology studies have described phenology shifts in terms of thermal conditions
- Temperature has been proven to be the most significant factor in plant phenology
- It shows the highest relevance for plant phenology than other climatic factors such as sunshine, frost, and snowmelt
- Precipitation, which describes the moisture content of soil, also could be a factor that can affect plant phenology, especially in a dry environment

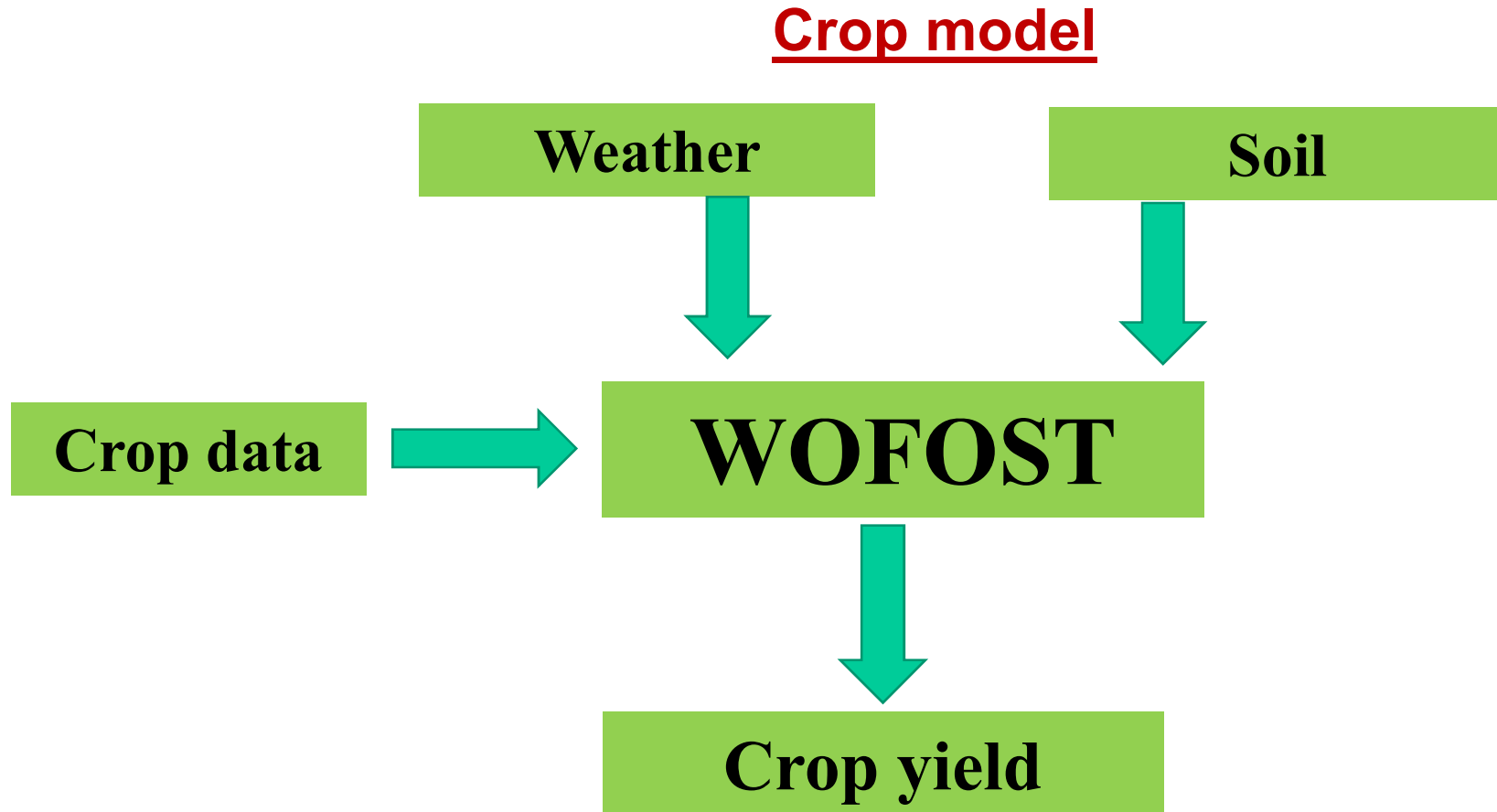
South Korea (Lee et al., 2020)

- The changes in the temperature and precipitation during the January–February–March period and the phenological shifts of all research species during 1920–2019 indicate that warm and dry spring weather advances the FFDs
- Moreover, the temperature has a greater impact on this phenological shift than precipitation. Earlier flowering species are more likely to advance their FFDs than later flowering species.
- The temporal asynchrony among plant species will become worse with climate change.

3. Geographical shift -MaxEnt

- Changes in suitable locations for their growth
- Future geographical/climate suitability of potato in India (Tutorial)

4. Yield variations/reductions



1. Increased conc. of CO₂:

- A higher concentration of carbon dioxide in the atmosphere will have different effects on different crops
- In C₃ plants: the photosynthesis relies on the concentration of carbon dioxide that is naturally available in the atmosphere. A higher concentration of carbon dioxide in the atmosphere will have a small fertilizing effect on these crops, if all other factors remain favorable
- C₄ plants have the capacity to increase the carbon dioxide concentration within their leaves before the photosynthesis begins. This is why increased concentrations of carbon dioxide in the atmosphere will not provide benefits to C₄ plants under normal conditions

2. **Changes in temperature:**

- The increase in average temperature during the growing season typically causes plants to use more energy for respiration for their maintenance and less to support their growth
- With a 1°C increase in average temperatures, yields of the major food and cash crop species can decrease by 5 to 10 percent (Lobell and Field, 2007; Hatfield *et al.*, 2009)
- With higher average temperatures plants also complete their growing cycle more rapidly (Hatfield *et al.*, 2011)
- Higher nighttime temperatures may increase respiration at night causing declines in yield (e.g. rice) and flowering or reproduction (e.g. beans)

- Extremely high temperatures above 30°C can do permanent physical damage to plants and, when they exceed 37°C, can even damage seeds during storage

3. **Changes in precipitation:**

- The impact of changes in precipitation will be particularly marked when they are combined with temperature alterations that affect the crop's evaporative demands
- This may lead to different forms of moisture stress depending on the phenological stage the crop has reached
- The specific impacts of changes in precipitation regimes on crops vary significantly because around 80 percent of the cropped area is rainfed and produces 60 percent of world's food (Tubiello *et al.*, 2007).

4. Pests:

- The distribution of insect pests is influenced by temperatures
- With global warming, insects, whose body temperature varies with the temperature of the surrounding environment are most likely to move pole-wards and to higher elevations (Bebber *et al.*, 2013)
- Pest distribution will also respond to changes in cropping patterns to cope with climate change

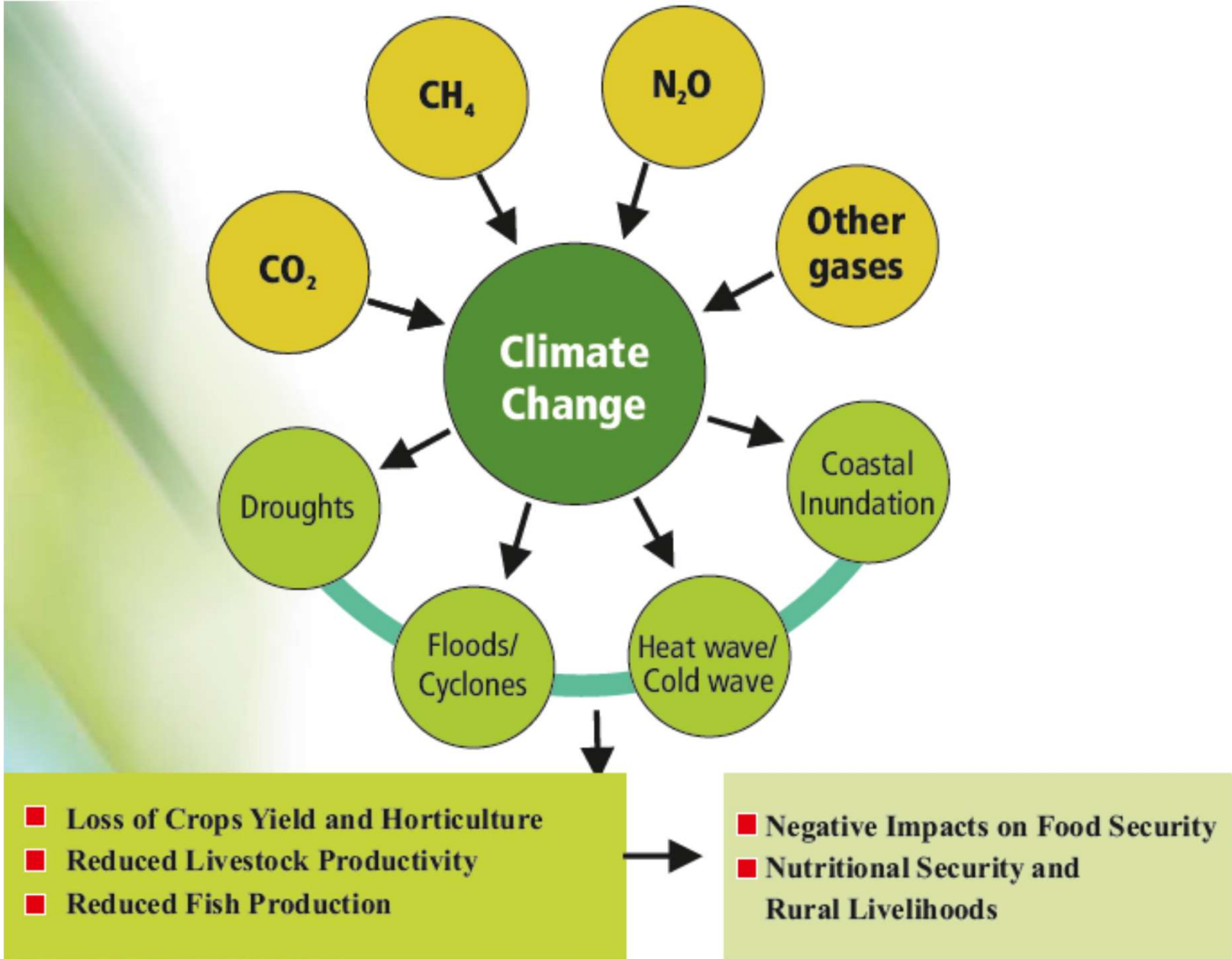
Crop yield losses

- Future climate change could reduce yields in the short-run (2010–2039) by 4–9 per cent and in the long-run (2070–2099) due to lack of adaptation by about 25 per cent (Guiteras, 2009)
- The projected agriculture output loss by 2100 lies between 10–40 per cent in India (Aggarwal, 2008)
- Kumar and Parikh (2001) reported that the anticipated 2 °C upsurge in temperature and 7 per cent upturn in rainfall can diminish farm returns by 9 per cent
- Sanghi and Mendelsohn (2008) reported that net revenue of agriculture in India could drop by 4–26 per cent

Global crop yield losses

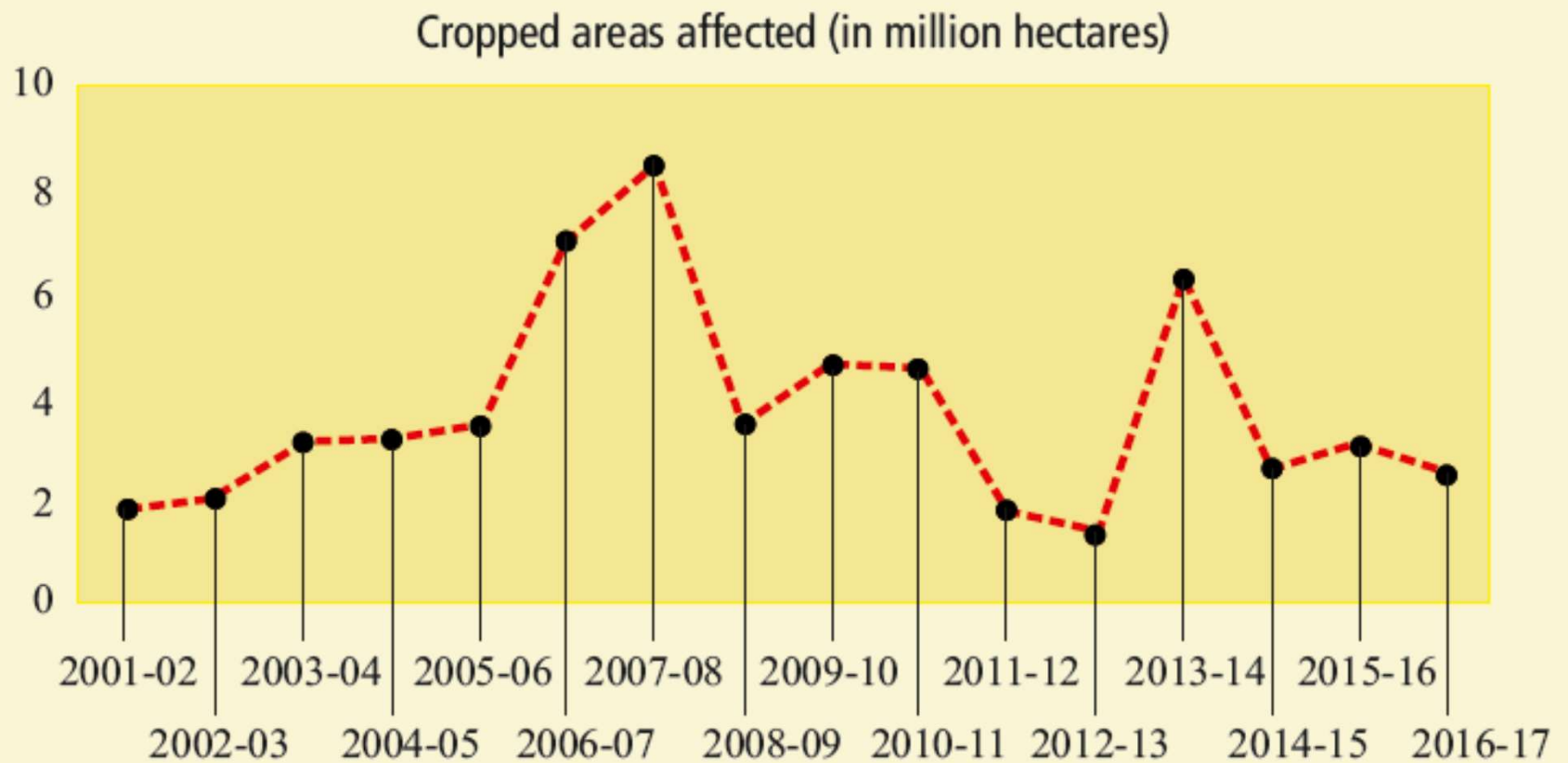
Scenario	Yield changes (%) due to temperature changes by the end of century				
	Wheat	Rice	Maize	Soybean	Mean
RCP2.6	-6.9	-3.3	-8.6	-3.6	-5.6
	[-15.0, -1.4]	[-9.2, 0.8]	[-18.6, -1.8]	[-11.2, 1.7]	[-14.4, -0.1]
RCP4.5	-11.4	-5.5	-14.2	-5.9	-9.2
	[-21.7, -3.9]	[-13.8, 1.0]	[-27.9, -4.9]	[-17.0, 3.1]	[-21.2, -0.3]
RCP6.0	-14.0	-6.8	-17.4	-7.2	-11.3
	[-25.7, -5.1]	[-16.8, 1.3]	[-33.1, -5.8]	[-20.2, 3.6]	[-25.6, 0.1]
RCP8.5	-22.4	-10.8	-27.8	-11.6	-18.2
	[-40.2, -8.5]	[-25.3, 2.4]	[-50.4, -9.7]	[-31.0, 6.0]	[-38.6, -0.7]

Source: Chuang Zhao et al. PNAS 2017;114:35:9326-9331



Economic losses in India due to climate change on agriculture

- Government of India's economic survey (2018) estimated that the annual loss of US\$ 9-10 billion was due to the adverse effects of climate change



Adaptations & Mitigations

- Adaptation led Mitigation' to climate change is the only option to prepare our community, locality, country, and the societies for the consequences of same
- 'Adaptation' is nothing but the adjustments in human or natural ecosystem in response to climate change, and it moderately harm or destruct the opportunities
- Practically, it means changing the regular activities because of change in climate but not completely different, rather purposefully modifying the existing practice

- 'Mitigation' is any technological modification that reduces the addition of inputs and its emission (GHGs into atmosphere) per unit of output (IPCC)



Government of India Initiatives for Climate Change Adaptation

National Mission on Sustainable Agriculture (NMSA):

- This Mission was structured under the *National Action Plan on Climate Change* (NAPCC) during 2014-15
- It aimed to synergize resource conservation, enhancing or restoring the soil fertility, thereby, improving productivity with focus on soil health management, Integrated Farming System (IFS), integrated animal component and Water Use Efficiency (WUE) specifically in drylands or rainfed agriculture areas

National Adaptation Fund for Climate Change (NAFCC):

- This Scheme was implemented during 2015-16 mainly for supporting concrete adaptation activities dealing with mitigating the adverse effects of global climate change in sectors such as agriculture, water, forestry, animal husbandry, tourism, *etc.*

Pradhan Mantri Krishi Sinchayee Yojna (PMSKY):

- This Scheme was planned and formulated to give more priority on water conservation and its management in agriculture with the vision to extend the area under irrigation from 1st July 2015
- The main motto of this Scheme is 'Har Khet Ko Paani' to improve water use efficiency, 'More crop per drop' to provide end-to-end solutions in water source creation, distribution channels and its management

Pradhan Mantri Fasal Bima Yojna (PMFBY):

- This Scheme was introduced on 14th January, 2016 in order to reduce the agricultural distress and farmer's welfare without affecting substantial hikes in the Minimum Support Prices (MSP) on agricultural produces during monsoon fluctuations or any other natural calamity by providing full insured amount on crop losses

Soil Health Card (SHC):

- This Scheme was launched in February, 2015 by the Central Govt. to issue soil health cards (SHC) to the farmers providing detailed information on test based soil nutrient status of their own land along with recommended dose of fertilizers for improving productivity through judicious use of inputs
- The Govt. of India targeted to issue 10.48 crores of SHCs since inception of the Scheme

Green India Mission (GIM):

- This Mission was started in February 2014 and outlined under NAPCC
- The main objective of this Mission was to protect, restore and enhance the diminishing forest cover in India, and to fight climate change with adaptation and mitigation measures

National Water Mission (NWM):

- A Mission was mounted to ensure Integrated Water Resource Management (IWRM) for conserving the water sources and minimizing its wastage, and also to optimize Water Use Efficiency (WUE) by 20 per cent including agriculture sector.

Paramparagat Krishi Vikas Yojna (PKVY):

- It is an extended component of Soil Health Management (SHM) launched in 2015 under NMSA with the objective of supporting and promoting organic farming through adoption of organic village by cluster approach, which in turn result in improvement of soil health

National Action Plan on Climate Change (NAPCC) and State Action Plan on Climate Change (SAPCC):

- The NAPCC was released on 30th June 2008 in order to create awareness among public, Govt. agencies, industries, scientists and the society on the risks posed by global climate changes, and steps to encounter the same
- It pulls all the existing Government's national plans on energy efficiency agriculture, renewable energy, water, and others
- The SAPCC have enlisted climate adaptation and mitigation strategies aligned with eight national missions under NAPCC

Agricultural Contingency Plans and National Innovations on Climate Resilient Agriculture (NICRA):

- Agricultural Contingency Plans are technical documents comprising integrated information on field crops, livestock, horticulture, poultry and fishery and technological solutions for all weather-related problems for the respective farming activities
- These are useful to plan earlier towards sustainable agriculture system during weather aberrations and extreme climatic conditions

Sub-mission on Agro-forestry:

- This Mission was launched during 2016-17 with the objective of planting trees on farm bunds
- Agroforestry has the potential to bring sustainability in agriculture and also achieving the optimum productivity by mitigating the impact of climate change

National Livestock Mission:

- This Mission was initiated by the Ministry of Agriculture and Farmers' Welfare and got commenced from 2014-15 focussing mainly on livestock development through sustainable approach ultimately protecting the natural environment, ensuring bio-security, conserving animal biodiversity and farmers' livelihood

Innovative Poultry Productivity Project:

- The National Livestock Mission launched this Project on pilot basis during 2017-18 in 15 recognized poultry potential states to provide nutritional support to the poor farmers and also give supplementary income

- The State Action Plan on Climate Change (SAPCC) is a flexible and dynamic policy framework follows a continuous interaction process for bringing changes in national, state and local levels
- It was directed by National Government to create a coherent national framework under the line of NAPCC