



## **A Review: Impact of Heatwave on Agriculture**

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### **ABSTRACT**

*The agriculture industry has suffered a lot as a result of the recent spike in the frequency of heat waves. Long-lasting heat waves and high temperatures can harm soil, animals, and crops, reducing yields and costing farmers money. The effects of heatwaves on agriculture can have serious economic repercussions, especially for small-scale farmers who depend on agriculture for a living. With little capacity to adjust to climate change, the effects of heatwaves on agriculture are particularly important. Increasing heatwaves not only cause a drop in total yield but also rise different other issues like changes in the nutritional value of crops reduction in water availability and rise in insect and disease activity. High heat reduces sources of water supplies, and heatwave effects on crops can be very severe, resulting in drought stress and crop loss. Heat waves can be lethal in cattle, together with dehydration, heat stress, and decreased output. In communities that depend on agriculture, these effects may result in food shortages, revenue loss, and other detrimental effects. Besides affecting agriculture negatively, heat waves may harm wider socioeconomic problems like hunger and poverty. In this review, we have shown different agricultural areas which have a direct impact on heatwaves.*

**KEYWORDS:** Heatwave, Climate Change, Crop Yield, Food Security

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### **INTRODUCTION**

Since the last few decades, the average temperature on the earth has started to rise, however, these changes reach an extreme level in the past few years. Since the "Industrial Revolution", human activities have contributed to global warming and climate change through various modes like the burning of fossil fuels, thoughtless destruction of forests, and agricultural activities. These activities, either directly or indirectly, are responsible to rise the global temperature. Higher temperatures, altered rainfall patterns, shifts in the frequency and distribution of weather events like droughts, storms, floods, and heat waves, as well as an increase in sea level, are all examples of observed and anticipated changes in the climate, as well as their effects on both natural and human systems (1).

The most obvious indication of climate change is the increasing amount of heat, and while we fail to take action, fatal heat has started to become worse over the last few years. The temperature is rising and the frequency or the time period for the heating is also increasing around the globe (2). Scientists have long warned that the hazards associated with hot weather are rising as a result of the increase in the global average temperature as greenhouse gas concentrations in the atmosphere rise (3).

Since from old era, the Indian economy has been majorly dependent on agriculture. Over 58 percent of rural households in the nation depend primarily on agriculture as their source of income. It provides different job opportunities to the labor in versatile areas, raw material supplies to the processing industries, and excess products to the market (4). However, recent extreme heat waves have had a huge negative impact on Indian agriculture, leading to crop losses, water shortages, and livestock mortality.

### **HEATWAVE IN INDIA**

Heatwaves can be defined in different ways. On the basis of quality, a heatwave can be known as a condition when the temperature of the air becomes fatal to the exposed body area (5). However, if consider in quantity based, a condition temperature reached over the threshold for that particular region. In simple terms, a heatwave can be defined as a time period when an abnormal amount of rise in temperature can be detected. Generally, the time period for summer, in India, starts in March and ends in June. However, with recent factors, it started to extend till July. Central, Northern, and some parts of south India have major impacts due to heat waves. The major states which have a high impact due to heatwaves are Rajasthan, Gujarat, Delhi, Punjab, Haryana, Uttar Pradesh, Bihar, Madhya Pradesh, Jharkhand, certain parts of

Maharashtra and Karnataka, Telangana and Andhra Pradesh. The frequency of the heat wave can be varied in different states (6).

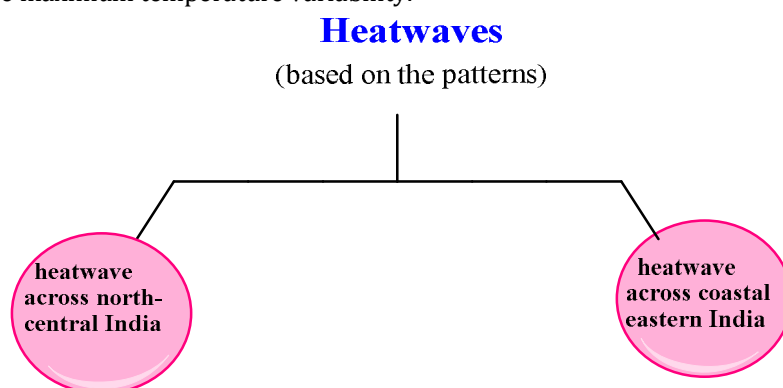
**FACTORS THAT INDUCE HEATWAVE**

- No moisture in the surrounding atmosphere which allows the heat or solar lights to direct penetrate the area.
- Cloudless sky which can be responsible to give maximum insulation in that region.
- Excess transportation and human activity which can induce dry air production in the particular region. However, the air is not able to circulate properly so cannot cool down and remain hot for a longer time period.

**OCCURRENCE AND TYPES OF HEATWAVES**

There are sporadic hot weather periods over several portions of India from March through July. These spells are frequently seen to migrate from one area to another. Thus, a heat wave is a phrase used to describe this phenomenon. When heat waves become extreme, several fatalities are reported (7).

We distinguished two types of heatwaves based on the patterns that were observed and statistical assessments of the maximum temperature variability.



**Fig. 1: Types of Heat wave in India**

It has been discovered that the first type of heatwave across north-central India was caused by blockage over the North Atlantic. At upper levels, the blockage across the North Atlantic causes a cyclonic anomaly west of North Africa. Around the entry of the African Jet, the stretching of the vorticity creates an abnormal Rossby wave source. Due to the positive phase of the ensuing quasi-stationary Rossby wave train along the Jet across the Indian subcontinent, there are anomalous sinking motions and hence hot conditions over India (8).

On the other hand, it is discovered that the second kind of heatwave across coastal eastern India was caused by an unusual Matsuno-Gill reaction to the anomalous cooling in the Pacific. Heatwaves are caused by the Matsuno-Gill response's tendency to produce northwesterly anomalies across the landmass by diminishing the land-sea wind (9). According to the India Meteorological Department (IDM), the effect and severity of heat waves can be classified on the basis of different Color codes. This color code is divided into four groups: Green, Yellow, Orange, and Red. The effect and Action needed to take, on the basis of color code, are given in Table 1.

Table 1: Different Color codes and actions needed according to that color code (10).

Color Code	Indication	Warning	Impact	Suggestion
Green	Normal Day	Temperature is in the normal range, no action is needed	Normal temperature	-
Yellow	Heat alert	The effect of Heatwave in the area is increased constantly over 2 days	Moderate temperature. Bearable for normal healthy people Careful with infants, children, elderly and sick	Avoid excess heat exposure Use any protection to cover head Wear clothes with maximum absorbance, lightweight
Orange	Severe Heat alert	Severe heat wave persistent for 2 days Or	Higher cases of heat illness symptoms who have	Avoid excess heat exposure, Avoid dehydration,

		Not severe but heat wave persistent for 4 or more days	prolonged exposure to heat or doing heavy work. High health risk for vulnerable people like infants, children, elderly and sick	Increase water consumption, Use ORS and other beneficial drinks to avoid Heatstroke
Red	Extreme heat alert	Severe heat wave persistent for more than 2 days Or Total number of Heat or severe heat persistent for more than 6 days.	Start to affect all age groups. Severe Health issues like fainting, heat stroke, breathing difficulty, Severe Headache, etc. Will notice in all age group	Avoid going out in the heat Always protect the Head and any other body part from heat Extra care is needed for vulnerable people

### HEATWAVE CASES

Throughout the course of human history, heat waves have happened, but recently they have increased in frequency and intensity. These historical heatwaves are prominent examples:

S.No.	CASES	DESCRIPTION
1.	<i>The 2003 European Heatwave</i>	From June through August of that year, Europe experienced a heatwave that resulted in more than 70,000 fatalities. Climate change was blamed for what was one of the worst heatwaves ever recorded (11).
2.	<i>The North American Heatwave of 1936</i>	During the height of the Great Depression, North America saw one of its worst heatwaves ever. A severe drought also resulted from it, killing thousands of people (12).
3.	<i>The 2010 Russian Heatwave</i>	This summer's heatwave was among the worst to have hit Russia. More than 10,000 people died as a result, and there were several wildfires (13).
4.	<i>The 2019–2020 Australian Heatwave One</i>	One of the worst heatwaves to ever hit Australia happened during the summer of 2019–2020. The country's environment and economy were severely damaged, and there were several extensive bushfires (14).

### EFFECT OF HEATWAVE

#### ❖ AGRICULTURE

Agriculture is the backbone of the Indian economy. Over the course of the twenty-first century, heat waves are more frequent and more intense than they were previously which have created a great impact on agriculture, directly or indirectly. One of the major impacts was frequent drought stress coexisting with heat waves. By 2020 and 2040, it is predicted that a quadrupling of the world's land area will be subject to heat waves (15). Heatwaves may harm crops via withering, dehydration, and heat stress, all of which can lower yields and quality (16). Lower agricultural yields may result from slower plant growth and photosynthesis caused by high temperatures (17).

The majority of plants are vulnerable to the direct impacts of high temperatures, low precipitation, floods, and abrupt freezes during crucial growth periods. Through effects on soil dynamics, nitrogen cycling, and pest species, additional effects on crops can also be indirect (18). Heatwaves can worsen agricultural water stress, especially in locations with few water supplies, which can result in crop failure and financial loss for farmers (19). It can also increase the prevalence of pests and illnesses in crops, which can lower quality and yields (20).

Due to climate change, extreme weather events and pesticide exposure are occurring more frequently and intensely. When animals are starved, their combination might be very dangerous (21). Food production, food security, and the price of food globally can all be impacted by heat waves' considerable effects on agriculture. These effects can be very severe in areas that are already sensitive to climate change and have few means to adapt to changing climatic conditions.

- **FRUITS AND VEGETABLES:** Heatwaves can reduce crop yields as they cause wilting of flowers, fruits, and vegetables. They can also increase the ripening process or sunburn. Increased temperature can induce the breakdown of chlorophyll which results in premature yellowing in fruits and vegetables. It also causes rapid softening, wilting, and dehydration in crops. When temperatures rise over 30°C, it can destroy the enzymes in vegetables that are responsible for color changes and maturation. For example, capsicums and tomatoes held at over 30°C may fail

to develop normal red color (22,23). Also found that increasing EWD-related crop losses for cereals between 1964 and 2007 at the global level. In some crops like sweet corn, heat wave, during flowering, can have detrimental effects on the morphology as well as the functioning of reproductive organs. Anomalies in sweet corn, and

- the flowering organs (tassel ear) can result from periods of heat, with adverse effects on ovule fertilization and hence insufficient tip-fill, causing reduced grain development and lower husk cover (24). Heatwaves will lead to photo-oxidative stress in fruits. In chlorophyll-containing tissue, when exposed to intense solar irradiation and elevated temperatures during the growing season it will lead to some irreversible changes in fruits like apples (25,26,27).
- **INSECT-PEST:** Climate change has affected not only agricultural crops but also their corresponding pests either directly or indirectly. They have different effects in direct or indirect ways:
  - **Direct impacts:** Reproduction, development, survival, and dispersal of pest
  - **Indirect impact:** The relationship between pests, their host as well as their predators can alter due to heatwave. Their interaction with other insects like natural enemies, competitors, vectors, and mutualists as well as their environment can also be varied (28).

#### ➤ LIVESTOCK

Heat waves and heat stress are key factors that negatively affect dairy cattle's productivity and performance in hot climates or throughout the summer in many areas of the world. Heat stress has an effect on both the health and performance of lactating and dry cows (29). Increasing heat not only causes an adverse impact on production but also causes infertility in animals as well as birds.

Animal have their own mechanism which is known as homeothermy. When an animal cannot evacuate enough heat to maintain homeothermy, heat stress results. High ambient temperatures, relative humidity, and radiant radiation reduce an animal's ability to dissipate heat. As a result, heat stress significantly reduces the profitability of the animal output (30). The effects of heat stress can be apparent in feed intake, production efficiency (as determined by milk yield or weight gain per unit of feed energy), growth rate, egg production, and reproductive performance (31).

Additionally, it harms dairy cows' mental well-being by making them feel hungry and thirsty, both of which have negative consequences on their physical health and biological processes. Additionally, it lowers their capacity for reproduction and milk production (32).

There are four ways that heatwave can impact animal production, which are:

- 1) Availability of feed-grain stock and their market value
- 2) Impact of the heat wave on the production of forage/fodder crop and its quality
- 3) Effect of weather on animal health, their growth, and reproducing ability
- 4) Distribution of disease and pest in livestock due to changed temperature

Future improvements in nutritional formulation, better cooling capacity, and genetic advancement—including selection for heat tolerance or the identification of genetic traits that increase heat tolerance—will likely be required to maintain cow performance in hot, humid climates (33).

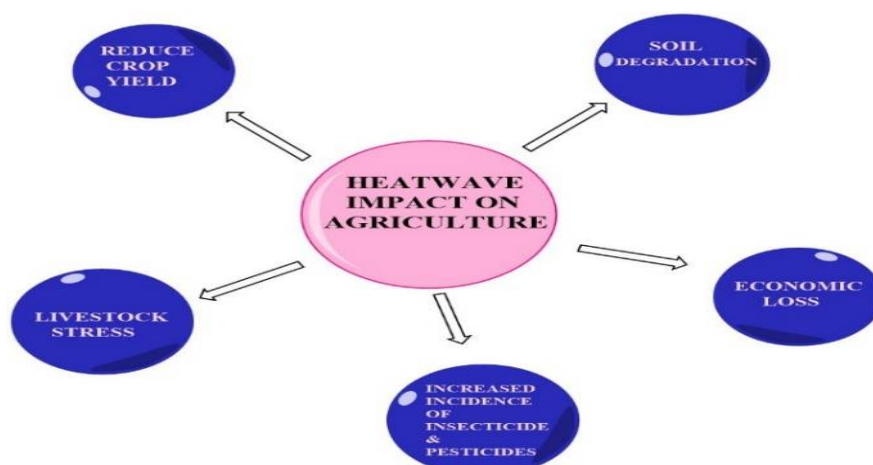
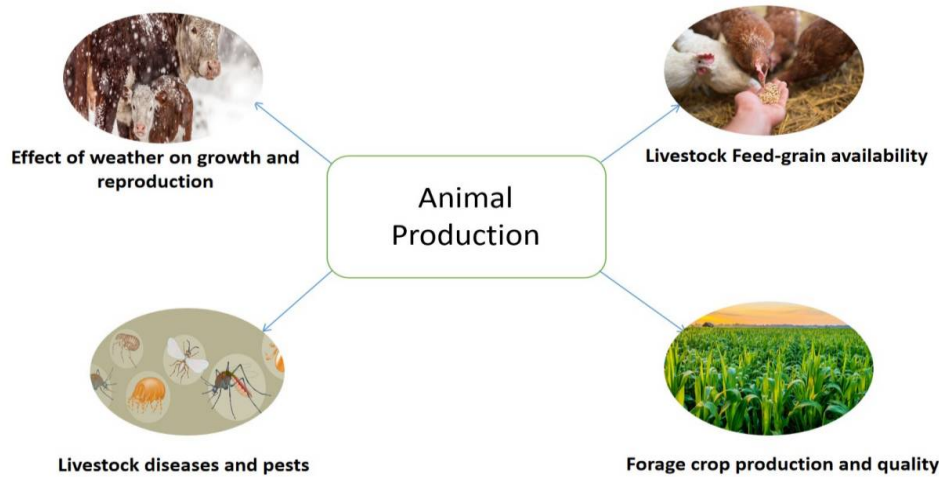


Fig. 2: Heatwave impact on agriculture



**Fig. 3: Impact of climate change on animal production**

### CONTROL MEASURE

To combat the effects of heatwaves on agriculture, a mix of adaptation and mitigation strategies is required. We can contribute to ensuring food security and sustainable agricultural practices in the face of a changing climate by implementing proactive measures to increase resilience in agricultural systems.

- Good irrigation and water management practices can assist in lessening water stress in crops during heatwaves. This may entail the use of mulching, drip irrigation, and water-saving strategies (34).
- Plant breeding programs can create crop varieties that are better suited to hot weather and dry circumstances. These types can aid in lowering production losses and enhancing the heat-stress tolerance of agricultural systems (35).
- Healthy soils may better retain moisture, which helps lessen water stress on crops during heat waves. Improved soil health and increased resiliency of agricultural systems to heatwaves may both be achieved by using soil conservation techniques like conservation tillage and cover crops (36).
- Planting trees and other perennial crops can assist in decreasing soil erosion, boost soil moisture retention, and offer shade for crops during heat waves (37).
- During heatwaves, providing animals with shade, clean water, and a healthy diet can assist in decreasing heat stress. Farmers can prepare for and lessen the effects of heatwave by developing early warning systems (38).
- Reducing greenhouse gas emissions can assist in lessening the frequency and severity of heat waves as well as their effects on agriculture by addressing the primary cause of climate change, which is human activity (39).

### CONCLUSION

In conclusion, heat waves may considerably impact agriculture, which can influence food security, food prices globally, and farmers' livelihoods. Crop loss, lower crop growth, water stress, increased pest and disease incidence, and animal stress are just a few ways that heat waves can affect agriculture. These effects can be more severe in areas that are already at risk from climate change and have few resources available to them.

Implementing adaptation strategies, such as better irrigation and water management, the use of heat-tolerant crop types, and improved animal management techniques, is essential to addressing the effects of heat waves on agriculture. Moreover, initiatives to ameliorate climate change, such as lowering greenhouse gas emissions, can aid in reducing the frequency and severity of heat waves as well as their effects on agriculture. We can contribute to ensuring food security and sustainable agricultural systems for future generations by being proactive in addressing the effects of heat waves on agriculture.

### CONFLICT OF INTEREST

No conflicts of interest are disclosed by the authors.

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