4. Climate Change

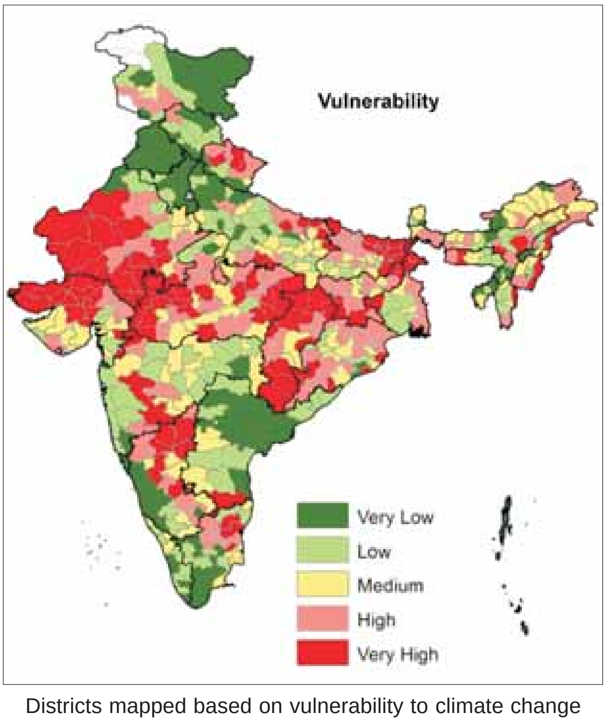
Climate change and variability pose serious challenges. There are evidences of negative impacts on yield of wheat, rice and other crops in certain parts of India due to increased temperature, water stress and reduction in number of rainy days. Research aimed at enhancing resilience of Indian agriculture to climate change and climate variability has been a major mandate of the ICAR.

Mapping vulnerability of agriculture

Vulnerability is a function of the character, magnitude, and the rate of climate variations to which a system is exposed, its sensitiveness and adaptive capacity. A database for 572 districts in India was developed with this perspective. To assess the degree of change in climate in the district in terms of change in drought occurrence, incidence of dry spells, change in annual rainfall, heat wave, cold wave, climate projections of the PRECIS model for A1B scenario for 2021-2050 were employed. The changes in different climatic parameters were computed relative to the baseline 1961-90 of the same model. Finally, the vulnerability index (VI) was computed :

VI = Sensitivity + Exposure – Adaptive Capacity

Based on the index, the districts were divided into five sensitivity categories. The districts with higher levels of vulnerability are located in the western and eastern regions and some parts in lower Indo-Gangetic Plain and Karnataka.



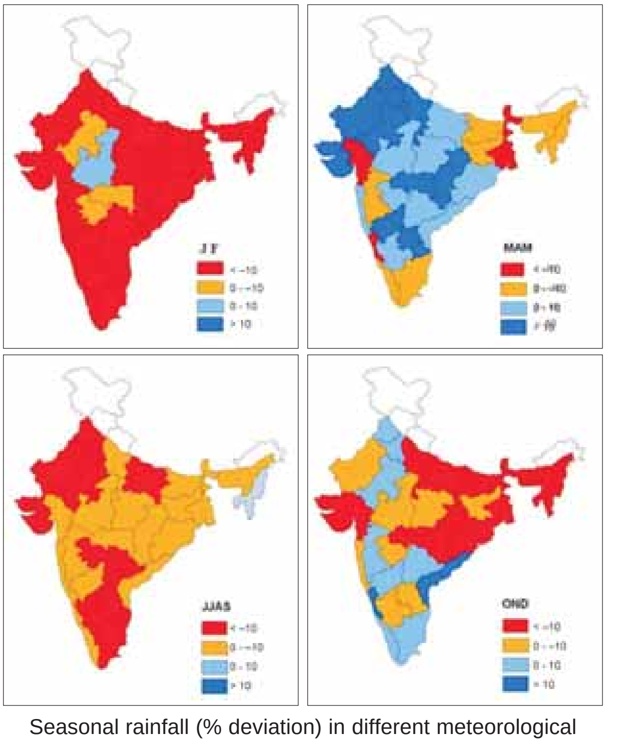
Districts mapped based on vulnerability to climate change and variability

El Nino and seasonal rainfall shifts over India

To study the changes in seasonal rainfall amounts over the country during El Nino, sub-divisional rainfall data collected from the Indian Institute of Tropical Meteorology, Pune (1901–2009), El Nino data from the National Oceanic Atmospheric Administration (NOAA), US website, and rainfall for summer (March to May), monsoon (June to September), post monsoon (October to December) and winter (January to February) during El Nino years were analyzed.

Results indicate that summer (except in coastal Karnataka, West Bengal and Gujarat, where less than 10% deviation was observed) and post-monsoon rainfall (except in Saurashtra and Kutchh, Gujarat region, entire Uttar Pradesh, Bihar, West Bengal, Odisha, Chhattisgarh and Vidharba where < 10% is observed) increased during El Nino events. Except western Madhya Pradesh, winter rainfall showed negative deviation (<10%).

Increased post-monsoon season rainfall was observed over Punjab, Haryana, eastern Rajasthan, North Coastal Karnataka, Madhya Maharashtra, coastal Andhra Pradesh, northern Telangana, Tamil Nadu and Kerala. This clearly indicates the seasonal rainfall shift during El Nino events.



Seasonal rainfall (% deviation) in different meteorological Sub-divisions during El Nino years

It calls for appropriate planning to implement suitable crop and natural resources management strategies to stabilize *kharif* and *rabi* crops.

Technology demonstration to help farmers cope with climate variability

Under the National Initiative on Climate Resilient Agriculture, technology demonstration was taken up in 100 vulnerable districts of the country. In each of the village clusters, a Village Climate Risk Management Committee (VCRMC) was formed, and also village-level weather station and custom-hiring centres were established to promote weather literacy and enable farmers in timely completion of farm operations during delayed monsoon.

Increasing rainwater harvesting capability along with crop production supporting activities such as introduction of improved cultivars, addressing micronutrient deficiency through site-specific nutrient management, supplemental irrigation, mulching, use of zero-till drill have brought in new energy into the NICRA villages. Mobilization of people to build a sand bag check-dam across a rivulet in Gumla, Jharkhand, has improved water-table in open wells and enabled farmers to secure the *rabi* crop. Land shaping and harvesting rainwater helped reclaim lands affected by sea water inundation due to *Aila* cyclone in South 24 Parganas, West Bengal. Custom hiring centres make available farm implements and equipment at normal hiring charges to the farmers and total amounts ranging from ₹ 10,000 to ₹ 100,000 have been collected as hire charges during a single season.

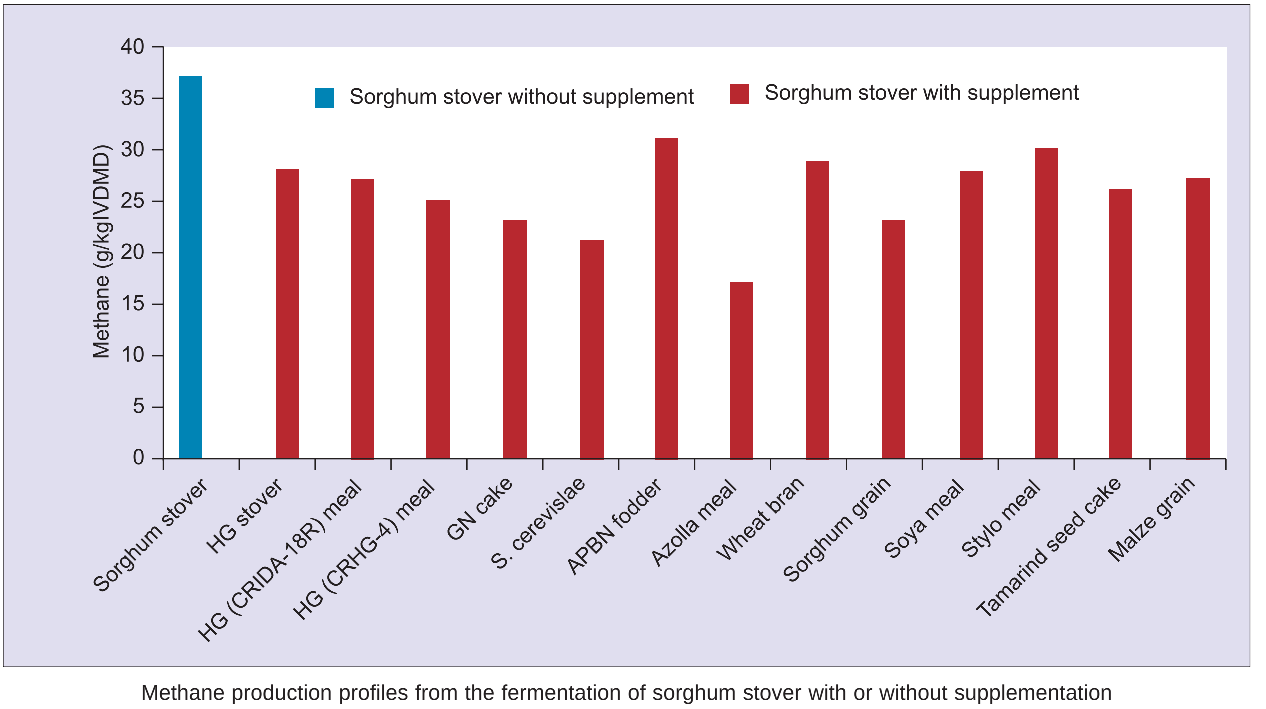
Reducing methane emission in livestock through feed manipulation

Microbial digestion in the rumen of cattle results in production of waste products such as carbon dioxide (CO_2) and methane (CH_4), and approximately 7% of dietary gross intake energy is lost to atmosphere as CH_4. *In vitro* gas production was employed to assess cumulative gas pool and the concentration of methane in cumulative gas from fermentation of coarse crop feed (sorghum stover) with different supplements. Gas volume was reduced significantly with supplementation and maximum reduction was observed with *Saccharomyces cerevisiae*, followed by groundnut cake. Tanniferous feed ingredients like stylo meal, sorghum grain, horsegram meal and tamarind seed cake also substantially reduced *in vitro* gas production. Similarly, methane concentration in the *in vitro* gas was less with supplementation compared to sole sorghum stover fermentation; 17 to 37 g/kg *in vitro* dry matter digestibility with maximum from sole sorghum stover and minimum with azolla supplementation. Further, *in vitro* degradability of dry matter and organic matter also enhanced with supplementation. These results indicate the significance of supplementation while feeding coarse crop residues in enhancing productivity and reducing GHG emissions.

Water resources development and management to adapt to climate change

To adapt to the climatic variability under irrigated command area, site-specific surface water harvesting and groundwater recharge structures were designed and evaluated in Odisha (Puri, Dhenkanal, Balasore, Nayagarh, Cuttack, Kendrapara), Tamil Nadu (Coimbatore), Rajasthan (Udaipur) and Gujarat (Junagarh).

A total volume of 12,842 m^3 (three ponds), 50,323 m^3 (nine ponds), 28,652 m^3 (six ponds), and 4,640 m^3 (one pond) was created at Nayagarh, Puri, Kendarpara and Cuttack, respectively, based on the available runoff at 67% probability, benefiting 155 farmers. Pond-based farming systems (crops, on-dyke horticulture, fisheries) were developed in the created water resources in three canal commands and one coastal area of Odisha to enhance water productivity and to overcome dry spells. Groundwater resources were created through 17 dug-wells in Dhenkanal and Cuttack districts of Odisha for



Methane production profiles from the fermentation of sorghum stover with or without supplementation

Creation of groundwater resource for irrigation during dry spell at Dhenkanal, Odisha

growing vegetable crops. Basic soil–water–plant relationships were assessed for different land ecologies.

Groundwater recharge structures were evaluated in Coimbatore (Tamil Nadu), Udaipur (Rajasthan) and Junagadh (Gujarat). The average groundwater recharge in Parambikulam–Aliyar Project basin at Coimbatore under hard rock condition varied from 2.29 to 11.06% rainfall with an average recharge of 5.22% during South West monsoon period. Average groundwater recharge varied from 4.34 to 28.62% with an average recharge of 12.5% due to North-east monsoon season.

Three types of recharge structures, viz. dry stone masonry pond, single wall cement masonry pond, single wall cement masonry pond, were designed and constructed in Girwa and Jhadol block of Udaipur district. The average recharge rate was found to be 7.63 cm/day. The additional quantity of water available in the well due to recharging was utilized for irrigating wheat in 1.2 ha.

Influence of climate on biochemical profile of host trees of lac insect

Key biochemical indicators of stress of host trees lac insect were studied at different periods at two locations to understand the impact of climate vis-à-vis lac insect survival. Proline content has shown significant reduction due to inoculation during active feeding stage of lac insect (February–March) in case of *ber* (*Ziziphus* sp.). Malone dialdehyde (MD) content, an indicator of oxidative stress, behaved differently with respect to host trees tested as well as locations. In case of *ber*, more oxidative stress was observed during the winter period. In case of *palas* (*Butea monosperma*), same pattern of increase/decrease in MD content was observed. Moreover, the inoculated *ber* showed significant difference with respect to locations (i.e. West Bengal showed maximum MD while Jharkhand showed the minimum). Proline content was significantly higher in lac-inoculated plants both in case of *ber* and *palas*.

Predictions on future temperature

Temperature predictions for 2020 and 2050 were computed and compared with the present levels to meet the likely impact of climate change on shrimp farming. As per the projections, the lowest minimum temperature is expected to be warmer by more than 2°C in 2020 and 2050 compared to the present and the average monthly maximum temperatures will increase by 0.65°C by 2020 and 1.84°C by 2050. The increase in temperatures will have an adverse effect on the water availability and water quality parameters thereby affecting shrimp growth. However the increase in temperature during winter would have a beneficial effect on pond productivity and shrimp growth with better food conversion rate and reduced white spot disease outbreaks.

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