Agricultural Implications of Shifting Precipitation Patterns and Mitigation

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Abstract

Long-term changes in the weather patterns that define various parts of the world are represented by global warming and climate change. Elevated temperatures intensify evaporation, whereas precipitation, or the falling of condensed water vapor, occurs at a rate 10–25% faster than evaporation. Aside from affects on agricultural output, other related effects include modifications to cyclone and precipitation patterns. Wet areas can grow wetter and dry areas can become dryer as a result of even slight changes in wind patterns and precipitation processes. It is anticipated that these adjustments will persist in the future. Precipitation is more likely to fall as rain than snow as temperatures rise. Snow also melts more quickly, increasing runoff and raising the possibility of flooding. On the other hand, because of the greater rate of evaporation, certain regions are more vulnerable to drought.

Introduction

There are several methods in place to address the issue of greenhouse gas reduction, as the current environment scenario requires it. However, it is concerning that precipitation trends are shifting. In light of the gravity of the problem, precipitation—a critical component of climate and water—is highlighted in this research. When water vapor moves from the atmosphere to the Earth's surface, it takes on a solid or liquid form and is referred to as precipitation.

The process of precipitation is influenced by a number of variables, such as sunshine, wind patterns and intensity, and ambient humidity. Additionally, clouds, which are an essential component of precipitation, are formed largely by evaporation from the surface and the subsequent accumulation of water vapor.

The hydrological cycle is the ongoing movement of water between continents, oceans, and the atmosphere. Winds help to contribute to atmospheric humidity by heating water evaporating from ocean and continental surfaces due to solar radiation. Higher altitudes cause the water vapor to cool and expand, a process known as condensation, which results in the formation of clouds. Through precipitation, these clouds subsequently bring water back to the Earth's surface. Therefore, there are three primary phases in the hydrological cycle:

1. Dissipation

2. The process of condensation

3. Rainfall

The dramatic patterns of changing precipitation patterns, which have changed the overall benefits of precipitation to Earth, highlight the significance of precipitation in today's setting. In order to keep the Earth system functioning normally, precipitation is essential. It transfers heat from the tropical regions to higher latitudes, assisting in the regulation of world temperatures. Warm air rises and cool winds descend during this process, which is started by solar radiation and evaporation. Convectional currents are created as a result, warming the upper atmosphere.

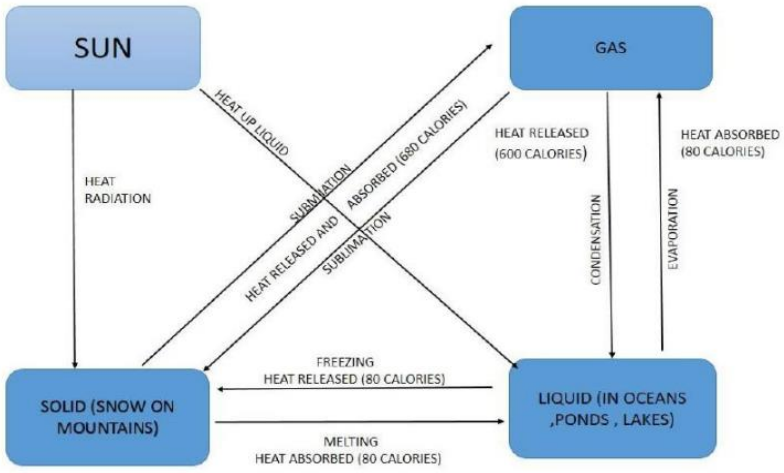
The need for precipitation to control global temperatures has changed, which has an impact on how hot it becomes on Earth. We refer to these modifications as "climate alteration" overall.

THE PRECIPITATION METHOD

As the environment cools, suspended water vapor condenses into either a solid or liquid state. The variables of temperature, wind speed, and humidity affect this process, which is known as precipitation. One important factor that starts the process is temperature, which causes evaporation to increase the atmosphere's humidity levels. Moving air, or wind, carries the extra moisture in the air from the surface to the atmosphere. The warm, humid air turns into clouds, which then return to Earth as precipitation in the form of either solid or liquid, as soon as it reaches the dew point, which is the temperature at which air ceases to absorb water vapor.

Relative humidity, or the amount of water vapor in the air at a given temperature, and precipitation have a substantial link. The likelihood of precipitation increases with relative humidity.

When the dew point is achieved before the freezing point, precipitation takes place in liquid form. When the freezing point is exceeded and the dew point is attained, solid precipitation is seen.



Hydrological Cycle, Figure 1

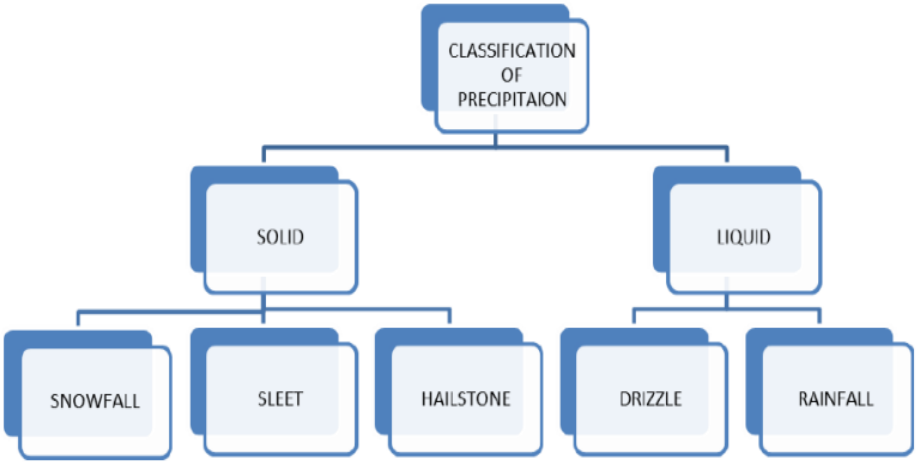


Figure 2: Precipitation Classification

Solid Precipitation: Hail, sleet, and snowfall are examples of solid precipitation.

- Snowfall: When temperatures close to the Earth's surface fall below the freezing point, usually around 300 meters above ground level, condensed water droplets rise to the surface as snowflakes. Snowfall is the term for this falling snow.

- Hailstones: Water droplets turn into solid droplets known as hailstones when they travel through an atmospheric layer that is colder than the freezing point.

- Sleet: Rainfall that falls through a chilly layer and condenses into ice pellets is known as sleet. The temperature needs to be cool at the Earth's surface and slightly warmer in the upper layers for sleet to form.

- **Liquid precipitation:** Rainfall and drizzle are examples of liquid precipitation.

- Drizzle: Usually arising from stratus clouds, drizzle is composed of many tiny, homogeneous droplets with a diameter of less than 0.02 inches.

- Rainfall: One important kind of precipitation is rainfall. Rainfall is the term for atmospheric moisture that condenses into water droplets and descends to the surface in liquid form. The size of these water droplets is noticeably bigger than that of drizzle.

PRECIPITATION AND CLIMATE CHANGE

The problem of climate change, which is mostly caused by human activity, is enormous. The main cause of changes in climate, particularly temperature, is the overabundance of greenhouse gas

emissions and the rising atmospheric concentrations of these gases. Although other gases are also essential, carbon dioxide is the most major greenhouse gas. The amount, kind, and frequency of condensed vapors that fall on Earth's surface are directly impacted by changes in the mean state of the climate. The average global surface temperature has risen by 0.74°C since the 19th century and is predicted to climb by 1.4°C to 5.8°C by the year 2100 AD.

East Anglia's climate research indicates that temperatures increased irregularly following a period of fall from 1945 to 1973. Urbanization, other greenhouse gases, and excessive carbon dioxide emissions are blamed for this dramatic shift. Higher evaporation rates brought on by warmer temperatures cause shorter rain events and more intense precipitation without changing the overall volume. Higher temperatures have led to a rise in air moisture, which has hampered the hydrological process and delayed the onset of the monsoon in some places.

The water cycle is negatively impacted by the observation that air's water-holding capacity rises by 7% for every degree Celsius increase in temperature. If all other factors stay the same, a 6% increase in moisture could lead to a 20% increase in rainfall since the rate of falling condensed water vapor is 10–25% greater than the rate of evaporation. Rather than evaporation, storm circulation is the main cause of heavy rainfall.

Noteworthy Points:

1. The Clausius-Clapeyron effect's increased moisture content and the resulting decrease in precipitation vary less, indicating that precipitation will become more intense.
2. At the start and finish of the season, there is a change in precipitation from solid to liquid, which raises the danger of heat waves, droughts, and wildfires.
3. Changing storm paths cause complex pattern changes by making some areas drier and others wetter.
4. In certain areas, pollution layers block out the sun, which lowers evaporation and the amount of moisture that reaches the atmosphere.

DETECTION OF PRECIPITATION CHANGES

It is anticipated that the hydrological cycle will strengthen going forward after weakening in the past. It is anticipated that this shift may affect precipitation patterns, causing seasonal variations in certain areas and heavy rains in others. According to studies, worldwide precipitation has increased by 2% overall during the 20th century.

1. Latitudes in the Middle and High Ranges

The amount of precipitation has increased by 7% to 12% in the latitudes between 30° North and 85° North, and by 2% in the latitudes between 0° South and 55° South. Due to the uneven distribution of land and oceans, precipitation changes differ in the northern and southern hemispheres. Variations in fall and springtime temperatures in the northern hemisphere have been linked to rising amounts of

precipitation in the mid- and high-latitudes. For instance, precipitation has risen by 5% to 10% in the USA, while certain regions had higher summertime precipitation than others. Over the 20th century, precipitation has risen by more than 10% on a regional level in Canada. Regarding the precipitation in the Canadian prairies, there are, nevertheless, contradicting accounts. While Gan (1998) noted an increase in precipitation between 1949 and 1990, Akinremi et al. (1999) reported an increase from 1965 to 1995.

Over China, there has been a 3.9% decline in the number of wet days each decade, indicating a decrease in precipitation. Studies show that since 1981, the rate of precipitation decrease in the USSR has grown by 5%. While certain places had a 15%–20% increase in precipitation, Southwest Australia has also seen a decline in wet days and precipitation totals. The northern hemisphere has seen notable increases in precipitation, with rain rather than snow falling in the majority of the regions. In the southern hemisphere, Argentina has had a sustained rise in precipitation from 1900 to 1998.

2. Tropics and Subtropics:

Since 1980, there has been a decrease in precipitation in the subtropics, and since 1995, there has been a decrease in precipitation even in the equatorial zone. Extreme rainfall increased during India's summer monsoon, and a shift in the monsoon to levels 70% below average was forecast. The start of the monsoon over Southeast Asia is negatively impacted by this change and is predicted to be delayed by 15 days. Southeast Asia and the western and central South Pacific have seen a decline in the number of rainy days, while Fiji and Polynesia have seen increases. Since the 1960s, much of North Africa, including the region south of the Sahara, has experienced prolonged drought. Thus, even though mean precipitation is constant, the kind of precipitation is changing, with some places experiencing an increase in torrential downpour. In certain places, flooding has grown in response to hurricanes and cyclones.

3. Global Agriculture's Effect on Climate Change

The majority of nations are agrarian states, and the world's population primarily obtains their food from agriculture. A crucial component of agriculture, precipitation is negatively impacted by aspects of a changing climate. Variations in rainfall patterns cause problems for farmers and lower agricultural production in the end. Changes in precipitation patterns have led to a decrease in crop production this century; by 2080, it is expected that overall productivity will have dropped by 3% to 16%. In the 2080s, productivity in developing nations is predicted to fall by 10% to 25% on average in areas where temperatures are close to or above crop tolerance levels. Some nations, like India, can experience a 30%–40% decline.

On the other hand, some nations are addressing these shifts' implications favorably. For instance, Australia has used irrigation techniques to counteract its decreased rainfall, whereas North America has profited from more precipitation and more temperate temperatures, which may increase food production. Crop and livestock farming have been impacted by variations in precipitation. There have been fewer rainy days on the calendar and a delayed start to the seasonal rains, which has had a

negative impact on yields, according to observations. Since the 1980s, there has been a decline in the key growing seasons of March, April, May (MAM) and December, January, and February (DJF) in Ethiopia, Kenya, Tanzania, Zambia, and Malawi. In India, summer rainfall has increased during the growing seasons of June-September and November-January.

4. Crop Reaction to Shifting Patterns:

Temperatures have risen due to climate change, which has changed precipitation patterns. Crop yields are susceptible to these fluctuations, which affect transpiration, photosynthesis, and moisture availability.

With an increase in CO2 concentration, net photosynthesis would rise and transpiration levels would fall. Yield would rise by 0.5 t/ha with every 75 ppm increase in CO2 levels, but yield would fall by 0.6 t/ha for every 1°C increase in temperature.

5. Agriculture: Mitigation and Adaptation

i. Supporting Farmers: By offering weather services, enabling farmers to adjust to climatic change by modifying crop rotations, selecting varieties with varying growth lengths, or rearranging sowing dates, we can help farmers manage the risks associated with climate change.

ii. Early Outbreak Warning: Early alerts on disease and pest outbreaks should be sent. Pest control methods should be based on integrated pest management, which takes into account a variety of pests in a particular climatic condition.

iii. Climatic Predictions: One useful tool for improving planting and irrigation schedules is seasonal weather forecasts.

iv. Efficient Use of Fertilizers: Crops can be shielded from deterioration by using fertilizers effectively, such as the best nitrogenous and potassium fertilizers.

v. Education and Research: More funding should be made available to support research in order to address the issue of shifting precipitation patterns and adapt to a dynamic world.

vi. Crop Protection: Customers can be protected against crop failure by purchasing crop insurance, which will motivate them to produce more.

vii. Irrigation Facilities: It is important to encourage the use of efficient irrigation techniques, such as frequent yet shallow irrigation, drip and sprinkle irrigation for high-value crops, and irrigation at key points.

Conclusion

The relationships between precipitation and climate change are discussed in this work. As a result of global warming, climate change is beginning to affect the entire world and is changing precipitation patterns. Precipitation patterns have changed significantly, with variations noted all throughout the

planet. Analysis reveals that in areas where overall precipitation has increased, there has been a rise in heavy and intense precipitation occurrences. However, despite a drop in overall precipitation, extreme precipitation events have increased in some places. We find that considerable increases in total precipitation resulting from heavy and intense precipitation events have occurred, mostly in the northern hemisphere and in mid- and high-latitude regions.

Undoubtedly, variations in precipitation patterns are an indicator of climate change and have an immediate impact on the world's food output. The nature and qualities of vegetation and crops are determined by a region's environment, making the agriculture industry especially vulnerable to changes in the climate. It is imperative that we take global, national, and local action in order to deal with these drastic changes.

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