

Climatic aberrations in Punjab: Impact on agriculture and contingent planning

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Climate is a major factor which decides the production potential of an area. During the recent years, Punjab has witnessed the climatic calamities, due to which rice and wheat production declined significantly. The 2015-2021 period was the warmest on record with shifting seasons, and increasing frequency of extreme weather events such as heat waves, floods and droughts are particularly evident. The catastrophic floods that struck Punjab during August-September 2025 impacted 18 out of 23 districts. Rainfall patterns have become increasingly irregular, marked by a reduction in the number of rainy days while an increase in the frequency of extreme rainfall events. Such climatic aberrations result in the crop losses that not only reduce the production but also threaten the national food and nutritional security. The article provides information on climate variability impacts on agriculture in the Punjab state and the countermeasures which can be adopted under such conditions.

Keywords: Climate change, Floods, Heat wave, Rice–wheat cropping system, Weather variability

PUNJAB is often referred to as the 'Food Bowl of India', and has a geographic area of 50,362 km², accounting for 1.54% of the nation's land area. Punjab contributed 46.8% of the wheat and 22.7% of the rice to the central pool during 2023-24. Punjab state's contribution in the agriculture sector played a remarkable role in shifting the country from food importer to self-sufficiency and food exporter. The IPCC's Sixth Assessment Report (2021) revealed that climate change is accelerating and intensifying globally. Atmospheric CO₂ levels have surpassed 415 ppm, and global temperatures have risen by 1.1°C, projected to exceed 1.5°C by 2040 and possibly reach 3.5°C by 2100 under current trends.

Punjab experienced heat wave stress during 2022, and floods during 2023 and 2025. Northern India witnessed catastrophic rainfall resulting from an unusual interaction of weather systems

during July 2023 and August 2025, notably the increased frequency of western disturbances combined with moisture-laden winds from the Arabian Sea. The occurrence of high-intensity rainfall over short durations in Himachal Pradesh accelerated the filling of dams and reservoirs; subsequently, vast quantities of water released from dams became a major factor contributing to the floods in Punjab. Approximately 60,000 hectares of agricultural land in the district were submerged, resulting in the destruction of standing crops such as paddy, sugarcane, maize, and fodder, while leaving behind sand and silt deposits ranging from 1–3 feet in depth in various locations.

Impact of climate change on agriculture

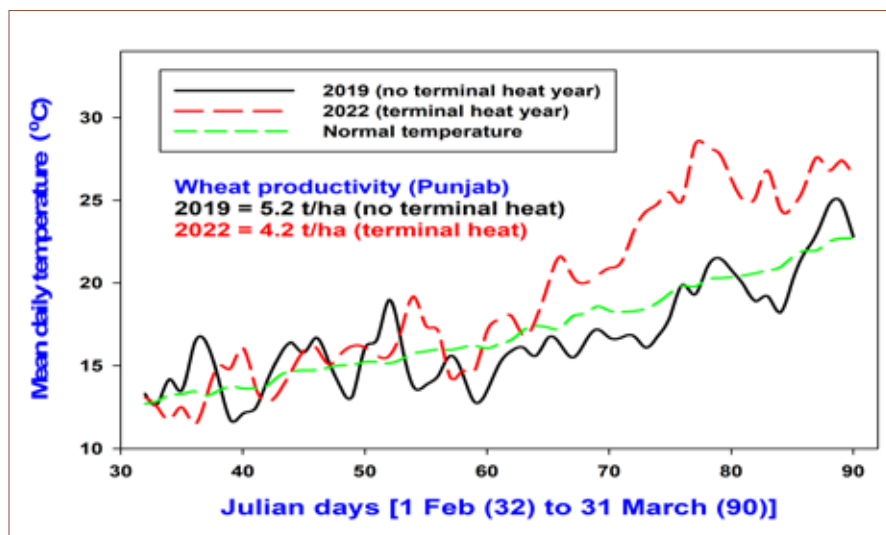
The IPCC Sixth Assessment Report highlighted that climate change poses significant risks to agriculture, with far-reaching implications. These climatic shifts

have translated into tangible impacts on agriculture which are evident in Punjab and are discussed in this article.

Effect of heat wave on wheat in Punjab state during *rabi* 2021-22

In Punjab, wheat productivity is affected due to the incidence of heat stress during February-March months of *rabi* 2021-22. The maximum temperature remained normal up to the month of February but a sharp increase i.e. 2.6–6°C was seen in March, while the minimum temperature remained more than normal during January and March, however there was a sudden rise of 2.1–6.6°C in March. This increase in temperatures was unfavourable for the crop, and led to the formation of shriveled grains. Wheat yield was reduced by approximately 20% during 2021-22 as compared to 2018-19.

Contingent planning for heat stress management: Under the



Normal temperature and mean daily temperature during *rabi* 2018-19 and 2021-22, and its effect on wheat productivity

National Innovations in Climate Resilient Agriculture (NICRA) initiative, various climate-resilient technologies were implemented and demonstrated in the districts of Bathinda and Faridkot. The adoption of these resilient technologies effectively mitigated the adverse effects of the temperature rise. Sowing of wheat at appropriate time significantly reduced the detrimental effects of heat stress and helped in the attainment of near-normal yields in Punjab. The direct-seeding of rice using short-duration rice varieties such as PR 115 and others facilitated the early sowing of wheat. Furthermore, sowing wheat with zero-till, Happy seeders and super seeders, along with efficient paddy residue management techniques enabled rapid sowing immediately after rice harvest, achieving up to 97% of normal wheat yields. Additionally, deploying heat-tolerant wheat cultivars like PBW 803, DBW 187, and DBW 222, combined with foliar application of 0.5% KNO₃ at the booting and anthesis stages, further minimised yield reductions under heat stress conditions.

Happy seeder sown wheat showed resilience to heat stress in Punjab during *rabi* 2021-22. A survey of 400 farmers in 15 districts of Punjab state was conducted to assess the losses due to heat stress and its impact on wheat sown with three different methods i.e. conventional sowing (removing paddy straw

and seeding wheat with seed drill), Happy Seeder (HS) sown wheat and Super Seeder (SS) sown wheat during 2020-21 (normal year) and 2021-22 (intense heat wave period). The average wheat yield recorded was 49.80 q/ha, 52.46 q/ha and 50.58 q/ha in conventional, HS-sown and SS-sown wheat, respectively during 2020-21. During 2021-22, it was 42.92 q/ha, 47.14 q/ha and 44.63 q/ha in conventional, HS-sown and SS-sown wheat, respectively. The yield obtained by Happy seeder grown

Table 1. Promising technologies to minimise yield loss due to heat wave in wheat during 2021-22

Technology	Yield (q/ha)
Early sowing of wheat during 20-30 th Oct, 2022 after short duration rice	43-44 (95%)*
Timely sowing of wheat during 1 st and 2 nd week of November	43 (95%)
Heat tolerant wheat varieties PBW 803, DBW 187 and DBW 222	44-45 (97%)
Wheat sown with Happy seeder	45-46 (97%)
Providing irrigation during heat stress	46-47 (98%)
Timely sowing with Happy seeder	45-46 (97%)
Late sowing of wheat after Nov 15 th 2022	41-42 (93%)

*The values in parenthesis indicates the per cent yield obtained compared to normal year (2020-21).

Source: Heat wave 2022 Causes, impacts and way forward for Indian Agriculture. Technical Bulletin No. ICAR/CRIDA/TB/01/2022.

crop was 9.8% and 5.6% higher than that of conventional and SS-sown wheat, respectively which shows that wheat seeding with Happy seeder is a promising technology in tackling such weather extremes.

Effect of floods on rice in Punjab state during *kharif* 2023

From 7th to 11th July 2023, Himachal Pradesh experienced highly active to strong monsoon conditions, characterised by extensive, very heavy to extremely heavy rainfall in the majority parts of the state. In just four days, the state recorded 223 mm of rainfall, significantly surpassing the normal rainfall of 41.6 mm, representing 436% deviation, which is an unprecedented event in the context of long-term records especially Kinnaur, Kullu, and Solan districts recording an exceptional 7,800% above their normal rainfall. High-intensity rainfall increased water level of rivers, resulting in the flooding of agricultural lands up to 5-7 feet in certain regions of Punjab.

In Punjab, approximately 31.49 lakh hectares were under paddy cultivation during the *kharif* season, and transplanting typically starts on June 15. Due to the floods, around 2.21 lakh hectares of paddy fields were submerged, accounting for nearly 7% of the total paddy area.

Table 2. Heavy rainfall in Himachal Pradesh during 7th to 11th July 2023

District	Actual (mm)	Normal (mm)	Departure (%)
Bilaspur	335.9	44.5	654.8
Chamba	207.9	49.6	319.2
Hamirpur	258.7	49.2	425.8
Kangra	225.3	93.7	140.4
Kinnaur	107.6	11.2	860.7
Kullu	280.1	30.7	812.4
Lahaul and Spiti	124.8	21.0	494.3
Mandi	245.5	68.2	260.0
Shimla	268.9	35.4	659.6
Sirmaur	514.0	67.9	657.0
Solan	472.6	52.0	808.8
Una	265.3	49.0	441.4
Himachal Pradesh	223.0	41.6	436.1

Although rice is a semiaquatic plant and can survive under waterlogging conditions, complete submergence up to more than 15 days lead to the complete failure of crop. Estimates suggested that if the rice crop had not been retransplanted, the financial loss could have amounted to approximately ₹2,800 crore. However, during the retransplanting of rice, farmers faced additional costs, including additional labour expenses (₹8,750/ha), diesel costs for re-puddling using their tractors (₹2,500/ha), and the re-application of weedicide (₹1,000/ha). As a result, the total additional expenditure incurred for the retransplanting of rice crops due to flooding was estimated to be ₹ 245 crore.

Table 3. Estimated loss due to inundation in transplanted paddy fields (approximately 2 lakh ha)

Particular	Cost incurred
Average productivity of paddy in Punjab	65 q/ha
Total production from flooded area	13 lakh tonnes
Economic loss (@MSP ₹2,183/q)	₹2,800 crore
Additional expenditure	
Cost of labour for re-transplanting of seedlings (@ ₹8,720/ha)	₹175 crore
Cost of diesel for re-puddling using own tractor (@ ₹2,500/ha)	₹50 crore
Cost of herbicide + application during re-transplantation (@ ₹1,000/ha)	₹20 crore
Total additional expenditure	₹245 crore

Other crops grown in fields during *kharif* 2023 were maize, fodder crops, vegetables, etc. were also adversely affected. Farmers cultivating vegetables, maize, sugarcane, and cotton faced significant losses due to the flooding. These crops are highly sensitive to waterlogging, and timely drainage procedures were not available. Fodder fields were inundated, and fodder quality declined as the fodder foliage was covered with silt. Fields located near riverbanks were

deposited with silt to a depth of 2–6 feet, worsening the situation. The accumulated silt presents a major challenge for farmers, as removing it from their fields is a labour-intensive task.

Along with crops and humans, livestock of the state were also impacted. The primary livestock in Punjab includes cows, buffaloes, poultry, and goats. The flooding severely impacted these animals, leading to significant losses for farmers in two main ways. First, many animals drowned or were swept away by the floodwaters. Second, the shortage of fodder and feed during and after the flooding severely hindered livestock productivity. Additionally, concerns about potential disease outbreaks heightened the distress among farmers.

Contingent planning to mitigate floods: Punjab Agricultural University (PAU) played a crucial role in supporting farmers during the floods by issuing agro-advisories through research stations, extension centres, collaborating with the Department of Agriculture, farmer groups, NGOs, and volunteers. The university guided farmers via WhatsApp, digital newspapers, and farmer portal. The university also worked for the proper functioning of crop contingency plan and distributed free seeds and nurseries of short-duration rice varieties (PR 126 and Pusa Basmati 1509), raised at University Seed Farms, Krishi Vigyan Kendras, and Regional Research Stations. These short duration varieties are ready for harvesting in 123–130 days from seeding. The short-duration variety PR 126 is recommended for transplanting between June 20 and July 15, while Pusa Basmati 1509 is optimal for transplanting in the second half of July. These varieties were prioritised in community nurseries to recover lost planting time due to flooding. This strategy of community nursery is designed to produce nursery in a shorter time span in case of sudden adverse weather events.

SUMMARY

Climate change directly as well as indirectly affects agriculture and allied sectors productivity through floods, drought, deforestation, damage to dams or irrigation sources, etc. To address these challenges, the National Agricultural Research System has developed several technologies that can reduce the adverse effects of heat waves. Under NICRA, such technologies are demonstrated in 151 climate-vulnerable districts, achieving 95–97% of normal wheat yields during heat waves. The adoption of climate-resilient crop and varieties aids in sustainable food production and security. Furthermore, there is also an indispensable need to strengthen weather forecasting, particularly for extreme events, and strengthening agro-advisory services is crucial for informed decision-making by farmers. Upgrading district agromet field units (DAMUs), issuing block-level advisories, and expanding their outreach will improve preparedness. Central government, State government and dams' management boards should work together for the proper monitoring of dams, via quantifying water inflow and outflow. Water should be stored or released as per rainfall forecasting by Indian Meteorological Department. In the past, the spirit of volunteerism, shared resources, flexible policies (like community nursery, compensation, clearance of silt and sand, loan relief), and collective problem solving has helped accelerate field restoration and offered a beacon of hope for Punjab's agrarian heartland. Therefore, in such weather extremes, the participation of rural youth, coupled with other working institutions, is necessary for achieving agricultural resilience. Integrating promising technologies into programmes of KVKs, state departments, and NGOs, along with large-scale awareness and capacity-building efforts, will promote adoption and strengthen agricultural resilience to climate extremes.

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