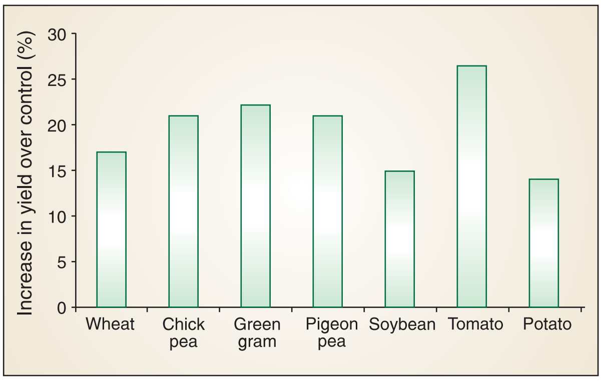
4

Climate Change

Impact of increased carbon dioxide on crops: A rise in atmospheric carbon dioxide to 550 ppm enhanced the yields of wheat, chick pea, greengram, pigeon pea, soybean, tomato and potato between 14% and 27%. There was a under controlled environment conditions (free air CO_2 enrichment, Open Top Chambers) and modeling. In most of the crops this was accompanied by a small reduction (2 to 10%) in the protein content. In plantation crops, viz. coconut, arecanut and cocoa, increased CO_2 led to higher biomass.

The larval duration of two pests- *Spodoptera litura* and *Achaea janata* - in 550 ppm CO_2 was studied. The larval duration of *Spodoptera litura* increased by 1 to 3 days in groundnut, castor and blackgram. Similarly, the larval duration of *Achaea janata* on castor increased by 2 days at elevated CO_2.



Increase in yield of different crops as CO_2 concentration was enhanced to 550 ppm

Carbon sequestration potential of coconut: The carbon sequestration potential of coconut plantations was assessed using field measurements and simulation modeling for 4 major coconut growing states accounting for 90% of the production, viz. Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. The carbon sequestered in stem in coconut plantations is 0.732 million tonne of carbon every year. These values will be significantly higher, if the carbon sequestered in other plant parts of the coconut such as shell and coir are also considered. This suggests that coconut has a large carbon sequestration potential.

Assessment of farmers' coping strategies to climatic risks: A survey was conducted in dry temperate regions of Spitti in Himachal Pradesh to assess farmers perception of increasing climatic risks and the strategies adopted by them to cope with these risks. All farmers realized that climate is changing. They have experienced increased frequency of dry spells and a reduction in snowfall. They also noticed that the flowering pattern and fruit setting of trees has advanced by almost a week.

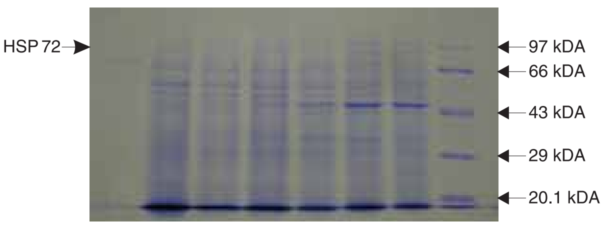
The farmers increased their investment on storage structures. Apple farmers switched to varieties with less chill unit requirement to cope up with increasing heat stress. Many farmers planted short duration crops like peas, turnip and black lentil as these crops also provide better returns in a short time. Since these areas receive low rainfall but considerable snow, and the soils are sandy and highly drained, some farmers also invest in water harvesting.

Vulnerability of coastal fishing villages of Maharashtra to sea level rise: The CMFRI reported that about 75 coastal fishing villages of Maharashtra are located within 100 m from the high tide line. To find out the vulnerability of these fishing villages to sea level rise, validation of available primary data from vulnerable fishing villages along Maharashtra coast was completed by ground truthing by using GPS. For ground validation, data were collected from Ground Control Points (GCPs) at different elevations from all 5 coastal districts of Maharashtra, and images were generated for all 5 coastal districts of Maharashtra.

After geo-referencing these villages, 3 different scenarios of sea level rise were created to determine critical area likely to be submerged. Base mark (0 m), points at 0.3 m, 0.6 m and 1.0 m were obtained through software to calculate the perimeter and area for 3 SLR scenarios. All elevations are generated from mean sea level by the software. The results were validated by ground-truthing during field observations. A sample map thus generated for Juhu fishing village, Mumbai is given below. Consolidation of all the maps to identify vulnerable coastal fishing villages in Maharashtra is under progress.

Projected area of inundation of Juhu fishing village, Mumbai for 3 sea level scenarios; blue colour indicates 0.3 m, blue+yellow 0.6 m, blue+yellow+red 1.0 m rise in sea level

Adaptation of livestock to climate change-role of HSP's: A study on Sahiwal and Holstein Friesian crossbred (Karan-Fries) heifers was carried out to find out the pattern of expression of HSP72 under natural environment and at extreme temperature exposures in a climatic chamber (40ºC and 50% RH and 45°C and 50% RH for 4 hr). It showed that HSP72 protein level increased due to thermal exposures; relatively Karan-Fries exhibited higher increase (106%) than Sahiwal (22.4%).



SDS-PAGE of HSP72 (purified, sigma) and total protein in lymphocyte cell lysates of Sahiwal and Karan-Fries exposed at 45°C and 50% RH. Lane 1- HSP72 (purified), lane 2 and 5- Before exposure, lane 3 and 6– after 2 hr of exposure, lane 4 and 7 after 4 hr of exposure; Lanes 2,3, and 4 are for Sahiwal and 5,6, and 7 are for Karan-Fries. M- Molecular weight marker

Emission of greenhouse gas

Assessment of greenhouse gas inventory that identifies and quantifies a country's primary anthropogenic sources and sinks of greenhouse gas emission is central to any climate change study. India being a party to the United Nations Framework Convention on Climate Change needs to develop, periodically update, publish and make available to the Conference of Parties, a national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gas. Accordingly the inventory of greenhouse gas emission by Indian agriculture was developed for the base year 2000.

Greenhouse gas inventory for Indian agriculture for the base year 2000

Source	CH_4(Tg)	N_2O(Gg)	CO_2 eq.(Tg)
Ruminant	10.1	–	252.0
Rice cultivation	3.5	–	87.3
Manure management	0.1	0.1	2.5
Crop residue	0.2	4.0	4.9
Soil	–	132.3	39.4
Total	**14.7**	**137.3**	**386.1**

Tg, million tonnes; Gg, thousand tonnes

In 2000, Indian agriculture contributed 386.1 million tonnes (Tg) CO_2 eq. The agriculture sector primarily emitted methane CH_4 (14.7 Tg) and nitrons oxide N_2O (137.3 thousand tonne, Gg). The emission sources accounted for in the agriculture sector are enteric fermentation in livestock, manure management, rice cultivation, agricultural soils and burning of agricultural crop residue. The bulk of the greenhouse gas emission from the agriculture sector was from enteric fermentation through ruminant (65%) followed by rice cultivation (23%) and the rest were contributed by manure management, burning of agriculture crop residue (1%) and application of N fertilizer to soil (10%) and manure (1%).

Methame emission: Livestock rearing, an integral part of Indian agriculture, is the major contributor of methane (CH_4). Although the livestock includes cattle, buffaloes, sheep, goats, pigs, horses, mules, donkeys, camels and poultry. The bovines and the small ruminants are the most dominant feature of Indian agrarian scenario, and the major source of methane emission. Methane (CH_4) emission due to enteric fermentation in 2000 was estimated to be 10.1 Tg. Buffalo and indigenous cattle, which are the main milk-producing animals in the country, contributed 44% and 42% total methane emission from livestock sector. Crossbred cattle emitted 8% and the small ruminants emitted about 7% of methane.

In India rice is cultivated under various water management conditions, depending on availability of water. Methane emission due to rice cultivation was estimated to be 3.5 Tg. Continuously flooded

Area and methane emission in various rice-ecosystems in India

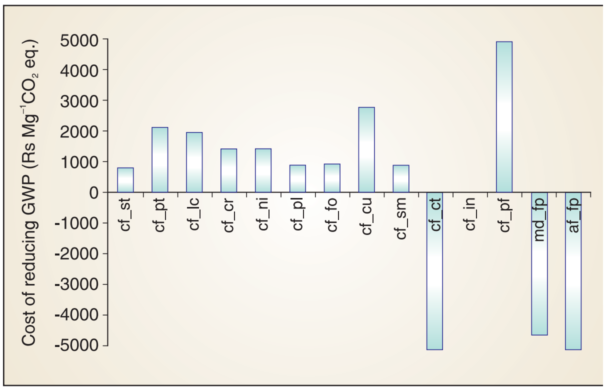
Ecosystem	Water regime	Area (M ha)	Emission (Gg)
Irrigated	Continuous flooded	6.85	1,111
	Single aeration	9.08	598
	Multiple aeration	9.49	175
Rainfed	Drought prone	8.66	570
	Flood prone	4.35	827
Deep water		1.37	218
Upland		4.83	0
Total		**44.62**	**3,499**

rice emitted maximum methane (1,111 Gg) followed by flood prone (827 Gg) and single aerated (598 Gg) rice cultivated areas.

N_2O emission: During 2000, Indian agriculture produced 137.3 Gg of N_2O-N. Nitrogenous fertilizer application contributed 68% of that emission followed by manure (13%) and crop residue (11%) and soil mineralization (8%).

Though the inventory of greenhouse gas (GHG) emission from Indian agriculture is fairly robust but it still suffers from various deficiencies like non-availability of country specific emission factors, lack of adequate monitoring stations and data quality. To capture the diverse soil and climatic conditions, different management practices and socio-economic status of the farmers influencing GHG emission, an appropriate national exercise is needed. This will not only improve estimates of emission and related impact assessments, but also provide a baseline from which future emission trajectories may be developed to identify and evaluate mitigation strategies.

Greenhouse gas mitigation: A decision support system, named InfoNitro (Information on Nitrogen Management Technologies in Rice), has been developed to quantify inputs, outputs and balance of N in soil; greenhouse gas emission and N use efficiency with the prominent N management technologies in rice. Sixteen technologies, which differed in water regime, method of N application,



Marginal abatement cost for reducing global warming potential (GWP) from the baseline technology of continuous flooding and farmers' practice (cf_fp) in Haryana. With resource conserving technology (cf_ct), mid-season drainage (md_fp) and alternate flooding (af_fp) technologies GWP is reduced without any extra cost involved. With integrated nutrient management (cf_in) technology GWP is increased.

forms of N and tools of fertilizer recommendation were analyzed for their greenhouse gas emission and N loss reducing potential and economic return in Haryana, a rice growing region in India. The technologies reduced global warming potential by 1 to 9%. Resource conserving technology was the most cost effective strategy to reduce N loss and greenhouse gas emission whereas integrated N management cost high for mitigating greenhouse gas emission.

Estimation of carbon footprint by marine fishing boat

It is estimated that annual CO_2 emission of marine fishing boats in India was 3.6 estimated million tonnes during 2005–2007. It was found that the mechanized boats emitted 1.67 tonnes of CO_2 per tonne of fish catch, and motorized boats with outboard engine emitted 0.48 tonne CO_2 per tonne of fish catch. Among the mechanised craft, the trawlers emitted more CO_2 than the gillnetters and dolnetters. Based on the data available on the number and size of fishing boats in India in the past years, it is estimated that CO_2 emission per tonne of fish caught has increased by 64% in 25 years.

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