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Research Article

ISSN: 2395 -5775

IMPACT OF CLIMATE CHANGE ON RAINFED AGRICULTURE: A STUDY OF ITS IMPACT ON THE SOCIO-ECONOMIC LIFE OF FARMERS IN RAYALASEEMA REGION OF ANDHRA PRADESH

Narayana Reddy M*[1] and Sreenivasa Reddy B[2]

Abstract

Temperature and its associated seasonal patterns are critical components of agricultural production systems. Rising temperatures associated with climate change will likely have a detrimental impact on crop production, livestock, fishery and allied sectors. It is predicted that for every 20 C (which has been predicted by 2030) rise in temperature, the GDP will reduce by 5 per cent. Accelerated warming has already been observed in the recent period 1971-2007, mainly due to intense warming in the recent decade 1998-2007. This warming is mainly contributed by the winter and post-monsoon seasons, which have increased by 0.80°C and 0.82°C in the last hundred years, respectively. The pre-monsoon and monsoon temperatures also indicate a warming trend. The main results of the study will be to point out on the one hand the high influence of climate change on food supply and welfare; on the other hand its important distributional consequences as the stronger negative effects are concentrated on dry regions. The simulation exercise is introduced by a survey of the relevant literature.

INTRODUCTION

Climate is changing naturally at its own pace, since the beginning of the evolution of earth, 4–5 billion years ago, but presently, it has gained momentum due to inadvertent anthropogenic disturbances. These changes may culminate in adverse impact on human health and the biosphere on which we depend. The multi-faceted interactions among the humans, microbes and the rest of the biosphere, have started reflecting an increase in the concentration of greenhouse gases (GHGs) i.e. CO2, CH4 and N2O, causing warming across the globe along with other cascading consequences in the form of shift in rainfall pattern, melting of ice, rise in sea level etc. The above multifarious interactions among atmospheric composition, climate change and human, plant and animal health need to be scrutinized and probable solutions to the undesirable changes may be sought.

The agricultural sector represents 35% of India's Gross National Product (GNP) and as such plays a crucial role in the country's development. Food grain production quadrupled during the post-independence era; this growth is projected to continue. The impact of climate change on agriculture could result in problems with food security and may threaten the livelihood activities upon which much of the population depends.

Climate change can affect crop yields (both positively and negatively), as well as the types of crops that can be grown in certain areas, by impacting agricultural inputs such as water for irrigation, amounts of solar radiation that affect plant growth, as well as the prevalence of pests. The impacts of climate change can be broadly divided in to three categories viz. 1. Direct effects on crop growth-Physiology Phenology, Morphology, 2. Indirect effects-Soil fertility, Irrigation availability, Pests, Floods and droughts and mean Sea level rise, 3.Socio-economic – food security, costs and benefits, policy, trade, farmers response.

Climate is the primary determinant of agricultural productivity. Plant systems, and hence crop yields, are influenced by many environmental factors, and these factors, such as moisture and temperature, may act either synergistically or antagonistically with other factors in determining yields. Plausible climate change scenarios include higher temperatures, changes in precipitation, and higher atmospheric CO2 concentrations. Although temperature increases can have both positive and negative effects on crop yields, in general, temperature increases have been found to reduce yields and quality of many crops, most importantly cereal and food grains. Increases in precipitation (i.e. level, timing and variability) may benefit semi-arid and other watershort areas by

[1,2]Departmentof. Economics, Sri Krishna Devaraya University, Anantapuramu, Andhra Pradesh

Correspondence and Reprint Requests: Narayana Reddy M

Received: June 15, 2016 | **Accepted:** July 5, 2016 | **Published Online:** August 28, 2016

Conflict of interest: None declared | **Source of funding:** Nil

increasing soil moisture, but could aggravate problems in regions with excess water, while a reduction in rainfall could have the opposite effect. An atmosphere with higher CO_2 concentration would result in higher net photosynthetic rates. Higher concentrations may also reduce transpiration (i.e. water loss) as plants reduce their stomatal apertures, the small openings in the leaves through which CO_2 and water vapor are exchanged with the atmosphere.

The net change in crop yields is determined by the balance between these negative and positive direct effects on plant growth and development, and by indirect effects that can affect production. These indirect effects have been largely ignored in the assessment of climate change effects. Indirect effects may arise from changes in the incidence and distribution of pests and pathogens, increased rates of soil erosion and degradation, and increased tropospericozone levels due to rising temperatures.

Additional indirect effects may arise from changes in runoff and groundwater recharge rates, which affect water supplies, and changes in capital or technological requirements such as surface water storage and irrigation methods. In general, these indirect effects are not captured in existing assessments (the exceptions are changes in water supplies).

Vulnerability is the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed as well as the system's sensitivity and adaptive capacity. Vulnerability to climate change varies across regions, sectors, and social groups. Understanding the regional and local dimensions of vulnerability is essential to develop appropriate and targeted adaptation efforts. At the same time, such efforts must recognise that climate change impacts will not be felt in isolation, but in the context of multiple stresses. In particular, the dramatic economic and social changes associated with globalisation themselves present new risks as well as opportunities.

Studying the potential socioeconomic impacts of climate change involves comparing two future scenarios, one with and one without climate change. Uncertainties involved in such an assessment include: (1) the timing, magnitude and nature of climate change; (2) the ability of ecosystems to adopt either naturally or through managed intervention to the change; (3) future increase in population and economic activities and their impacts on natural resources systems; and (4) how society adapts through the normal responses of individual, businesses and policy changes that after the opportunities and incentives to respond. The uncertainties, the long periods involved and the potential for catastrophic and irreversible impacts on natural resources systems raise questions as to how to evaluate climate impacts, investments, and other policies that would affect or be affected by changes in the climate.

In India, substantial work has been done in last decade aimed at understanding the nature and magnitude of change in yield of different crops due to possible climate change. The objective of the present review is to a) examine the present status of the knowledge of climate change impact on Indian agricultural production, b) discuss the uncertainties and limitation of these studies in Indian conditions and identifying future research needs.

OVERVIEW OF LITERATURE

Lonergan (1998) estimates that India's climate could become warmer under the conditions of increased atmospheric CO_2. Climate change projections made up to the year 2100 for India indicate an overall increase in temperature by 2 to 4 °C, with no substantial change in precipitation (Kavikumar, 2010). However, different regions are expected to experience variations in the amount of rainfall;

Kumar and Parikh (1998) examine adaptation options while estimating the agricultural impacts. The relationship between farm level net revenue and climate variables is estimated using cross-sectional data in India. The authors demonstrate that even with adaptation by farmers of their cropping patterns and inputs in response to climate change, losses would remain significant. The loss in farm-level net revenue given a temperature rise of 2°C–3.5°C is estimated to range between 9 percent and 25 percent. Kumar and Parikh (1998) projected a 30–35 percent reduction in rice yields for India given a similar temperature increase (or losses in the range of US$3–4 billion). Moreover, the authors conclude that controlling for yearly weather deviations did not appear to make a significant difference, thereby suggesting that various other factors, such as government policy and prices, were having a major influence on variations in net revenues.

Mehta D.R., (2002) analysed the weekly rainfall data for 39 years (1958-1996) recorded at Main Dry Farming Research Station, G.A.U., Targhadia, for seasonal and weekly periods, weekly rainfall probabilities and yield prediction models using rainfall and productivity (1960-1995) worked out. As per the study the mean seasonal rainfall was 567 mm

(CV 52 %) which received in 27 rainy days. The seasonal rainfall indicated that there is 33 % chance of drought with variable intensities and 38 % chance of getting more than normal rainfall. The mean weekly rainfall was 26 mm with a CV of 73 %.Initial probabilities exceeded P=0.6 of receiving> 20 mm rainfall/ week was observed in mw 27 and CV was also low. Sowing of Kharif crops should be undertaken during this period. Significant and positive correlation between yield and rainfall was observed for groundnut, pearlmillet and sorghum. The predictability of productivity of crops using seasonal rainfall is low at the centre for all the crops except groundnut which explained 56 % variation in productivity.

Rupa Kumar *et al*. (2003) concluded that under future scenarios of increased greenhouse gas concentrations (GHG) indicate marked increase in both rainfall and temperature into the 21st century, particularly becoming conspicuous after the 2040s in India. Over the region south of 25 N (south of cities such as Udaipur, Khajuraho and Varanasi) the maximum temperature will increase by 2–4 C during 2050s. In the northern region the increase in maximum temperature may exceed 4 C. This study also indicates a general increase in minimum temperature up to 4 C all over the country, which may however exceed over the southern peninsula, northeast India and some parts of Punjab, Haryana and Bihar. There is an overall decrease in number of rainy days over a major part of the country. This decrease is more in western and central part (by more than 15 days) while near the foothills of Himalayas (Uttaranchal state) and in northeast India the number of rainy days may increase by 5–10 days. However, increase in GHG may lead to overall increase in the rainy days intensity by 1–4 mm/day except for small areas in the northwest India where the rainfall intensities decrease by 1 mm/day.

Shukla, P.R *et al* (2003) predicts that either direct effects due to changes in temperature, precipitation or CO_2 concentrations or indirect effects through changes in soils, distributions and frequency of infestation of pests, water stress, etc. there will be decline in GDP for India. The adaptability of farmers in India are severely restricted by the heavy reliance on natural factors and the lack of complementary inputs and institutional support systems which adds to the worsening of the scenarios.

Krishna Kumar K. et.al. (2004) in their paper presents an analysis of crop–climate relationships for India, using historic production statistics for major crops (rice, wheat, sorghum, groundnut and sugarcane) and for aggregate food grain, cereal, pulses and oilseed production. Correlation analysis provides an indication of the influence of monsoon rainfall and some of its potential predictors (Pacific and Indian Ocean sea-surface temperatures, Darwin sea-level pressure) on crop production. The study reveals that all-India annual total production (except sorghum and sugarcane), and production in the monsoon (except sorghum) and post-monsoon seasons (except rice and sorghum) were significantly correlated to all-India summer monsoon rainfall. Monsoon season crops (except sorghum) were strongly associated with the three potential monsoon predictors. Results using state-level crop production statistics and subdivisional monsoon rainfall were generally consistent with the all-India results, but demonstrated some surprising spatial variations. Whereas the impact of sub-divisional monsoon rainfall is strong in most of the country, the influence of concurrent predictors related to El Nino–southern oscillation and the Indian Ocean sea-surface temperatures at a long lead time seem greatest in the western to central peninsula.

Mall *et al*. (2006) provide an excellent review of climate change impact studies on Indian agriculture mainly from physical impacts perspective. The available evidence shows significant drop in yields of important cereal crops like rice and wheat under climate change conditions. However, biophysical impacts on some of the important crops like sugarcane, cotton and sunflower have not been studied adequately.

World Bank (2008) climate change is affecting agricultural regions throughout the world. It has been estimated that the overall economic impact on agriculture could be up to 10 percent of GDP. The countries that are most affected by climate change will have to increase their involvement in international trade as their environment worsens (and they become unable to adequately provide for themselves). Economic reforms that would help countries negatively affected by climate change could include the introduction of flexible land-use policies and the elimination of subsidies. Increased access to financial services such as credit, marketing systems, training and irrigation would also mitigate the impacts.

Guiteras (2009) studies temperature and precipitation effects in India, and uses a 40-year district-level panel to estimate the sensitivity of yields to climate changes. The study then predicts climate change effects beyond 2010 under a variety of climate change scenarios generated by external models. However, these results are averaged over the crops studied, and evidence suggests that crops differ in their sensitivities to climate changes. Thus, if farmers make crop choices partly in response to their suitability to regional climate conditions, these results may overestimate yield reductions.

Due to changes in rainfall pattern during the Kharif season (crops which are sown in the rainy season and harvested in the autumn season, or monsoon crops) and temperature variations in the Rabi season (crops sown in the winter and harvested in the spring, or winter crops), changes in the crops and crop rotations have been observed in Chhattisgarh. For example, the cultivated area under rice in the state is decreasing continuously. Because of the decreasing rainfall pattern, rice farming is failing in fragile ecosystems, for example upland areas. Similarly, during the Rabi season, the area of wheat is showing a decreasing trend (Sastri, 2009).

The 4x4 Assessment Report by the Ministry of Environment and Forests (MoEF) (Kulkarni *et al*., 2010) provides information about the monsoon rain, temperatures and extreme events in the past as well as plausible scenarios for the future in all India. The mean annual minimum temperature has significantly increased by 0.27 °C per 100 years during the period 1901–2007. The number of heavy rainfall events is increasing almost over the entire landmass of the country. Moreover, the frequency and intensity of extreme events defined as one-day maximum precipitation shows an increasing trend everywhere except some northern parts of the country. A 10 per cent increase in the monsoon rainfall over central and peninsular India is projected in the 2030s. In addition, a 1.5-2 °C warming in the annual mean temperature over the Indian landmass is projected, while winter (Nov – Feb) and spring (Mar – Apr – May) seasons show relatively higher warming (Kulkarni *et al*., 2010).

Lobell *et al* (2011) examines a 20-year country-level panel to estimate historical global impacts of temperature and precipitation trends on crop yields, and find that changes have reduced yields for some crops. However, using country-level data may overlook climatic differences within each country, and could overstate yield losses if farmers in regions more prone to harmful climate changes for affected crops are less likely to grow those crops, or employ differential production processes.

Yunous Vagh (2012) in his case study employed both qualitative and quantitative methods for the analysis of geographic data in an agricultural context. The geographic data was made up of land use profiles that were juxtaposed with previously captured rainfall data from fixed weather stations in Australia which was interpolated using ordinary krigeing to fit a grid surface. The resultant stochastic annual rainfall profiles for a selected study area within the South West Agricultural region of Western Australia were used to identify areas of high crop production. The areas within the study area were spatially scaled to individual shires. The rainfall was sampled for the years 2002, 2003, 2005 as a mix of low and high rainfall and high production attributes. The patterns suggested that crop production was closely linked to the annual rainfall for some shires, with location being of significance at other shires.

Research Gaps

The study of climate change impacts on Indian agriculture has gained recent attention, due to the size of India's agricultural sector, and reports suggesting that developing countries are more vulnerable to negative climate change effects. Studies in India have focused on predicting future trends using standard climate change scenarios from externally developed models. However, these studies are not generally able to provide accurate error estimates of their predictions, and are limited in their consideration of farmer adaptations that may offset climate change impacts. One drawback of this approach is that these studies are generally unable to provide accurate standard errors of their final predictions, since their results depend on the accuracies of specific scenarios that make assumptions about future policies and behaviors. Another drawback is that most of these studies make few allowances for farmer adaptations to climate change. Some studies use time-series data in a single region to examine how climate changes have affected yields in practice. Moreover, there is no study

Statement of Problem

Climate change is no more an environmental concern. It has emerged as the biggest developmental challenge for the planet. Its economic impacts, particularly on the poor, make it a major governance issue as well. Changing weather patterns, including less predictable seasons and increasingly erratic rainfall, is one of the most important but least understood impacts of climate change. Long-term and seasonal weather patterns are critical to the viability of many natural resource-dependent livelihoods. For example, the onset and duration of rainy seasons; the quantity of rainfall; its variability and even intra-seasonal rainfall shape farmers' decisions about sowing and harvesting, as well as the success or failure of their crops. Therefore, it is of great concern that many small landholding farmers and pastoralists report marked changes in the timing, quality and quantity of rainfall. Their observations are striking for several reasons, including geographic scope and the consistency of described changes. Climate change is worsening the odds of longstanding risks, such as heat stress, insufficient or too much rain at crucial moments in the plant cycle, in addition to pests and diseases. These interact with a range of escalating stresses on rural livelihoods, that is, land pressure, soil erosion, deforestation and depleted water resources that would exist regardless of climate change. Because of climate change, Indian agriculture is doubly vulnerable. First as around 60 percent of India's total agricultural areas are rain-fed, it is highly vulnerable to climate change impacts on monsoon. Secondly, more than 80 percent of farmers in India are small and marginal thus having less capacity to cope with climate change impacts on agriculture. Hence the proposed study will look in to problems facing by farmers community as a result of climate change.

Objectives of the Study

The specific objectives of the proposed study are as follows.

1. To study the causes of global and regional climate change.
2. To examine the relationship between changing weather patterns, food security and human mobility in India.
3. To investigate how droughts (and positive weather shocks) affect human capital, exploiting fluctuations in monsoon rainfall over time and across districts and;
4. To understand the voices of farmer community on how and to what extent the rainfall variations are impacting their livelihoods in the study area.

Table -1 Sample Frame Work of the proposed Study

District	Number of Mandals	Number of Villages	Category of Farmers	No. of Sample Respondents
Anantapur	Mandal –I	Village-I	Marginal	15
			Small	15
			Medium	15
		Village-II	Marginal	15
			Small	15
			Medium	15
	Mandal –II	Village-I	Marginal	15
			Small	15
			Medium	15
		Village-II	Marginal	15
			Small	15
			Medium	15
Chittoor	Mandal –I	Village-I	Marginal	15
			Small	15
			Medium	15
		Village-II	Marginal	15
			Small	15
			Medium	15
	Mandal –II	Village-I	Marginal	15
			Small	15
			Medium	15
		Village-II	Marginal	15
			Small	15
			Medium	15
Y.S.R. Kadapa	Mandal –I	Village-I	Marginal	15
			Small	15
			Medium	15
		Village-II	Marginal	15
			Small	15
			Medium	15
	Mandal –II	Village-I	Marginal	15
			Small	15
			Medium	15
		Village-II	Marginal	15
			Small	15
			Medium	15
Kurnool	Mandal –I	Village-I	Marginal	15
			Small	15
			Medium	15
		Village-II	Marginal	15
			Small	15
			Medium	15
	Mandal –II	Village-I	Marginal	15
			Small	15
			Medium	15
		Village-II	Marginal	15
			Small	15
			Medium	15
Total	**8**	**16**		**720**

Source: Field work.

Research Questions

The proposed study will make answer to the following research questions in the context of climate change and rainfed agriculture include:

1. Is Indian agriculture get adversely affected by climate change? If so what is the extent of impact?
2. How to characterize the vulnerability of a farmer to climate change and climate variability?
3. Which regions are relatively more vulnerable to climate variability and change?
4. How to assess effectiveness of adaptation options in ameliorating the present and future vulnerability?

Sampling

The universe of the study is Rayalaseema region of Andhra Ptadesh. For selecting the universe for the study, a multistage and purposive sampling technique was adopted in selecting the Mandals and the farmers. In the first stage four districts were selected. In the second stage two mandals from each district will be selected. In third stage, from each mandal 2 Villages were selected. In the fourth stage, three categories of farmers namely marginal, small and medium will be selected. From each category of farmers 15 respondent farmers will be selected from each village. Finally, altogether four districts, eight Mandals, 16 Villages and 720 farmers will be selected. Thus, the total universe of the sample for the study constitutes 720 respondents. The Table1 clearly depicts all such details.

Data Collection

Keeping in view the objectives of the study the data for the proposed study will be collected both from primary and secondary sources. The primary data is collected by administering pre-tested Interview Schedule. The Interview Schedule will elicit the opinions of sample respondent farmers. The secondary data which includes general information related to the four districts of Rayalaseema region, socio-economic profile of villages, irrigation facilities and village maps will be collected, interpreted and verified with the help of key informants as well as through personal observations. Temperature and rainfall data, population details, settlement patterns and occupations were obtained from published literature and from various government departments and academic institutions.

Data Processing

The study will be descriptive and analytical in nature. Therefore, the collected data will be presented in the form of tables, charts and appropriate graphs for analytical purpose. Besides statistical tools like Chi-Square test, T- Test, ANOVAs Two way classification will be applied for further analysis.

Conceptual Framework of the Study

Kharif season: There are two main agricultural seasons in the study area, *viz., kharif* and *rabi*. The *kharif* season commences from the first week of June, *i.e.,* from the first day of the *Mrug Nakshatra* and continues up to November-December. The south-west monsoon starts from June which is mainly useful for pre-sowing, preparatory tillage of the soil. The regular south-west rains set in by the fourth week of June and the sowing operations start with these rains. Special importance is given to sowing of the cotton crop during the *Mrug Nakshatra* as it results in good yield. For the *kharif* crops lands are ploughed during April and May and preparatory tillage consisting of harrowing is done before the onset of the monsoon. With the onset of the monsoon, the farmers start sowing operations. *Kharif* crops are harvested in the months of November-December. Due to the uncertainty rains, irrigation is also required to be given to *kharif* crops wherver irrigation facilities are available. In the study region main crops grown in *the Kharif* season are cotton, ground-nut, *bajri, tur,* maize, *mug,* paddy, etc. so timely set of south-west monsoon influences the ceop production, yield and livelihood opportunities of millions of people in study area.

Rabi season: This season commences from the middle of October. The he land is ploughed in the months of October-November for *rabi* season. The preparatory tillage such as harrowing is done before sowing. Sowing of *rabi* crops begins from the first week of October. They are sown in non-irrigated fields. The crops in irrigated fields could be own later. The *jowar* crop is harvested in the month of January, while wheat and gram crops are harvested in the month of March. The *rabi* crops like *jowar,* wheat and gram are generally grown as rain-fed crops on a large scale and are irrigated wherever the irrigation facilities are available.

Hot-weather crops: Besides the *kharif* and *rabi* crops, hot-weather crops are also grown in the study area. The preparatory tillage is completed immediately after the harvest of *rabi* crops for the sowing of hot-weather crops. The crops like maize, ground-nut, etc., are sown in the months of March-April. The irrigated cotton crop is also planted in the month of April, where adequate irrigation facilities are available. Other hot-weather crops such as ground-nut and maize are also grown where adequate irrigation facilities are available. The other agricultural practices are the same as those for the *kharif* crops.

Weather is the mix of events that happen each day in our atmosphere including temperature, rainfall and humidity. Weather is not the same everywhere. Perhaps it is hot, dry and sunny today where you live, but in other parts of the world it is cloudy, raining or even snowing. Everyday, weather events are recorded and predicted by meteorologists worldwide.

Climate in a particular place on the globe controls the weather where we live. Climate is the average weather pattern in a place over many years. Climates are changing because our Earth is warming, according to the research of scientists. Hot summer days are quite typical of climates in many regions of the world, even without the affects of global warming.

South-West Monsoon

The southwestern summer monsoons occur from June through September. The Thar Desert and adjoining areas of the northern and central Indian subcontinent heats up considerably during the hot summers. This causes a low pressure area over the northern and central Indian subcontinent. To fill this void, the moisture-laden winds from the Indian Ocean rush in to the subcontinent. These winds, rich in moisture, are drawn towards the Himalayas. The Himalayas act like a high wall, blocking the winds from passing into Central Asia, and forcing them to rise. As the clouds rise their temperature drops and precipitation occurs. Some areas of the subcontinent receive up to 10,000 mm (390 in) of rain annually.The moisture-laden winds on reaching the southernmost point of the Indian Peninsula, due to its topography, become divided into two parts: the *Arabian Sea Branch* and the *Bay of Bengal Branch*. The concept is related to the study as the South-West Monsoon accounts for 80% of the rainfall in India. Indian agriculture (which accounts for 25% of the GDP and employs 70% of the population) is heavily dependent on the rains, for growing crops especially like cotton, rice, oilseeds and coarse grains.

Northeast monsoon

Around September, with the sun fast retreating south, the northern land mass of the Indian subcontinent begins to cool off rapidly. With this air pressure begins to build over northern India, the Indian Ocean and its surrounding atmosphere still holds its heat. This causes cold wind to sweep down from the Himalayas and Indo-Gangetic Plain towards the vast spans of the Indian Ocean south of the Deccan peninsula. This is known as the Northeast Monsoon or Retreating Monsoon.

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