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Impact of Environmental Change on Agriculture Production and Groundwater Depletion: Adaptation Strategies in Response to Farmers in Maharashtra

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Abstract

Agriculture is the sector most vulnerable to climate change due to its high dependence on climate and weather and because farmer and rural people involved in agriculture. Close relationship between Environmental Change and Agriculture production, both of which take place on a worldwide scale. The Maharashtra agriculture sector is already facing many problems relating to sustainability. Occurrence and intensity of drought have increased over the years in Maharashtra. Drought is a major challenge in Maharashtra Agriculture (e.g., rainfed cropping and livestock) is the major income activity of over 60% of the state's population. The impact of a changing climate will affect not only bulk water availability, but also worsen the extremes of drought Groundwater depletion can lead to a significant reduction in agricultural production. Groundwater depletion can have implications for human being as this can increase the cost of production of the farmers.Groundwater over-exploitation problems because growing water crisis facing of farmer in Maharashtra. Examine that if productivity of water is to be enhanced on a sustainable basis through technological interventions. We argue integrated water management for sustainable management of groundwater resources and improving the livelihoods of the farmer communities in Maharashtra, sustainable enhancements in the economic efficiency of water use in agriculture based on water-saving technologies that are adaptable strategy in the state. Farmers deliberately adapting to climate change are innovative and independent of government support. Rainwater - harvesting techniques are the most popular risk management and adaptation strategy used sustained. We Examines this study indicate that government policies must be informed and guided by the risks and opportunities faced by farmers.The objective of this paper is to identify climate change related threats and vulnerabilities associated with agriculture as a sector and farmers' livelihoods (exposure, sensitivity, adaptive capacity of farmers). The paper analyses the connections between the nature of human action as drivers of threats as well as opportunities for sustainable agriculture and better human well being outcomes. Also, it examines the impact of climate change on rural livelihoods, agriculture production. It will discuss the ground water depletion options for adaptation strategy and mitigation of these measures. It shows linkages between Environmental Change and Agriculture production using Granger Causality test.

Keywords: Environmental change, Water, Agriculture production, Adaptation, Granger Causality test.
JEL Code: Q22, P28, C11, Q540, Q560.

Introduction

Drought is particularly frequent and severe in the state. Under these circumstances,identification of appropriate adaptation options seemed to be the right policy. The right adaptation policy was to look at the existing vulnerability reduction mechanisms and improve upon them by plugging the gaps.Climate change and variability are concerns of human being. The recurrent droughts and floods threaten seriously the livelihood of billions of people who depend on land for most of their needs.Agriculture in Maharashtra has always been vulnerable to the vagaries of the monsoon.The rainfall-related volatility in agricultural production is a big concern for food security. These concerns have grown in recent years as altered rainfall patterns associated with climate change have become more frequent, increasing the likelihood of short-run crop failures and long-run production declines. Small, Marginal farmers and agricultural laborers, who are poor and have few assets and limited access to credit and insurance, are the worst affected. It is crucial for them and for the agriculture sector that farmers are able to adjust their farming practices to adapt to the changing climate.

The worst affected are Solapur, Osmanabad, Nanded, Aurangabad, Ahmednagar, Sangli, Satara, Beed, Nashik, Buldhana, Latur, Jalna, Jalgaon and Dhule districts.

The rapidly declining stock of groundwater for irrigation poses a significant threat to agriculture in Maharashtra.As a result, there has been great interest in policies that could be used to encourage farmers to adopt various water-saving technologies.

Climate change and agriculture

Impact of climate change on agriculture will be one of the major deciding factors influencing the future food security of mankind on the earth. Agriculture is not only sensitive to climate changeBut also one of the major drivers for climate change.The climate sensitivity of agriculture is uncertain, as there is regional variation in rainfall, temperature, crops and cropping systems, soils and management practices.The crop losses may increase if the predicted climate change increases the climate variability.

Marathwada, Vidarbha, Northern Maharashtra and parts of Western Maharashtra are reeling under unprecedented hail storms and unseasonalble rainfall. Hailstorms in end of February 2014, initially thought of as a one-off phenomenon, continue to batter places like Solapur for nearly two weeks now, absolutely destroying the farmer. Rabi crops like Wheat, Harbhara, Cotton, Jowar, summer onion are lost, horticultural crops like Papaya, sweet lime, grapes are battered and orchards which took years to grow are ridden to the ground. For many farmers the tragedy is unbearable as majority of crops were about to be harvested. Turmeric was drying in the sun, grapes were waiting to be graded, wheat was harvested and lying in the fields.

Review of literature

Review of existing empirical literatures, there are strands of studies on the Impact of environmental change on Agriculture production and Groundwater Depletion.

Bergkamp et.al. (2006) Examined that the Groundwater degradation and depletion was far reaching consequences to the environment, economy and society in general. Over abstraction can reduce habitat for species dependent on groundwater during the dry season. Pressure on groundwater sources can also reduce irrigation capacity, compromising food security, and further impoverishing the vulnerable sectors of society. Despite the consequences of mismanagement and neglect of groundwater, interactions between economic, social, political and institutional elements continue to feed into the vicious cycle of groundwater depletion and degradation. Ecosystem services are increasingly recognized as important assets for sustainable development. A close interdependency between ecosystem services and groundwater exists.. Groundwater resources are dependent on recharge through infiltration of rainwaters. The close linkages between groundwater and ecosystem services are often not recognized and under valued. They argue the relationships are clarified and an indication of their value is provided.

Sanjay Rode (2011): Stated that the demand for water is increasing in Maharashtra because of urbanization, population growth, changing cropping pattern. The rainfall is not equally distributed in the region due to physical features of the state. Due to high industrialization, the government tried to give first preference in water supply to the industry but it was unsuccessful. The work of the NREGA is good in water storage through check dams, but there are no laws for water use. In order to reduce the water stress in the state government should allow check dams, farm ponds and compulsory rain water harvesting for each household in each village will reduce the water scarcity.

Parmeshwar Udmale et.al (2014) Examined that the recurring drought is a major challenge in the Drought Prone Area of Maharashtra State in India. The objective of this study is to understand the rural farming community's perception of drought impacts on their socio-economic activities and environment, their adaptation at the household level and opinions on government drought mitigation measures. Variables are associated with decreased income of farmers, were the most immediate economic impacts of drought. Groundwater depletion was perceived by farmers to high extent. In spite of good perception of severity of drought impacts by farmers and their familiarity with various adaptation options, the preference given for their adoption in agriculture was not good enough. Also to mitigate drought, the government provided various mitigation measures, but the level of satisfaction amongst farmers was low.

Objectives

1. Identify water saving technology and water management, adaptation strategies for climate change by farmers in solapur district.
2. To Know the policy and institutional interventions for small and marginal farmers
   to adapt to changes in water availability due to climate variability (droughts).
3. To study assist for climate variability and to develop adaptation strategies by the government.

Crop irrigation & groundwater

Groundwater is mostly used for irrigating farmland. in Maharashtra groundwater to such an extent that there is a continuous depletion in this resource over time. The state Potential for groundwater irrigation (in '000 hectares) is 3,652 and Percentage of land that can be irrigated with groundwater is 21% of their farmland through groundwater.

Reforms in Irrigation Sector
The State has initiated few reforms in irrigation sector, which include declaration of water policy, establishment of Water Resources Regulatory Authority, Management of Irrigation System by Farmers and Water Users Associations (WUA). About 4,553 WUA covering command area of 21.20 lakh ha are under various stages of formation

Sprinkler and Drip Irrigation
Sprinkler and drip irrigation is the targeted, intelligent application of water, fertilizer, and chemicals. The State encourages cultivators to adopt these irrigation systems by giving 60 per cent subsidy to small & marginal farmers and 50 per cent subsidy to other farmers for purchase of sprinkler and drip irrigation equipments. Year-wise Sprinkler & drip sets distributed and expenditure incurred are given in following table.

Year	No. of sets	Area(ha)	No. of sets	Area (ha)	Expenditure incurred (crore)
2007-08	35,288	37,719	63,298	63,548	167.28
2008-09	34,701	41,851	58,014	74,782	197.55
2009-10	36,329	37,552	91,058	81,660	192.11
2010-11	38,030	38,029	1,40,764	1,27,967	407.88
2011-12	38,959	37,904	1,77,150	1,50,995	448.04

Source : Commissionerate of Agriculture, GoM.

Subsidy for Agricultural Pumps
There are about 34 lakh agricultural pumps in the State. Electricity is supplied to the agricultural pumps at subsidized rates and provision of ` 3,649 crore has been made for the year 2012-13

Sr.no.	Administrative Unit	Stage of Ground Water Development %	Pree -mansoon		Post -mansoon	
			Water level Trend	Is there a significant decline	Water level Trend	Is there a significant decline
1	Akkalkot	53.35	-2.69	No	-12.26	No
2	Barshi	79.96	-5.16	No	-12.83	No
3	Karmala	65.42	3.40	No	-5.11	No
4	Madha	81.20	3.34	No	-6.81	No
5	Malshiras	100.90	10.27	Yes	-2.40	No
6	Mangalwedha	79.43	-9.24	No	-7.4	No
7	Mohol	88.39	-3.57	No	-9.97	No
8	N.Solapur	63.48	-12.41	No	-14.12	No
9	Pandharpur	77.78	4.50	No	-7.93	No
10	S.Solapur	60.18	-3.39	No	-9.93	No
11	Sangola	77.57	-5.41	No	-7.11	No

Table No.2Assessment Of Dynamic Ground Water Resources Of The Maharashtra Administrative Unit-Wise Categorization - 2011-2012
Source: GSDA GOM

In Maharashtra State, about 82% of the rural population are directly dependent on groundwater for irrigation, drinking and domestic purposes. The total rechargeable fresh groundwater resources in the State are computed as 35.79 billion cubic meters (BCM), whereas the net groundwater availability is to the tune of 33.91 BCM. The present annual gross draft of groundwater, in the State, for all purposes is 17.00 BCM. Out of this about 15.95 BCM of groundwater is used for irrigation purpose and rest for drinking and domestic uses. This quantum of groundwater for irrigation is extracted through 1.87 million abstraction structures throughout the State. These structures include 1.68 million dugwells (with mhot and pump sets) extracting 14.44 BCM of groundwater and 0.19 million borewells extracting 1.51 BCM of groundwater, annually. There are total 1531 watersheds in Maharashtra State and the groundwater development has reached more than 100% in most of these watersheds, as compared to groundwater recharge. This has resulted into depleting groundwater levels during either post or pre-monsoon seasons or both, such that out of the total, 66 watersheds are categorized as over exploited (GEC 1997; CGWB 1998a, 1998b, 1999; Duraiswami 2007; 2008; CGWB and GSDA 2005, 2009).

The management of water depletion (Drought)

1. Rainwater harvesting and irrigating at critical stages like flowering/grain filling.
2. Replacing sugarcane with less water requiring crops

3. Mulching at critical stages of crop growth
4. Use of early harvesting and processing strategies
5. Use of anti-transparent
6. Thinning
7. Defoliation: removal of leaves at the bottom
8. Contour farming
9. Strip Farming
10. Deep ploughing
11. Repair of existing water resources.
12. Mixed cropping, inter cropping, delayed sowing

Adaptation strategies

Climate variability and climate change- can influence crop yields and can force farmers to adopt new agricultural practices in response to altered climatic conditions. Climate variability / change, therefore, has a direct impact on food security. Seasonal precipitation distribution patterns and amounts could change due to climate change.the following table shows the adoption stategy for mitigation of climate change.

Local Coping Strategies as Adaptation Tools to mitigate the impacts of Climate Change Agriculture: Maharashtra:

Maharashtra	Local Area	Natural Disaster	Impacts	Adaptation Action	Local coping strategies
	Solapur District	Drought and/aridity	Water Shortage/scarcity/Loss of crops	Rainwater Harvesting/Water bank water saving technology	Changing cropping pattern

Methodology and Data:

In this paper, we use the data both secondary sources and a primary surveys we conducted in 20 villages of solapur district in maharashtra.In each village, the goal was to survey all land-owning farmers. In total, we surveyed 100 individual land-owning farmers across the twenty villages.

Granger Causality test:

For this study uses the secondary annual time series data of Agriculture production (AP) and Rainfall (RF) for the period of 2000-2012. Data are obtained from the Economic survey produced by the government of Maharashtra and district Stastical Dept of solapur.. In this paper, Agriculture production (AP) is expressed in terms of "00" Tonnes and Rainfall (RF) is expressed in terms of ‘mm’. The choice of the starting period was constrained by the availability of data on Agriculture production and rainfall. We have used Engle-Granger (1987) procedure for testing the null of no cointegration. The null of no cointegration implies that estimated residuals .We have used ADF test statistics for unit root testing of these residuals.

Results and Discussion:

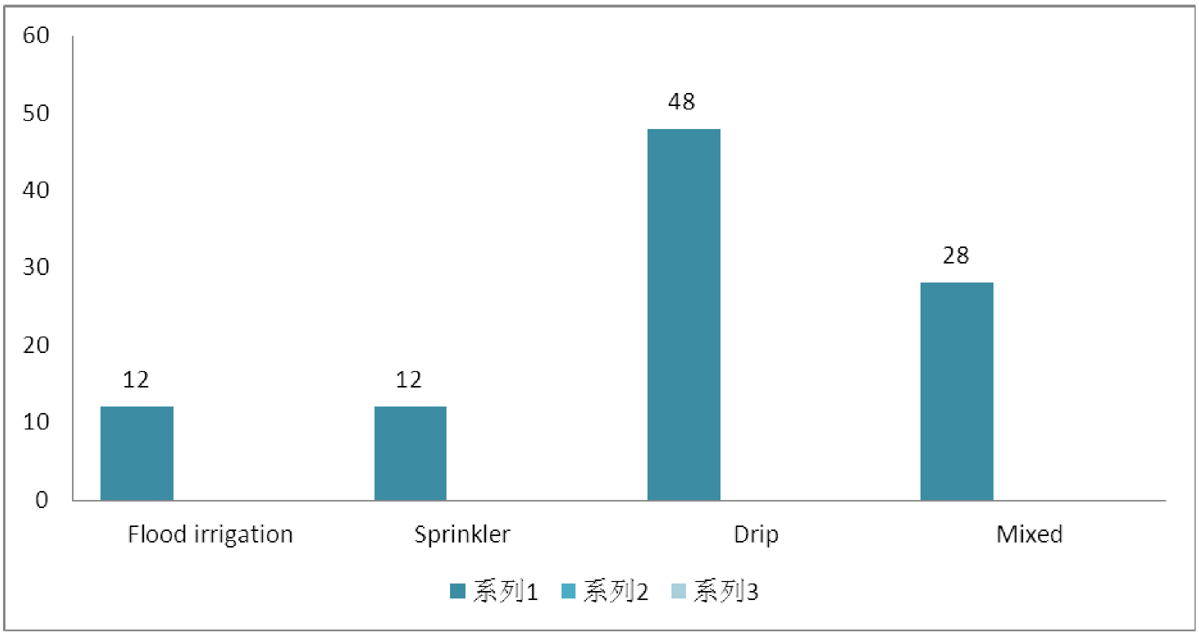

Fig: Irrigation practice used by farmers

Above Figure has shows that about 48% farmers has adopted Drip water saving technology,and very low 12 % farmers are uses sprinkler sets in farming.about 12% farmer they have use n traditional method such as flood irrigation.most of the 28% farmers have uses mixed method for cropping.

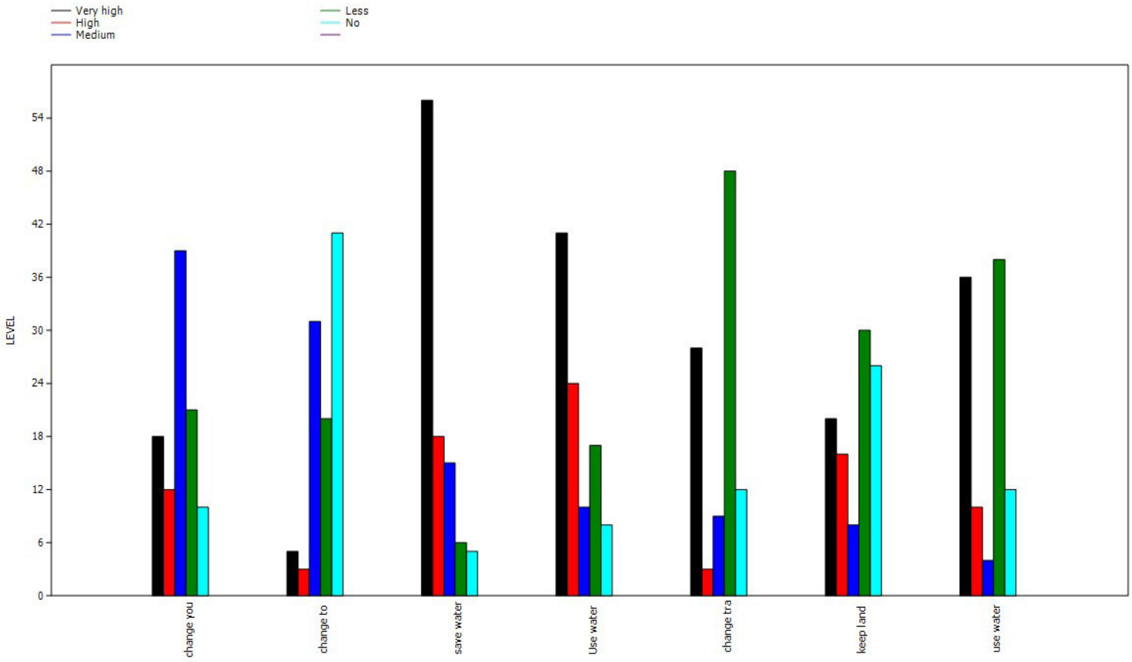

Fig: Agricultural adaptations adopted by farmers in the Solapur district

It was found that about 18% and 10% farmers gave high preference for changing their crop pattern or adjusting cropping in drought tolerant. Less water consuming crops respectively to mitigate the drought impacts.About 56%.farmer are major agricultural adaptations identified, such as changing the crop pattern, using low water consuming crops,using improved irrigation practices and reducing wastage of water during drought and depletion of water .These adaptation practices were widely used as these practices do not need extra financial cost and are easier to implement. In the case of rainwater harvesting through various structures and use of modern irrigation practices such as sprinkler and drip irrigation, farmers' preference for this response was low. Only 38 % of farmers rated as normaly use of water harvesting and conservation practices.The use of modern micro-irrigation practices such as sprinkler- and drip- irrigation was also not popular, due to high initial investment, The government of Maharashtra has given 50% subsidy after installation system. High cost involved in renewing systems and lack of irrigation water source. Use of this micro-irrigation technology by farmers has been reported 64% very low as com- pared with the potential this technology offers by the Government.

Granger Causality test:
The objective of the Granger test is to study the relationship between Agriculture production and Rainfall.in Solapur district context.

Hypothesis

1) Is uni-directional causality between Agriculture production and Rainfall = H_0
2) There is no unidirectional causality between the two variables = H_1

That means

- Rainfall does not cause Agriculture production.
- Agriculture production does not cause Rainfall.

The effect of Rainfall on Agriculture production has been estimated in the analysis by using the model below

X=α +β + ε ………… 1.

AP = $\alpha + \beta$RF were AP=(Agriculture Production),RF(Rainfall).

Conventional unit root tests such as the ADF. Whether the variables include unit-root or not will be tested as in the test of time series analysis Stationary of data will be analyzed with the help of the equation below.

$$\Delta\, yt = \beta 1_{yt-1} + \beta 2\, \Delta\, y_{t-1} + \beta 3 \Delta y_{t-2} + \beta 4 + \beta 5_t \qquad \ldots\ldots\ldots\ldots 2.$$

To test for causality between AP and RF, we shall estimate the following regression equations: That Y Granger-causes X. If Y causes X and X does not cause Y, it is said that unidirectional causality exists from Y to X.

$$y_t = \alpha_1 + \sum_{i=1}^{n} \beta_i x_{t-i} + \sum_{j=1}^{m} \gamma_j y_{t-i} + \varepsilon_t \qquad \ldots\ldots\ldots\ldots (3)$$

$$x_t = \alpha_2 + \sum_{i=1}^{n} \theta_i x_{t-i} + \sum_{j=1}^{m} \delta_j y_{t-i} + \varepsilon_{t-1} \qquad \ldots\ldots\ldots\ldots (4)$$

If the F statistic is greater than a certain critical value for an F distribution, then we reject the null hypothesis that Y does not Granger-cause X (equation (1)), which means Y Granger-causes X.

Step 1: **testing for a unit root in Agriculture_Pro**

Augmented Dickey-Fuller test for Agriculture_Pro
including one lag of (1-L)Agriculture_Pro
sample size 11
unit-root null hypothesis: a = 1

test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: -0.014
estimated value of (a - 1): -0.732246
test statistic: tau_c(1) = -1.76494
asymptotic p-value 0.3985

The analysis of the first differenced variables shows that the ADF test statistics for all the variables are less than the critical values at the 5% levels. The optimal lags for the ADF tests were selected based on optimizing Akaike's information Criteria AIC, using a range of lags. Augmented Dickey-Fuller unit root test in levels and in first Differences of Log (FDI) in terms with an intercept, with an intercept and trend and with no intercept or trend.

Step 2: **testing for a unit root in Rainfall**

Augmented Dickey-Fuller test for Rainfall

including one lag of (1-L)Rainfall
sample size 11
unit-root null hypothesis: a = 1

test with constant
model: (1-L)y = b0 + (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: -0.001
estimated value of (a - 1): -0.573675
test statistic: tau_c(1) = -1.29916
asymptotic p-value 0.6323

Test of a unit root with differentiation. The Differentiated series has unit root with P-value is 0.63, which is More than 5%, which leads to Accept of null hypothesis about the existence of the unit root. The unit root results above table suggest that both series are stationary in first difference and thus integrated of lag1. Having found series exhibiting unit root in levels, the model is tested for the long run relationship between variables.

Step 3: **cointegrating regression**

Cointegrating regression -
OLS, using observations 2000-2012 (T = 13)
Dependent variable: Agriculture_Pro

	coefficient	std. error	t-ratio	p-value	
const	-397.663	1914.27	-0.2077	0.8392	
Rainfall	8.80890	3.32926	2.646	0.0228	**

Mean dependent var	4554.385	S.D. dependent var	1775.035
Sum squared resid	23104452	S.E. of regression	1449.277
R-squared	0.388917	Adjusted R-squared	0.333363
Log-likelihood	-111.9850	Akaike criterion	227.9700
Schwarz criterion	229.0999	Hannan-Quinn	227.7378
rho	0.204778	Durbin-Watson	1.517509

Step 4: **testing for a unit root in uhat**

Augmented Dickey-Fuller test for uhat
including one lag of (1-L)uhat
sample size 11
unit-root null hypothesis: a = 1

model: (1-L)y = (a-1)*y(-1) + ... + e
1st-order autocorrelation coeff. for e: -0.017
estimated value of (a - 1): -1.09491
test statistic: tau_c(2) = -1.81653
asymptotic p-value 0.6221

There is evidence for a cointegrating relationship if:
(a) The unit-root hypothesis is not rejected for the individual variables.
(b) The unit-root hypothesis is rejected for the residuals (uhat) from the cointegrating regression.

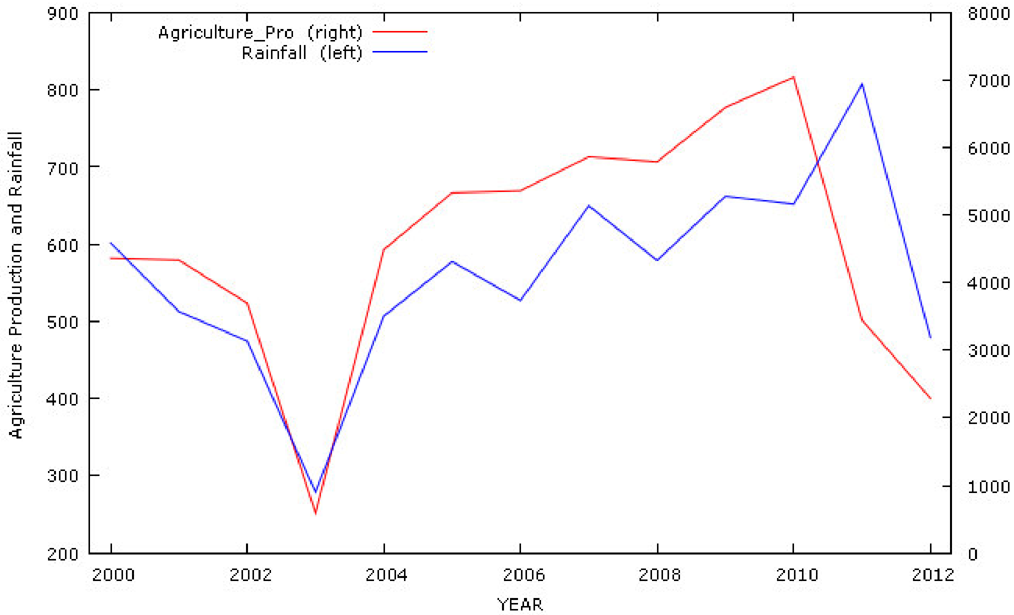

Fig: : unidirectional causality

Result interpretation

The results of the Granger causality tests of the model are shown in the above table**.**The table also shows the tests used to choose the lag lengths. The joint T-statistic value in step 3 is 2.646 with the probability value 0.0228.

From this we Accept the null hypothesis of there is uni-directional causality between Agriculture production and Rainfall. Also the Constant T-value from step 3 is -0.2077 with the probability value 0.8392 So we can reject the alternative hypothesis at the 10% level of significance. That is Rainfall Granger causes Agriculture production.The results in above Table provide a convincing evidence of a unidirectional causality running from AP to RF for Solapur District at the 10% level of significance.

Conclusion

The result shows that water depletion has a big impact on Agriculture production of crops. also it has indicated a relationship between the Rainfall and agriculture production. There is a need to develop, disseminate and implement the knowledge, tools and technologies required to effectively engage in reduce vulnerability to climate change. Financing and technological adaptation activities and costs associated with the impacts of climate change is a key concern for small and marginal farmers.Groundwater irrigation is expensive for marginal and small farmers in Maharashtra. Making irrigation, low cost could be the most effective strategy for agriculture.climate-smart. However, the state government has announced and committed provide five lakh solar pumps. Farmers with access to low cost irrigation from solar powered pump-sets in Maharashtra they should be that these farmers grew low water consuming crops, in spite of low rainfall.. These adoptions indicate that affordable groundwater irrigation is essential for effective drought proofing in the state also Solapur district.

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