Scenario of Climate Change in Indian Agriculture

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Mountain regions occupy about one –fifth of the Earth's surface and are home to one –tenth of the global population. They provide goods and services to about half of the mankind. Indian Himalayas cover 16 per cent of the geographical area and out of the 21 agro-ecological regions as estimated in India, the Himalayan regions have cold arid and warm sub humid to humid climate. Several agro-climatic zones, viz., Alpine zones, Temperate Zones, Sub- tropical hill zone, Sub –tropical plain zone, Mild tropical humid hill zone, Mild tropical humid plain zone are present in the region. The debate on climate change is on and the effect of climate change on the region is of high magnitude. From the report of the Inter Governmental Panel on Climate Change (IPCC), it is known that the average surface temperature has increased over the 20th century by about 0.6 ^{0}C. The number may seem insignificant but it is an unprecedented rise. In the past 150 years, the 11 hottest years were witnessed. It says that 1990s was the warmest decade and 1998 the warmest year since 1861. Worse, the artic is warming twice as rapidly as the rest of the world and there is a distinct possibility of the Greenland Ice sheet collapsing altogether and pushing up the sea levels. It is predicted that 2035 is the year when Himalayan glaciers may totally disappear. Following is the probable effect of climate change:

- 40 per cent of the world population faces water shortage
- 2/3rd of world's farm lands suffer from soil degradation
- Half of the world's wetland lost
- Since 1990, 24per cent of world's forests have been destroyed. The rate of loss is now 90,000 km2/year
- Air pollution now major killer accounting for 3 million people /year
- 800 wildlife species extinct and 11,000 threatened
- Of the 9964 bird species, 70per cent declined in numbers
- Almost 75 per cent of marine creatures are fished
- 1/5th of 10,000 fresh water species are now totally extinct

The globally averaged surface temperature is expected to rise by 1.8 to 4.0^{0}C and the global sea level is projected to rise by 0.18 to 0.59 metres (2090-2099 relative to 1980-1999).The impact of climate change may be on food production, water, animal productivity and human health. The climate change projections in India are presented in Table 1.

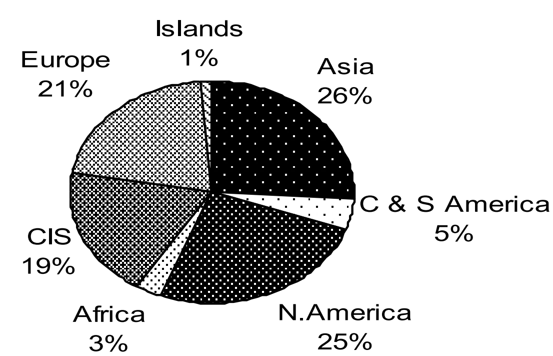
Table 1.Climate change projections in India

Year	Season	Temperature change (ºC)		Rainfall change (per cent)	
		Lowest	Highest	Lowest	Highest
2020	Annual	1.0	1.41	2.16	5.97
	Rabi	1.08	1.54	-1.95	4.36
	Kharif	0.87	1.17	1.81	5.10
2050	Annual	2.23	2.87	5.36	9.34
	Rabi	2.54	3.18	-9.22	3.82
	Kharif	1.81	2.37	7.18	10.52
2080	Annual	3.53	5.55	7.48	9.90
	Rabi	4.14	6.31	- 24.83	- 4.50
	Kharif	2.91	4.62	10.10	15.18

Both the increase in temperature and decline in rainfall particularly during the rabi season will have a direct negative impact on the crop productivity scenario in Indian agriculture.

Greenhouse gases

The maximum greenhouse gas emission in India is in the energy sector (61 per cent) followed by agriculture (28 per cent) and the contribution of green house gases towards the global warming is depicted in Fig. 1. Nearly 79 per cent of global warming is caused by carbon dioxide followed by nitrous oxide (15 per cent) and methane (6 per cent) (Fig. 2). Global atmospheric carbon dioxide has increased from the pre industrial value of 280 ppm to 379 ppm in 2005. On the other hand, the global methane concentration has increased from the pre industrial value of 712 ppb to 1774 ppb in 2005.There is an increase in global nitrous oxide concentration from 270 ppb to 319 ppb in 2005. The greenhouse gases in the globe is of wide variation



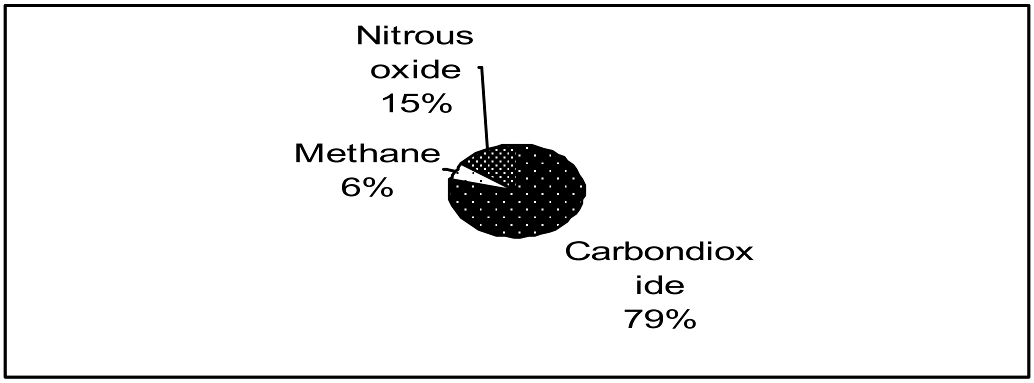


Fig1. Contribution of green house gases for global warming

Climate and Indian agriculture

Indian agriculture is considerably dependant on changes in weather. Contribution of agriculture to Gross Domestic Product (GDP) is decreasing, yet large population is dependent on this for livelihoods. There is a need to understand the impacts of increasing climatic risks and possible adaptations. Info crop model has been validated for rice, wheat, maize, sorghum, cotton, potato, groundnut, soybean, mustard in different agro-climatic regions. The impact of climate through simulation on wheat is presented in Fig. 3.

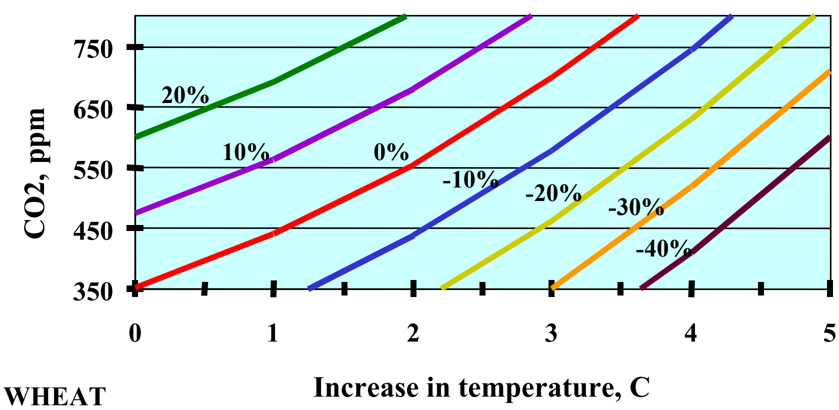


Fig. 3. Simulated effect of high carbon dioxide and temperature on wheat (Source PK Agarwala, IARI).

With the rise in carbon dioxide, the productivity may be augmented but the effect is nullified by the rise in temperature. The impact on food production is presented in Fig. 4 in such a way that the demand remains higher than the supply.

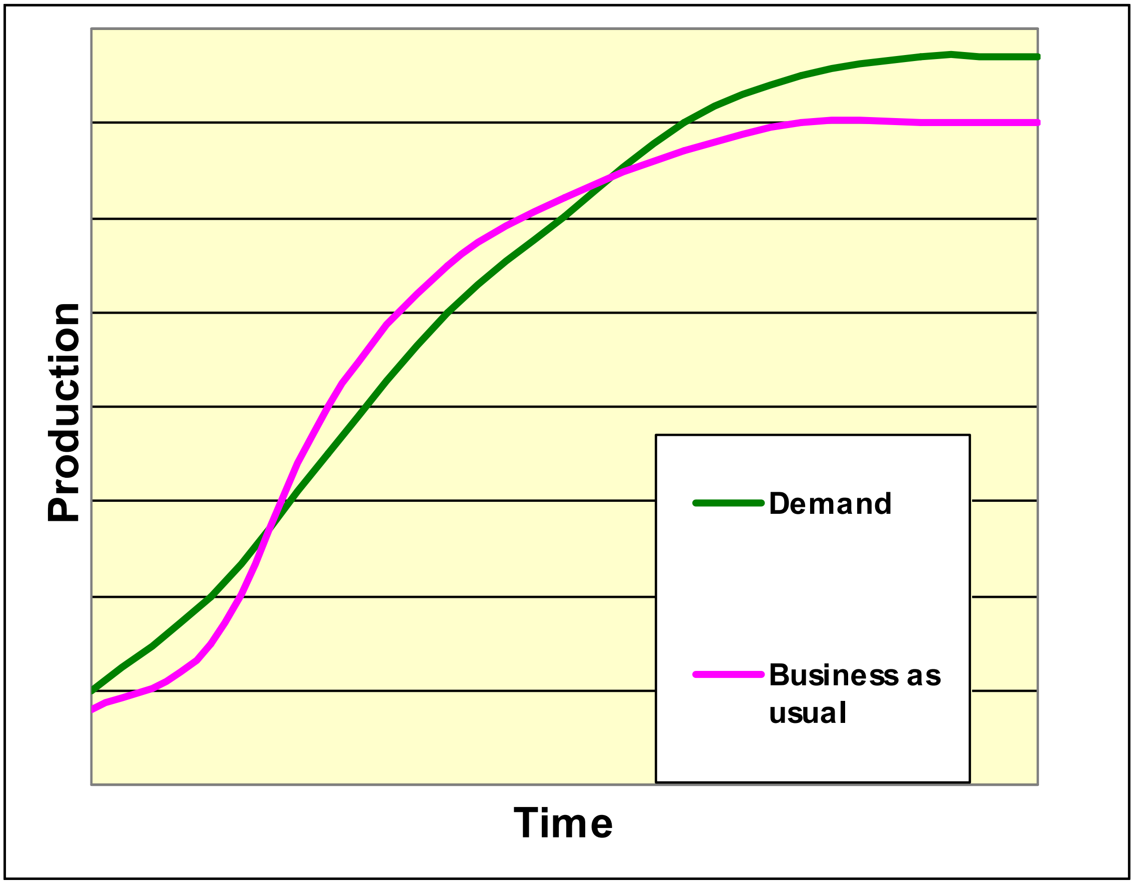


Fig. 4. Demand/supply of food upon climate change

The estimated impact of heat wave in 2004 on the productivity of wheat is summarized as below

- Increased heat: + 5-8 oC in north and central India from 5th March to 28th March, 2004
- Caused a loss of 4.5 million tons of wheat

Similarly there is a large decrease in the productivity in rice particularly in rabi season due to shortage of water in many parts of the country.The likely effects of climate change caused by increasing atmospheric carbon dioxide levels on rice production in Asia were evaluated using two rice crop simulation models, ORYZA1 and SIMRIW, running under 'fixed-change' climate scenarios and scenarios predicted for a doubled-CO_2 ($2 \times CO_2$) atmosphere by the General Fluid Dynamics Laboratory (GFDL), the Goddard Institute of Space Studies (GISS) and the United Kingdom Meteorological Office (UKMO) General Circulation Models. In general, an increase in CO_2 level was found to increase yields while increases in temperature reduced yields. Overall rice production in the region was predicted by the ORYZA1 model to change by + 6.5, − 4.4 and −5.6 per cent under the GFDL, GISS and UKMO $2 \times CO_2$ scenarios, respectively, while the corresponding changes predicted by the SIMRIW model were + 4.2, −10.4 and −12.8per cent. The average of these estimates would suggest that rice production in the Asian region may decline by −3.8 per cent under the climate of the next century. Declines in yield were predicted under the GISS and UKMO scenarios for Thailand, Bangladesh, southern China and western India, while increases were predicted for Indonesia, Malaysia, Taiwan and parts of India and China.

Adaptation

1. Agriculture diversity is a manifestation of climatic adaptation.
2. Farmers/society have always adapted when allowed by technology availability, their socio-economic capacity, and economics.
3. Induced adaptation by innovation:
   - Green revolution of 1960s
   - Resource conservation technologies such as zero tillage
   - GMOs

Following are the methods of adaptation to confront the rise in temperature:

- Drought proofing by mixed cropping
- Low yielding, tolerant crops
- Resource conservation
- Single cropping
- Heat stress alleviation by frequent irrigation
- Shelter belts
- Changing varieties/crops
- altering fertiliser rates to maintain grain or fruit quality and be more suited to the prevailing climate
- altering amounts and timing of irrigation
- harvest rain water
- conserve soil moisture (e.g. crop residue retention)
- use water more effectively
- altering the timing or location of cropping activities
- diversifying income including livestock raising

But the cost involved in adaptation is not known and as such emphasis on the following points needs to be given:

- Investments in adaptation research capacity
- Improved communication of climate changes and options to adapt to them
- Investments in infrastructure for water management and for product transportation and marketing
- Changes in policies and institutions, e.g. incentives for resource conservation and use efficiency
- Credit for transition to adaptation technologies
- Relocation to more productive areas
- Creating alternate livelihood options and reducing dependence on agriculture
- Greater insurance coverage for the farm

Modification of sowing dates at high latitudes, where warmer temperatures allowed a longer growing season, permitted a possible transition from single-cropping to double-cropping at some locations, an adaptation that could potentially have a large positive impact on national rice production in some countries. Planting dates could also be adjusted to avoid high temperatures at the time of flowering which can cause severe spikelet sterility in some varieties, although a delay in planting in some cases may prevent a second crop from being obtained because of high temperatures later in the season. Selection for varieties with a higher tolerance of spikelet fertility to temperature was shown to be capable of restoring yield levels to those predicted for current climates. The use of longer-maturing varieties to take advantage of longer growing seasons at higher latitudes may instead result in lower yields, due to the grain formation and ripening periods being pushed to less favorable conditions later in the season. A better strategy might be to select for shorter-maturing varieties to allow a second crop to be grown in these regions.

Mitigation of greenhouse gases

There should be attempt to reduce the emission of greenhouse gases from the agricultural interventions through

- Improve management of water and fertilizers
- Improve management of livestock population and its diet
- Increase soil carbon, minimum tillage and residue management
- Improve energy use efficiency in agriculture
- Increase area under agroforestry and bio fuels but trade off with food production

Some of the adaptation and mitigation strategy is stated below.

- **Alteration in crop agronomy:** Small changes in climatic variables can be adjusted by altering dates of planting, spacing and input management. Alternate crops or cultivars adapted to changed environment may be introduced.
- **Development of resource conserving technologies:** Zero tillage in upland crops may reduce cost of production, result in less weed growth, reduce the use of natural resources, show improvement in water/fertilizer efficiency and restrict release of soil carbon.
- **Increase in income from agricultural enterprises:** Stagnation in yield due to climate change produces an economic burden to the farmers. Cost of production needs to be reduced through adoption of location specific farming practices so as to increase the income to the farmers from their produce.
- **Improved land use and natural resource management:** Policies should be evolved to encourage the farmers to enrich organic matter in the soil, improve soil health such as financial compensation /incentive for green manuring.
- **Improved risk management through early warning systems and crop insurance:** The increasing probability of flood or drought or other climatic un-certainty may be brought to the knowledge of the farming community well in advance so as to make them prepared for the risk ahead. Agro-advisory services need to strengthen. Crop insurance should be given a top priority.

Conclusion

The earth is warming, snow caps are melting, rainfall patterns are changing and groundwater levels are receding at an accelerated pace. One of the early casualties of this cataclysmic change is found in the availability of water and its impact is beginning to manifest on one of the crops which requires huge amounts of water – rice. And this spells bad news for rice farmers and consumers. Rice is the staple food for half the people of this planet. And critically, 90 per cent of the world's rice production and consumption takes place in Asia — with around 200 million rice farmers producing the crop to feed half the global population. Being a crop of the tropics, the agro-climatic conditions required for growing rice is vastly different from most other crops. In stark contrast to other temperate food crops, one kilogram of rice requires 5,000 litres of water. Not only that, the requirements of fertiliser and pesticide has grown considerably after the introduction of the Green Revolution and the extension of high-yielding varieties like IR8. Despite the enormous appetite for huge amounts to raw materials, the Green Revolution helped to stave off a food crisis across the world, mainly in the poorer countries of the East. By the 1990s rice yields in India had grown to six tonnes per hectare up from the two tonnes of the 1960s. The surging production had also pushed down rice price to $200 per tonne in 2001, down from $550 per tonne during the seventies.

But now, 40 years after the Green Revolution, another food crisis is looming large over the world. With the surging growth story from India, China and other Asian countries gaining momentum, the demand for foodgrains are expected to rise by 50 per cent in the next 25 years. With better purchasing power backed by real demand, average price of rice have doubled in the last six years. But rice yields have remained stagnant for quite some time. And there is every possibility that the Asian rice crisis would spill over into the global economy. Sadly, the pressure is beginning to tell on the global environment, especially in the tropics where most of the rice is grown and consumed. As global warming becomes a reality, agro-climatic conditions are beginning to change and sinister signs are beginning to emerge over agriculture across the world. The flood resistant rice variety, which can survive under water, is expected to provide succour to rice farmers in countries like Bangladesh where the scourge of floods are a recurrent part of life. But will it provide respite from the rapid changes in environment and global warming? Reports suggest that global warming and resultant rise in sea waters could inundate over 40 per cent of Bangladesh with sea water — which is definitely not conducive to growing rice. Millions of farmers all across South East Asia would be confronting similar fate. Not that the rising sea levels and melting polar ice caps are a foregone conclusion. But the world seems to be persistently working towards it. Reports also suggest that rice farmers in Punjab have been tapping groundwater from increasing depths: from 60-70 feet a decade ago to over 300-400 feet today. Purloining of water for growing industrial use, for power generation and water pollution are other factors that will add to the woes of the rice farmers. The sky-rocketing price of crude and its impact on global fertiliser prices have also taken the cost of cultivation far above the Green Revolution days. Independent studies have shown that the demand for rice is expected to grow by 50 per cent from the current levels by 2030. But the world does not seem capable of meeting the growth requirements of today. It is estimated that that an additional 55-70 million hectares of additional land will have to be brought under cultivation in the next 3-4 years to maintain global stocks at their current level. Instead, we seem to be poised to lose more rice harvests to global warming and growing salinity. Let alone the potential demand growth by 50 per cent two decades from now, the more pressing question is will we be able to maintain the production and rice stocks at their current levels. The answer to the imminent crisis emanates from two fronts — constructively tackling the growing menace of global warming and ushering in ground breaking technology to increase production. Little seems to have emerged from the multilateral negotiations on global warming right from the Kyoto protocol to the Bali meeting. The technology front also offers little hope at the moment.

Scientists are working on a new strain of C4 rice that could boost rice production by as much as 50 per cent, while potentially reducing the need for excessive water and fertilisers. The unique C4 rice is expected to behave like corn and other plants that perform photosynthesis much more efficiently involving four carbon atoms — unlike the conventional rice strains which use three carbon atoms. But significantly, the new strain is a genetically modified crop for which global acceptance is still extremely limited. And even if it finds acceptance in the years ahead, it has long way to go from experimental laboratories to successive field trials before being tried in real-world conditions. Still, all these may not mean much to India. The country has transformed itself from a net rice importer to an exporter — sending abroad as much as 4.5 million tonnes annually. However, despite the surplus production and self-reliance, India's rice production is also critically linked to its long and vast coastline, where much of its cultivation takes place. Global warming and rising sea levels is as big a threat to India as it is other low lying regions of Asia and the world.