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Research Article

# Pollution, Climate change and Strategies to Increase Maize Production - An Overview

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## Abstract

In past, climatic parameters have seen to undergo changes, especially temperature and rainfall. The global temperature has increased significantly which has directly or indirectly affected economically important crops as well as humans. There has been an overall decrease in rainfall and increased fluctuation in temperature in various parts of the country. Pollutants cause severe injury to economically important plants and have caused biotic and abiotic stresses especially in all crops. Burning of crop residues surrounding especially around metro cities is a major concern. Fast growing peri-urban agriculture and industrialization has been associated with pollution threaten urban food production and its quality. The harvest of crop residues using latest farm machinery that converts them into bales which can be efficiently transported to storage or far-off markets. Sewage water and industrial wastes has been a major concern in peri-urban agriculture and animal husbandry. A multi-prong approach needs to be followed in crops. Development of new climate resilient cultivars/crops beneficial to humans and use of environment friendly technology may help in combating pollution and climate change.

**Keywords:** Crops, Maize, Per-urban, Production, Rainfall, Stress, Temperature

## Introduction

Since the beginning of urbanization, there has been increase in small- and large-scale industrialization. Globally, urbanization has affected the agriculture in its adjacent areas. Number of questions is asked, whether the climate is changing and if so, what are the factors responsible for it. How far the polluting factors has contributed to the overall climate change. It is said that in past few decades, the Global temperature has increased significantly which has directly or indirectly affected humans as well as economically important crops. As the cities are growing and the peri-urban area too is increasing vis-à-vis the rural area is decreasing. In addition, these crops as well as up-coming pre-urban have to withstand not only unpredictable stresses but also new climatic conditions.

Climate change has affected biotic and abiotic stresses in all crops. Among them maize (*Zea mays* L.) is very sensitive crop to the changes in climatic important variables such as temperature, precipitation, sunshine etc., which affects maize production. The maize area, production and productivity in 2015-16 had reached 21.806 million tons from 8.691 million hectare which is 2.509 ton per hectare. In last 10 years, there is continuous increase in area, production and productivity of maize at Compound Annual Growth Rate (CAGR) of 2.20%, 5.26% and 3.00%, respectively. Thus, there was a higher contribution of maize productivity to maize production than increase in maize area under cultivation.

The versatile industrial uses of maize have led to expansion of maize cultivation replacing sorghum and rice in non-traditional areas like Andhra Pradesh, Karnataka, Tamil Nadu and Maharashtra and increased on-farm income. As a result, maize area, production and productivity of the country have increased to 9.55 million ha, 24.35 million MT and 2658 kgs/ha respectively which is almost three, thirteen and five times respectively during the course of 60 years. With the result India has become not only self-sufficient but also one of the major exporters of maize.

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During 2006-14, around 20-25 per cent of the total maize produced in the country was exported to neighbouring countries earning foreign exchange.

## Understanding Climate Change and Pollution

Even though both animals and plants are affected by change in climatic conditions but is the economic plants which concern man the most. Maize is primarily grown in kharif (monsoon) season and is a rainfed crop was excellent crop to understand response of factors of climate change. Among various crops, maize is a very sensitive crop and quick to respond to controlled (such as irrigation, management practices, fertilizer application etc.) and uncontrolled (such as temperature, precipitation, sunshine etc.) environmental conditions which affects maize production and productivity.

In last two-decade, climatic parameters have seen to undergo changes, especially temperature, rainfall etc. The deficiencies in rainfall in various parts of the country were confirmed by various reports.[1, 5] INCCA (2010) validate the change in temperature and precipitation in the region.[14] Maize and mustard are also likely to experience decrease in productivity in the entire region by 2030.[14] The peri-urban agriculture has been affected by number of factors like air pollution, contaminated water and soil degradation. In addition, the cause of air pollution is industrialization (52%), vehicles (27%) and even agricultural burnings (10%). Air pollutants cause severe injury to economically important plants like ozone injury to soybean foliage, acute sulfur dioxide injury to raspberry, fluoride injury to plum foliage, severe ammonia injury to apple foliage, cement-dust coating on apple leaves & fruit. The pollutants affect soils in various ways like polluted Water from sewage/industrial effluents, excessive use of herbicides, pesticides etc., settling down of air pollutants, oxides of S & N, chlorides, fluorides, ammonium etc. from industry come down as acid rain in dry or wet deposition lower the soil pH. The polluting factors do contribute to the climate change and the historical data on main crops helps in understanding the trends and suggest ways to keep it under control and go for remedial measures.

The effect of climate change in rainfall in north-eastern region of India was studied by Mahajan V et al.[20] They showed a shift in peak of rainfall, reduction in peak of total rainfall during the rainiest months and less rainfall in the initial months of the maize crop season. As per the studies on regional basis in India, it was observed that the stations of southern and western India show a rising trend of 1.06 and 0.36°C per 100 years, respectively, while stations of the north Indian plains show a falling trend of 0.38°C per 100 years.[3] The seasonal mean temperature has increased by 0.94°C per 100 years for the post-monsoon season and by 1.1°C per 100 years for the winter season. It was reported that in India, the extreme maximum and minimum temperatures show an increasing trend in the south and a decreasing trend in the north.[28] In another study, from 1947 to 1993 in Kosi basin of the central Himalayan region showed some increasing tendency of temperature and precipitation.[25] Assessment of key climate variables such as precipitation (intensity and frequency), temperature fluctuations etc. over a period of years not less than a decade is a requisite to study impact on agriculture.

In order to understand the climate change, the historical data on climatic parameters as well as yield data on maize or the crop in question are important. Since 1991, there is reduction in total rainfall in the kharif season, is coupled with a shift in peak of rainfall by nearly 20-25 days, reduction in peak of total rainfall during the rainiest months and less rainfall in the initial months of the maize growing season in north eastern region of the country.[20] The critical assessment by them for different crops/ zones for vulnerability to climatic stresses and extreme events, especially of intra-seasonal variation in rainfall, temperature, pest and disease severity are requisite to justify changes in the climate. Mahajan V et al. found that the monthly fluctuations in rainfall during maize cropping season are high in all the agro-climatic zones during maize crop season and the trend was significantly increasing in the month of August in CWZ.[19] The seasonal rainfall decreased during the month of October in all the zones, however as per AICRP of maize, there was increasing trend for maize yields from 1991 to 2012 in all the zones.

## Effect of Climate Change on Maize Production

Organized research on improvement of maize started in India in 1957 under the auspices of All India Coordinated Research Project (AICMIP) and was the first in a series of coordinated projects under the ICAR system. Since then, huge data on maize productivity in maize trials were generated which had much to offer. Based upon agro-climatic conditions, the maize growing area in the country is broadly classified into five zones viz. Northern Hill Zone (NHZ or Zone 1), North Western Plains Zone (NWPZ or Zone 2), North Eastern Plains Zone (NEPZ or Zone 3), Peninsular Zone (PZ or Zone 4) and Central Western Zone (CWZ or Zone 5).[19] All zones have very specific climatic conditions and specific requirements for example in Zone I, early and extra-early maturing maize crop fits better in hill cropping system than full season maize crop. The full season maturity group in maize is grown in all parts of the Indian sub-continent except in Himalayan hills where extra-early, early and medium maturity group maize are grown so as to fit in cropping system. Similar system of independent assessment/evaluation for new varieties are in place in UK since 1919, with testing of varieties for multiple years for a minimum 2 years before national listing, with additional 1-3 years of testing before eligible for recommended list for the crop.[26] Based on the past data, the genetic progress was studied at Netherlands, UK and France.[7,12,17,24,29,30] Based on these agro-climatic zones past data was compiled and analysed in India by Mahajan V et al. (2014).[19,20]


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Climate change demands maize to withstand unpredictable biotic and abiotic stresses. The critical assessment of different crops/zones for vulnerability to climatic stresses and extreme events, especially of intra-seasonal variation in rainfall, temperature, pest and disease severity etc. is a requisite to justify changes in the climate. Jhajharia D, Singh VP studied the trends in temperature, diurnal temperature range and sunshine duration in Northeast India.[15] The study of Das A et al. observed in 27 years (1983 to 2009), fluctuations in the intensity and frequency of precipitation in Meghalaya.[8] Mahajan V et al. in a study in the north-eastern region - a high rainfall area of India, revealed that there was reduction in total rain fall in the kharif season, there is a shift in peak of maximum rainfall by nearly 20 days, reduction in peak of total rainfall during the rainiest months and less rainfall in the initial months (April and May) of the maize growing season.[20] Mahajan V et al. in another study on full season maturing maize grown in monsoon season in All India Coordinated Maize Improvement Project (AICMIP) trials from 1991 to 2012 in four agro-climatic zones (Zone 2 to Zone 5) of the country.[19] They observed that the monthly fluctuations in rainfall during maize cropping season are high in all the zones during maize crop season and the trend was significantly increasing in the month of August in Zone V. The seasonal rainfall decreased during the month of October in all the zones indicating that the trends in one of the climatic factors i.e. rainfall, has changed in these 22 years. On the other hand, the yield of best test entry has increased in maize yield trials from 1991 to 2012 in all the zones indicating that in spite of changing agro-climatic factors (rainfall) the maize yields increased. This indicated that either maize is more suitable to new climatic conditions vis-à-vis the maize scientists from AICMIP were continuously breeding new and improved hybrids which are more adaptable under new climatic conditions. It was also observed that there were high fluctuations in rainfall during the crop season and in spite of that there was continuous improvement in the new genotypes developed at AICMIP especially in past two decades. Thus, AICMIP had an important contribution in overall increase in zonal maize yields of the country even though the differential impact in different zones under changing climatic conditions.

## Strategies to Increase Production in Changing Climatic Conditions

The first thing that comes to our mind is the development of new climate resilient cultivars/crops, however it is also important to look into the technology that reduces pollution. Burning of crop residues surrounding especially around metro cities is a major concern. There is need to look into not only the alternative use of crop residues but economic and environment friendly technology for harvest, transportation and storage. There is around 65% deficit in green and dry fodder which is likely to be increased in future.[9] The harvest of crop residues using latest farm machinery that converts them into bales which can be efficiently transported to storage or far-off markets. In addition, the use of rotavator, intercropping, relay cropping is some of the technologies which increases organic carbon in soil that efficiently utilizes the fertilizer from the soil thus increases the overall production in crops. Suitable genotypes and management strategies are observed to maintain the productivity trend even under crucial climate changes as studied in past decades.[16,21,23,31]

Extensive research and development in various crops were done by Indian Council of Agricultural Research (ICAR) and associated Agricultural Universities. In maize over the past six decades at All India Coordinated Maize Improvement Project (AICMIP), established in 1957 under aegis of Indian Council of Agricultural Research, has led to development of >350 high yielding cultivars for different agro-climatic conditions of the country. The competitiveness of maize has increased due to highest yield potential, which is evident from the fact that presently the maize productivity in coordinated multi-location yield trials conducted under AICMIP across different agro-climatic conditions has reached 7000-9000 kg/ha in late maturing. Further, during last 25 years, there was gain in maize productivity of 117 kg/ha/year in North Western Plain Zone; 246 kg/ha/year in North Eastern Plain Zone; 100 kg/ha/year in Peninsular Zone and 113 kg/ha/year in Central Western Zone, in late maturity maize.[19] In spite of fluctuations in rainfall for past 20 years, there was continuous improvement in the new genotypes developed especially in past two decades for 'Zone 2' including Punjab state. The new and improved hybrids developed in the program were suitable for changing climatic conditions of this zone.[27]

In order to increase the maize production, a multi-prong approach need to be followed which can be extending to other crops. The most important approach is development of new single cross hybrids with wider genetic background will be more suitable for wider climatic conditions. In addition, the development of specific technology for specific niche in agro-climatic zones will fill the weaker gaps and meet the specific needs of the area. Suitable genotypes and management strategies are observed to maintain the productivity trend even under crucial climate changes as studied in past decades.[16,21-23,31] Exploring new areas for winter/spring maize is another way to contribute significantly to the maize production in different parts of the country. With the change in climatic conditions, the preparedness of various programs towards abiotic stresses like drought, cold etc. as well as dynamic change in pathogens is the need of the hour.[6,11,18] New pathogens will continue to arise which were unimportant in past may become a serious in future and agricultural scientists need to be prepared in advance.[10] In addition, exploring new crops which may be climate resilient may be suitable to new areas under changing climatic conditions.

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The new hybrids may be developed through inter-population improvement approach using diverse germplasm should not only be high yielding but also adaptable to wider areas. Use of molecular markers improve the nutrient content of maize grain has led to development, release and notified in 2008 as first QPM single cross hybrid.[13] 'Vivek QPM 9' is an extra-early maturing single cross hybrid with high tryptophan and lysine content and was extensively commercialized which lead to easy availability of seed to maize farmers of the country. To meet these needs the development of suitable inbred lines will be the key factors for economic hybrid seed production. Early maturing hybrids with superior nutritional quality, may be suitable for remote areas especially hills, which are more prone to environmental fluctuations. The nutritionally improved early hybrids will significantly contribute towards improving the nutritional status and well-being of the hilly populations, which are prone to the nutritional disorders, particularly protein energy malnutrition (PEM). Recycling of inbred and development of new inbred under high population density will be important steps in this direction. Development of climate resilient cultivars with tolerance to biotic and abiotic stresses by integrating conventional and genomic tools and techniques are under progress.

In order to double maize production to five tonnes per hectare by 2025, the area in rabiseason to be increased as well as develop maize hybrids with nine to ten tonnes/ha in kharif season in different zones.[2] There are number of upcoming hybrids with around 10 tonnes/ha yield which will contribute significantly in achieving national production of 5 million tonnes. The hybrids in pipeline that yielded above 9 tonnes/ha over locations and years in different agro-climatic zones in all maturity groups were very encouraging. In spite of high fluctuations in rainfall, there was continuous improvement in the new genotypes developed at AICMIP especially in past two decades.[19]

In addition to our conventional agriculture, peri-urban agriculture is growing fast and is facing different stresses. Increases in both industrialization and urbanization has been associated with pollution threaten urban food production and its quality. Sewage water and industrial wastes has been a major concern in peri-urban agriculture and animal husbandry. The serious pollutants get recycled back in urban population with short- and long-term serious health hazards in the human population. Another up-coming stress is of growing peri-urban agriculture, occurs surrounding the boundaries of cities throughout the world and includes products from crop and livestock agriculture, fisheries and forestry in the peri-urban area. Peri-urban agriculture plays an important role in diversifying urban diets and providing environmental services in urban and peri-urban areas.

In addition, exploring alternative crops which are climate resilient and known to be beneficial to humans like buck wheat, amaranth, Chenopodium, Fababean, Winged beans, Kankoda, Kalingada Perilla, jobs tear, Tumba, Pellipasara etc. can be future crops as pseudo-cereals, legumes, oilseeds and industrial crops. Our present discourse may help policy makers and agricultural scientists to evaluate future strategies for increasing national agricultural production and rural income under changing climatic conditions.

**Conflict of Interest:** None

## References

1. Anonymous 2002. 2002 termed all-India drought year. Business Line. Oct 05, 2002. Available from: https://www.thehindubusinessline.com/2002/10/05/stories/2002100502840300.htm.
2. Mahajan V, Yadav OP, Kumar P et al. Annual progress Report Kharif Maize 2016. All India Coordinated Research Project on Maize. Indian Institute of Maize Research, Pusa Campus, New Delhi. 2016. pp.999.
3. Arora M, Goel NK, Singh P. Evaluation of temperature trends over India. *Hydrological Science - Journal - des Sciences Hydrologiques* 2005; 50(1): 8193.
4. Baker NR, Farage K, Stirling CM et al. Photo inhibition of crop photosynthesis in field at low temperature. Photo Inhibition of Photosynthesis: From Molecular Mechanism to the Field. Baker NR, Boyer JR (Eds). Bios Scientific Publishers, Oxfords. pp.349-63. 1994.
5. Bhat GS. The Indian drought of 2002 - a sub seasonal phenomenon? *Quarterly J. Royal Metrological Society* 2006; 132(621): 2583-602.
6. Ahmad B, Kumar V, Singode A et al. Evaluation of maize (Zea mays) inbred lines for tolerance to low temperature stress under field conditions. *Indian Journal of Agricultural Sciences* 2014; 84(7): 873-6.
7. Brisson N, Gate P, Gouache D et al. Why are wheat yields stagnating in Europe? A comprehensive data analysis for France. *Field Crop Res* 2010; 119: 201-12.
8. Das A, Ghosh PK, Choudhury BU et al. Climate change in Northeast India: recent facts and events - Worry for agricultural management. ISPRS Archives XXXVIII-8/W3 Workshop Proc. *Impact of Climate Change on Agriculture* 2009: 32-38.
9. Datta D. Indian fodder management towards 2030: a case of vision or myopia. *International Journal of Management and Social Sciences Research* 2013; 2(2): 33-41.
10. Kingsolver CH, Melching JS, Bromfield KR. The threat of exotic plant pathogens to agriculture in the United States. *Plant Disease* 1983; 67(6): 595-600.
11. Farooq M, Aziz T, Wahid A et al. Chilling tolerance in maize: agronomic and physiological approaches. *Crop and Plant Science* 2009; 60(6): 501-16.
12. Foulkes MJ, Snape JW, Shearman VJ et al. Genetic progress in yield potential in wheat: recent advances and future prospects. *J Agric Sci* 2007; 145: 17-29.
13. Gupta HS, Mahajan V, Agrawal PK et al. Vivek QPM


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9'maize: A hybrid for Himalayan hills and Peninsular region. *Indian Farming* 2007; 60(6): 10-2.
14. INCCA. Climate change and India: A 4X4 assessment, A sectoral and regional analysis for 2030s. 2010. pp.160. Report #2. Ministry of Environment, Government of India.
15. Jhajharia D, Singh VP. Trends in temperature, diurnal temperature range and sunshine duration in Northeast India. *Int J Climatol* 2010; 31: 13531367.
16. Jonesa PG, Thornton PK. The potential impacts of climate change on maize production in Africa and Latin America in 2055. *Global Environmental Change* 2003; 13(1): 51-9.
17. Mackay I, Horwell A., Garner J et al. Reanalysis of the historical series of UK variety trials to quantify the contributions of genetic and environmental factors to trends and variability in yield over time. *Theor Appl Genet* 2011; 122: 225-38.
18. Mahajan V, Chikkappa GK, Kumar B et al. Performance of single cross maize hybrids during winter season of northern India. *Indian Journal of Genetics and Plant Breeding* 2012a; 72(3): 372-5.
19. Mahajan V, Singh KP, Bansal P et al. Rainfall trends and maize productivity in diverse agro-climatic regions of India. *Indian J Genet* 2015; 75(4): 468-77.
20. Mahajan V, Singh KP, Rajendran RA. Response of maize genotypes to changing climatic conditions in Himalayan region. *Indian J Genet* 2012; 72(2): 183-8.
21. Manyatsi AM, Mhazo N, Masarirambi MT. Climate variability and change as perceived by rural communities in Swaziland. *Res J Environ Earth Sci* 2010; 2: 165-79.
22. Oseni TO, Masarirambi MT. Effect of Climate Change on Maize (Zea mays). Production and Food Security in Swaziland. *American-Eurasian J Agric & Environ Sci* 2011; 11: 385-91.
23. Pardey PG, Beintema NM. Slow Magic: Agricultural R&D a century after Mendel. Food Policy Report, International Food Policy Research Institute, Washington, DC. 2001. p.30.
24. Rijk B, van Ittersum M, Withagen J. Genetic progress in Dutch crop yields. *Field Crops Research* 2013; 149: 262-8.
25. Sharma KP, Moore B, Vorosmarty CJ. Anthropogenic, climate and hydrological trends in the Kosi basin, Himalayas. *Climate Change* 2000; 47: 141165.
26. Silvey V. NIAB Recommended lists of cereal varieties: an aid to orderly marketing in the United Kingdom. *Plant Varieties Seeds* 19999; 1: 223-42.
27. Singh KP, Mahajan V, Srivastava E et al. Climate change and maize productivity in north-western plains regions of India. *Indian J Genet* 2014; 74(4): 568-571.
28. Sinha Ray KC, De US. Climate change in India as evidenced from instrumental records. *WMO Bulletin* 2003; 52(1): 53-9.
29. Sylvester-Bradley R. Management strategies for high yields of cereals and oil seed rape. In: HGCA Conference 2002, Agronomic Intelligence: The Basis for Profitable Production, Coventry, UK. 2002. 8.1-8.18.
30. Wellington PS, Silvey V. Crop and seed improvement. A history of the National Institute of Agricultural Botany 1919-1996. National Institute of Agricultural Botany, Cambridge. 1997.
31. White JW, Hoogenboom G. Crop response to climate: Ecophysiological models. In: Climate change and food security. Lobell DB, Burke MB. Eds. Springer, The Netherlands. 2010. 59-83.

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