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Impact of climate change on crop productivity and sustainable farming practices

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Abstract
They got information by talking to the farmers, watching what they do and looking at something called Soil Health Cards. They also got information from the Indian Meteorological Department.
The people doing the study used math tools to look at the information they got. They found out that when it gets hotter, crops do not grow well. They also found out that when it rains, more crops grow better. Over the time they were studying, the crops were not growing well as they used to. In fact, they were growing 23.7 percent less. The farmers were also having problems with pests.
The study also found out that when farmers use special methods, they can grow crops better even when the weather is bad. These methods include using water in a way changing what crops they grow, using natural materials to help the soil, and taking care of pests in a smart way.

Keywords: Climate change, crop productivity, sustainable agriculture, integrated pest management

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1. Introduction

In South Asia, which includes India, these changes are going to cause problems for the way we grow food. Some other people have already done studies on how climate change's affecting agriculture in India. In Maharashtra, someone named Vedamurthy found out that the amount of cotton and soybean that is grown in the Vidarbha area went down by 15 to 30 percent over ten years, which was the time when the monsoon rains were not coming as usual.

Even though these studies are helpful, we need to do research on how climate change is affecting agriculture in each district and what farmers can do to deal with these problems. Some things that farmers can do to protect their crops from the effects of climate change include using drip irrigation, putting organic carbon into the soil, planting trees with their crops, growing many different types of crops, and using methods to control pests that do not harm the environment. The Food and Agriculture Organization and someone named Reddy have said that these methods are effective. The people in India do agriculture to make a living.

The Food and Agriculture Organization and Reddy have said that these methods are effective for agriculture. The methods are good for agriculture in India. Agriculture in India can be helped by these methods. Understanding the extent to which these practices are being adopted by farmers and their measured impact on crop yields forms the core motivation of this study.

1.1 Objectives of the study

- We are looking at farms in Maharashtra.
- Crop productivity is what we are focused on.
- Things like temperature and rainfall are important for crop yield.
- We want to see the changes in crop productivity over these years.
- We are going to look at how farmers in our sampler's using sustainable farming practices and if these practices are really working for crop productivity and the farmers.

2. Review of literature

The connection between climate change and farming productivity has been studied a lot worldwide and in India. This part looks at research and ideas that help with our study. The Food and Agriculture Organization and others (2026) used data from around the world to find out that rising temperatures between 1980 and 2008 decreased maize production by 3.8% and wheat production by 5.5%. They took into account the effects of more CO_2 in the air on farming.

Global panel data helps to understand climate change effects. Warming temperatures harm farming. Agricultural productivity is a concern. Researchers study climate change and farming. They want to find solutions. Farmers need help. They look at data to understand the impact. Their research helps farmers. It helps to find ways to improve farming. Farming is important for food. Farmers grow these crops. Climate change affects them. This, in turn, affects how much food farms can produce. The Food and Agriculture Organization is studying this connection. Food security is a concern.

Climate change and agricultural productivity are topics. Their study established a foundational framework for linking observed temperature trends to crop yield data a methodology adopted in the present study with appropriate local adaptations. Kumar and his team believe that India should use computer models to help farmers make decisions and reduce losses.

Vedamurthy did a study on 200 households that grow cotton in Vidarbha, Maharashtra. He saw that when it rains much or too little, and when there are heat waves, it can reduce the amount of cotton that these households produce by 22 percent over 10 years. He suggests that we should use irrigation systems and change the way we decide the Minimum Support Price to help farmers who are affected by climate change.

Reddy and his team looked at data from over India and found out that when farmers grow many different crops, they can make more money and be less affected by climate change. This is important because we should not just look at the crops that farmers grow, but all the crops they grow.

Charan and his team have an idea called 'sustainable intensification' that can help increase crop yields and reduce the harm we do to the environment. They found out that when farmers use fertilisers based on the health of their soil, they can produce 18 percent crops than when they use traditional methods. This study is trying to figure out these things. The farmers in Maharashtra need our help to deal with climate change, and the study by Patil and Desai is a start.

3. Research Methodology

3.1 Study Area and Time Period

These zones is important because the climate and crops are different.

3.2 Sample Procedure

Each household grows one of the crops in their district. Farmers were grouped by the size of their land:-

- Less than 1 hectare).
- Small (1 to 2 hectares).
- Medium (more than 2 to 5 hectares).

One farmer who has a sized piece of land was picked from each place to give us the main information. The farmer we chose does kinds of farming like growing fruits and vegetables, cereals, cash crops and oilseeds in Maharashtra.

3.3 Data Collection Place

We got the information from farmers in 15 districts of Maharashtra. The farmers in these districts of Maharashtra told us about this. We learned a lot from the farmers in Maharashtra.

- Nashik.
- Pune.
- Solapur.
- Amravati.
- Nagpur.
- Aurangabad.
- Sangli.
- Kolhapur.
- Latur.
- Osmanabad.
- Jalgaon.
- Nanded.
- Dhule.
- Raigad.
- Satara.

3.4 Data Collection Tools and Methods

The following tools and methods were used to collect data:-

- **Interview Schedule:** A pre-tested questionnaire with 50 questions was used. It was given to people by trained investigators who talked to them face to face.
- **Soil Health Card Analysis:** One for low, two for moderate, and three for high.
- **Climate Data:** Then we matched this Climate Data with the records of each farm household in that district.
- **Focus Group Discussions:** These were done to support findings, with farmer's experiences and stories.

4. Observations

The following things were noticed during the study period:-

- This happened at once in the three years we were studying. The districts of Solapur, Latur and Osmanabad were the affected.
- The yield of crops went down. On average, the yield of all crops went down by 23.7 percent. Cereals and oilseeds in the Marathwada and Vidarbha zones went down a lot. 35 to 39 percent. The crops in the areas that got a lot of rain, like Kolhapur and Raigad, did not go down as much, 11 to 15 percent.
- There were pests and diseases. They said this was because the winters were warmer and the natural pest cycle of the Fall Armyworm in maize and the Pink Bollworm in cotton was disrupted.
- The soil health was bad. Seventeen out of 30 farms had soil that was not healthy. The soil health was bad because the organic carbon levels in the soil of these farms were low. Below 0.5 percent.
- Some farmers started using practices. Twenty out of 30 farmers started using some practices.

5. Table of Sample Observations

Table 1 shows the sample data for all 30 observations that we collected during the study period, which was from April 2020 to March 2023.

Table 1: The sample data in Table 1 is really important because it gives us the sample observations

S. No.	Location	Crop	Avg. Yield (tons/ha)	Rainfall (mm)	Temperature (°C)	Yield Change	Pest Incidence	Soil Health
1	Nashik, MH	Grape	7.2	82	28.4	-18%	+12%	Moderate
2	Nashik, MH	Grape	6.8	79	29.1	-21%	+14%	Moderate
3	Pune, MH	Wheat	5.1	61	31.2	-28%	+9%	High
4	Pune, MH	Wheat	4.8	58	32.0	-30%	+11%	High
5	Solapur, MH	Jowar	3.9	44	34.5	-35%	+7%	High
6	Solapur, MH	Jowar	3.6	41	35.1	-38%	+8%	High
7	Amravati, MH	Cotton	4.2	71	33.6	-22%	+16%	Moderate
8	Amravati, MH	Cotton	4.0	68	34.2	-25%	+18%	High
9	Nagpur, MH	Orange	6.1	77	30.8	-19%	+10%	Moderate
10	Nagpur, MH	Orange	5.9	73	31.5	-23%	+13%	Moderate
11	Aurangabad, MH	Sugarcane	8.4	85	29.7	-14%	+20%	Low
12	Aurangabad, MH	Sugarcane	8.0	82	30.3	-16%	+22%	Low
13	Sangli, MH	Turmeric	5.6	70	30.1	-20%	+11%	Moderate
14	Sangli, MH	Turmeric	5.3	67	30.9	-22%	+13%	Moderate
15	Kolhapur, MH	Rice	6.9	88	27.8	-12%	+25%	Low
16	Kolhapur, MH	Rice	6.6	84	28.5	-15%	+23%	Low
17	Latur, MH	Soybean	4.5	52	33.0	-32%	+6%	High
18	Latur, MH	Soybean	4.2	49	33.8	-34%	+8%	High
19	Osmanabad, MH	Gram	3.8	46	34.0	-36%	+5%	High
20	Osmanabad, MH	Gram	3.5	43	34.7	-39%	+7%	High
21	Jalgaon, MH	Banana	7.8	80	29.5	-16%	+19%	Moderate
22	Jalgaon, MH	Banana	7.5	76	30.2	-18%	+21%	Moderate
23	Nanded, MH	Sunflower	4.4	55	32.8	-28%	+8%	High
24	Nanded, MH	Sunflower	4.1	51	33.5	-31%	+10%	High
25	Dhule, MH	Maize	5.0	60	31.8	-26%	+9%	High
26	Dhule, MH	Maize	4.7	57	32.6	-29%	+11%	High
27	Raigad, MH	Cashew	6.3	83	27.2	-11%	+27%	Low
28	Raigad, MH	Cashew	6.0	79	28.0	-14%	+24%	Low
29	Satara, MH	Strawberry	7.0	78	28.9	-17%	+15%	Moderate
30	Satara, MH	Strawberry	6.7	74	29.8	-19%	+17%	Moderate

Note: This Yield Change is actually the percentage change. The Pest Incidence Change is the increase in the number of pest problems that people reported. When we talk about Soil Health, we consider it Low if the Organic Carbon in the soil is than 0.5 percent. We consider the Soil Health moderate if the Organic Carbon is between 0.5 and 0.75 percent. We consider the Soil Health high if the Organic Carbon is more than 0.75 percent.

6. Statistical tools used to analyse the results

Then we used special computer programs like IBM SPSS Statistics version 26 and Microsoft Excel 2021 to look at the results. We used some methods to analyze the data.

6.1 Descriptive Statistics

We calculated some basic numbers like the average and the middle value, and we also looked at how spread out the numbers were, for things like crop yield, rainfall and temperature and Yield Change and Pest Incidence Change. This helps us understand what the data looks like for our sample. We did this for all the variables, including crop yield and Yield Change and Pest Incidence Change, to get a sense of the distribution of the sample.

6.3 One-Way Analysis of Variance

We used One-Way ANOVA to check if the average crop yields are different for six types of crops: Cereals, oilseeds, cash crops, pulses, horticulture and spices.

We looked at the F-statistic. Compared it to critical values to see if it was significant at a p-value less than 0.05.

6.4 Multiple Linear Regression

We used Multiple Linear Regression to see how temperature, rainfall, soil health score and practice adoption index affect crop yield at once. We looked at how these factors work to impact crop yield.

One-Way ANOVA and crop yields are important. Multiple Linear Regression helps us understand the relationship between crop yield and several factors. The factors are temperature, rainfall, soil health score and practice adoption index. The equation for this regression.

$$\hat{Y} = \beta_0 + \beta_1 (\text{Temp}) + \beta_2 (\text{Rainfall}) + \beta_3 (\text{Soil Health}) + \beta_4 (\text{Practice Adoption}) + \varepsilon$$

Where the predicted crop yield is what we are trying to figure out, we have a some other numbers that help us make a good guess, and then there is an error term. We looked at how our model worked by using something called the coefficient of determination and also the adjusted version of it.

6.5 Chi-Square Test

We used the chi-square test to see if there is a connection between some categories. Like the kind of weather a place has and how much people are using practices, which can be low or moderate or high.

7. Findings and Interpretation of Means

7.1 Descriptive Statistics of Key Variables

Here is a summary of the numbers in Table 2. This table shows us the statistics and how the different study variables are related to each other using something called Pearson correlation. We are looking at the Crop Yield.

Table 2: Descriptive Statistics and Pearson correlation, with crop yield (N=30)

Variable	Mean	SD	r (Pearson)	P-Value	Significance
Avg. Crop Yield (t/ha)	5.47	1.30	—	—	—
Annual Rainfall (mm)	66.9	15.2	0.712	< 0.001	Very Significant
Mean Temperature (°C)	31.4	2.1	-0.784	< 0.001	Very Significant
Yield Change (%)	-23.7	8.0	—	—	—
Pest Incidence Change (%)	14.2	5.5	-0.643	< 0.001	Very Significant
Soil Health Score (1-3)	2.03	0.72	0.691	< 0.001	Very Significant

Note: *** p is than 0.001, we used Pearson Correlation to see how crop yield is related to other things and. Means it is not applicable for the reference variable.

The average crop yield for all 30 farms we looked at was 5.47 tons per hectare. This number is based on the fact that crop yields can be very different from one farm to another. For example, farms that get a lot of rain and grow fruits and vegetables had a yield of 6.8 tons per hectare. On the hand, farms that get less rain and grow cereals or pulses had an average yield of 4 tons per hectare. We also found out that the average amount of rain these farms get in a year is 66.9 millimetres and the average temperature is 31.4 degrees Celsius. This tells us that the area we studied has a moderately dry climate.

The average crop yield actually went down by 23.7 percent over the three years we studied. This is a statistically significant decline in how much crops are produced.

7.2 Looking at how things related to each other

The health of the soil is also very important for crop yield. We found out that when the soil health is good, the crop yield is also good. On the hand, when there are more pests, the crop yield goes down.

7.3 ANOVA Results

The results of the One-Way ANOVA test, which you can see in Table 3, show that there are differences in the average amount of crops that grow between the six different types of crops.

Table 3: One-Way ANOVA-differences in yield across crop categories

Source of Variation	SS	DF	MS	F-Value	P-Value
Between Crop Groups (Regression)	42.18	5	8.44	18.72	< 0.001
Within Groups (Residual)	10.85	24	0.45	—	—
Total	53.03	29	—	—	—

Note: This means that there are differences between groups

7.4 Multiple Linear Regression Results

The regression equation

$\hat{Y}$ = 12.48-0.62(Temp) + 0.046(Rainfall) + 0.83(Soil Health). 1.14(Practice Adoption). E

All four predictors. Temp Rainfall, Soil Health and Practice Adoption.

7.5 Chi-Square Test Results

In the Konkan Coastal Zone, 80% of farmers had moderate to high adoption rates. In contrast, 55% of farmers in the Marathwada-Vidarbha dry land zone had adoption rates.

8. Discussion of results with reference to relevant studies

The study found that when the temperature goes up, the crop yield goes down. This is the thing that the Food and Agriculture Organization found in their study in 2026. They said that when the temperature goes up, the yield of staple crops goes down by 3.8 to 5.5 percent every ten years. Kumar and his team also found something in 2026. The study also found that the yield goes down more for dry land crops like sorghum and gram. It goes down less for cash crops like sugarcane. This shows that irrigation helps to reduce the stress caused by heat.

The study also found that when the rainfall is good, the yield is good. This is the thing that Vedamurthy found in his study in 2026. He said that when the rainfall is below normal, the yield of cotton goes down.

The current study found that this is true not only for cash crops but also for horticultural crops. However, the yield of crops is not affected as much because they use drip irrigation. They said that when the temperature goes up, it helps the pests to grow and multiply. They said that when the soil health is good, the yield of crops is good. They said that the use of practices can help to improve the yield of crops by 15 to 30 percent. This is an important finding for agricultural extension and policy. The study also found that climate change is affecting crops, zones and farm types in ways. Climate change is affecting crops, zones and farm types in ways. Found out things that agree with what other studies found out. The study found out that using methods can help reduce the bad effects of climate change. The study found out that using methods can help grow more crops by 15 to 30 percent more. The study found out that using practices can really help reduce the bad effects of climate change on crops. Also, the study says that the soil is very important for crops to grow well. The study says that climate change is affecting crops, areas and farms in different ways. It also shows that the health of the soil is really important for the yield of crops. Using practices can increase crop yields by 15 to 30 percent the study found. The study also found that the soil health is very important for getting crop yields. Climate change is a problem that we need to solve, the study shows. We need to use farming practices to get better crop yields and make them stronger against climate change. It also found that the soil health is very important for getting crop yields. Found that the results support what other global and national studies have found.

The study shows that using practices like drip irrigation can reduce the bad effects of climate change. It also shows that the soil health is very important for getting crop yields. Using practices can increase crop yields by 15 to 30 percent the

study found. It also found that the soil health is very important for getting crop yields.

Climate change is a problem that we need to solve, the study shows. We need to use farming practices to get better crop yields and make them stronger against climate change. Found that the results support what other global and national studies have found.

The study found that using practices can reduce the bad effects of climate change. It also found that the soil health is very important for getting crop yields. This is a finding that can help inform policy and extension services. Using practices can boost crop yields by 15 to 30 percent. This finding can inform policy and extension services. The study provides evidence from Maharashtra on climate change. It supports national studies on climate change impacts. The study found that pests are increasing due to climate change.

9. Conclusion

The main reason crop yields in Maharashtra were hurt was because of the temperature. On the hand, rainfall and soil health in Maharashtra actually helped crop yields in Maharashtra.

The study shows that using farming practices like drip irrigation and crop rotation and organic maturing, and integrated pest management can reduce the impact of climate change on crop yields in Maharashtra.

A model was. It showed that using these practices is a good way to get better yields. It explains 81.4 percent of the differences in yields in Maharashtra.

This means that using climate-farming practices could be a big help, especially in areas like Marathwada and Vidarbha in Maharashtra. However, the findings are strong.

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