Climate change and investment in agricultural research: Policy challenges in India

Dayohimi Rymbai*, S.M. Feroze, Ram Singh, Atanu Sarkar and Lala IP Ray

College of Post Graduate Studies, Central Agricultural University, Umiam-793103, Meghalaya, India

ABSTRACT

Agriculture will continue to be the major sector supporting the Indian economy. On the other hand, the reported and projected impact of climate change raises question against its sustainability and stability. The present paper through reviewing of the relevant literature therefore aims to address three interrelated issues. The first issue on climate change reflected that the annual temperature increase by 0.5°C during the period 1901-2003 and to counteract the negative impact of climate change, the farming community resorted to adaptation strategies, mainly adoption of resistant cultivars. Concerning this need, the Central Government initiated the mega project National Initiatives on Climate Research Agriculture (NICRA) with a budget of ₹ 200 crores during the year 2010-11 and the National Mission for Sustainable Agriculture (NMSA) scheme with a budget support of ₹ 1,08,000 crores in order to provide resilient to agriculture with one of the main components on the development of crop cultivars. Emphasizing the need for research in agriculture particularly under the climate change scenario the third issue on the status of Agricultural R&D investment in India was discussed and revealed that the level of Agricultural Research Indicator (ARI) is below the recommended level of 2% being only 0.43% during the year 2012-13. Meeting the need of the farming community coupled with the objectives of the mentioned Government initiatives and the target set to attain 2% of ARI during the twelve plan the study recommended that Agricultural R&D investment needs to be strengthened to maintain the viability of Indian agriculture.

Keywords: Climate change, government initiatives and agricultural r&d investment

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India has already celebrated 68th years of its independence from the British governance, but the country is still dominated by 57.8% of the rural based agricultural households (NSSO, 2014). Constraints by increasing land fragmentation, with the small and marginal holdings (area less than 2 hectares) accounting for 85% of the total operational land holdings and 44% of the operated area in India (GoI, 2013) agriculture

Address for correspondence

Dayohimi Rymbai: College of Post Graduate Studies, Central Agricultural University, Umiam-793103, Meghalaya, India

E-mail: dayorymbai@gmail.com

faces the task of feeding 17.5% of the global population with only 2.4% of the world's land area and 4% water resources at its disposal (NAAS, 2013). Land use pattern is important in case of agricultural production as there is no possibility of increasing farm production through the use of new land. This consequently becomes the major contributing factor to the poverty level in the country. No doubt, Government has put its effort in addressing this problem through various programmes and schemes like i) wage employment programmes, ii) self-employment programmes, iii) food security programmes, iv) social security programmes and v) urban poverty alleviation programmes.

Addressing the developmental issues in India is a complicated aspect of all times and in the era where climate change is not just an environmental but a developmental issue the situation gets more intensified. South Asia contains majority of the world's poor and they are reported to be more vulnerable to the change in climate by virtue of their dependence on agriculture as their main source of occupation (CPRC, 2004). If climate change is at all detrimental to Indian economy reviewing it from the dimension of agriculture is very essential due to the fact that the climatic factors (*viz*., rainfall and temperature) are the direct inputs in agriculture and their pattern have changed over the years (Ravindranath *et al*. 2011; Varadan and Kumar, 2014; Nhemachena and Hassan 2007; Ford *et al*. 2011)

Change in climatic factors and future projections

India Meteorological Department (IMD) has reported that the all India mean annual temperature has increased by 0.5°C between 1901-2003. However during the last three decades the warming trend has been attributed by both maximum and minimum temperature. Das *et al*. (2009) reported that annually the average maximum temperature in North Eastern Region (NER) of the country is rising at the rate of 0.11°C per decade and the annual mean temperature at the rate of 0.04°C per decade.

Indian Network of Climate Change Assessment (INCCA) (2010) projected that the seasons may be warmer by around 2°C towards 2030's in India and precipitation indicate a 3 to 7% overall increase in all-India summer monsoon rainfall in the 2030's with respect to the 1970's. The International Centre for Integrated Mountain Development (ICIMOD) (2010) predicted that by the end of the century both the minimum and maximum temperature will increase by 2°C to 4°C, respectively leading to a mean surface temperature rise of 3.5°C to 5°C in Eastern Himalaya. Similarly, Kumar *et al.* (2011) projected that in Southern part of the NER maximum temperature will increase by 1.5°C and rainfall to reduce by about 10% from the normal.

Reported and projected impact of climate change on agriculture

Different parts of India are affected differently as a result of climate change, whereby, the large areas of Rajasthan, Andhra Pradesh, Gujarat, Orissa and Uttar Pradesh are frequently hit by drought, while approximately 40 million hectares of land in the North and North-Eastern belt is flood-prone (Ranuzzi and Srivastava 2012). The timely arrival of monsoon which forms the lifeline of Indian agriculture and holds crucial importance to food production in the country has been changed over the years, this form a threat to agriculture, consequently to the food security, and the overall economy of the country. On this line, Ranuzzi and Srivastava (2012) reported that the crop cycles have been altered and the cultivation in rain fed areas which account for nearly 60% of Indian agricultural system is detrimentally affected due to delayed onset of monsoon. The availability of food, access to food, utilization of food and stability of food supplies over time are the areas which get affected as a result of climate change besides the direct affect of food production (Vermeulen 2014).

In Tamil Nadu, as reported by Varadan and Kumar (2014) about 60% of the farmers crop yield got declined over the years, 23% noticed new pest in cotton and paddy and 13% experienced more pest and diseases attack. This lead to the change in the cropping pattern of 15% of the farmers as long duration crop varieties are getting replaced by short duration. The study suggested that Government policies need to support research and development of technology like drought tolerant varieties. Latha *et al*. (2012), in their study on rain fed agriculture in Dharwad found that 92% of the respondents reported of the reduced rainfall in the

area and 42% perceived of the change in temperature and seasonal pattern. As a response to this, 87% of the farmers expressed that their net income got reduced over the years, 76% reported yield reduction and 64% reported that soils are no longer suitable for cultivation. To encounter the effect, 50% of the farmers change their profession which is a threat to Indian economy, 42% had changed their cropping pattern and 25% started cultivating the tolerant varieties. Besides being the threat to food security, climate change was also reported to increase the burden on women and children because of the pre-existing gender division of labour, differences in the distribution of resources and inequalities in women's and men's access to the most critical productive resources in rural economy, agricultural land and associated production technology (Singh, 2011).

The simulation studies conducted under the Indian Council of Agricultural Research (ICAR) network project reported that with every 1°C rise in temperature the wheat production of the country could plunge by 6 million tonnes annually. But the loss could be moderated to some extent by utilizing adaptation strategies such as changing the planting dates and using different varieties. It is also projected that in Tamil Nadu, cereal production is likely to get reduced whereby; reduction on rice was expected to be higher, and estimated to be 6.7% in 2020 and 28.2% during 2080 and for the same year, the reductions in maize yield were estimated to be 3.0% and 18.3%, while in case of sorghum projection was 4.5 and 18.7%, respectively if no new management interventions are made (Aggarwal, 2009). By 2030, the yield of irrigated rice may get reduced by 10% in majority of the coastal districts, West coast rain fed rice by 20%, coastal districts irrigated maize yield loss was projected to be between 15 to 50% and rain fed maize up to 35%. Potato yield was projected to get reduced by about 4% in Central India and 4% in Southern India (Kumar *et al*. 2011). Wassmann and Dobermann (2007) projected the decrease in yields in case of non-irrigated wheat and in rice, and a loss in farm-level net revenue between 9% and 25% for a temperature increase of 2°C to 3.5°C. In Rajasthan, a 2°C rise in temperature was estimated to reduce production of pearl millet by 10 to 15% (Mahato, 2014).

Reviewing the past and the future projected impact of climate change made it clear that the food security of the nation is at stake if no initiatives are taken at the earliest possible. But the interesting fact is that the farm households have always resorted to some kind of adaptation strategies at their own cost which at the intense effect of climate change the options become more embedded and known as autonomous adaptation. The adaptation at the individual or household level arises mainly from a reactive response to existing stimuli which is basically short term and it is reported that the more intense is climate change the more difficult is to adapt (Ford *et al.* 2011; Smith *et al*. 2009), but in the absence of planned adaptation the consequences of long term climate change could be severe on the livelihood security of the poor (Jasna *et al*. 2014). Therefore, planning by the Government in this aspect is expected to play a crucial role and known as planned adaptation.

Government initiatives

The two major initiatives of the CentralGovernment to provide resilient to the Indian agriculture in this century has been the setting up of National Mission on Sustainable Agriculture (NMSA) in 2008 and the National Initiative on Climate Resilient Agriculture (NICRA) project by the ICAR in 2011.

National Mission for Sustainable Agriculture

The National Mission for Sustainable Agriculture (NMSA), one of the eight missions under the National Action Plan on Climate Change (NAPCC) was set up with the purpose to address issues regarding sustainable agriculture in the context of risks associated with climate change by devising appropriate adaptation and mitigation strategies measures in the domain of crops and animal husbandry for ensuring food security, equitable access to food resources, enhancing livelihood opportunities and contributing to economic stability at the national level. Prime importance was put on laying down the promotion of dry land agriculture by way of developing suitable drought and pest resistant crop varieties and ensuring adequacy of institutional support, it also expanded its coverage to rain fed areas for integrating farming systems with management of livestock and fisheries, so that agricultural production

continues to grow in a sustainable manner. The four functional areas of the mission are research and development, technologies, products and practices, infrastructure and capacity building. Within the area of research and development the mission seeks to address interventions, which basically stressed on the development of tolerant crops, livestock and fish varieties. The mission also seeks to harness the traditional knowledge and agricultural heritage for in-situ conservation of genetic resources.

The implementation of NMSA up to the end of XII Five Year Plan would require additional budgetary support of ₹ 1080 billion of which only ₹ 65 billion (6%) was proposed for research and development (GoI, 2010).

National Initiative on Climate Resilient Agriculture (NICRA)

Realizing the impact of climate change, the Government of India has prioritized the climate change research and a major network project NICRA has been initiated in February 2011 under the umbrella of ICAR with the objectives to take up long term strategic research on adaptation covering crops, livestock, fisheries and natural resource management to address the impacts of projected climate change on the Indian agriculture, to demonstrate the existing best practices to enable farmers cope with current climate variability and to enhance the capacity building of scientists and other stakeholders in climate resilient agricultural research and its application. The project constituted of 21 participating institutions for carrying the strategic research and 11 institutions as the sponsored research components.

To attain the set objectives, the main activity of focus under the project is the development of crops and varieties adapted to climatic stresses. Major food and horticultural crops are being evaluated for tolerance to abiotic stresses (drought, heat, flooding, and salinity). Work on genetic enhancement was initiated in a multi-institutional and multi-disciplinary network mode during the year and crop like wheat, rice, maize, pigeon pea, mango and tomato are being focused initially by the partner institutes (Venkateswarlu *et al*. 2013).

The outlay expenditure for the project was ₹ 200 crores during the initial year 2010-11 and ₹ 1.05 billion during 2011-12. The expenditure went down to ₹ 1.1 billion during the year 2012-13 and ₹ 0.8 billion during the year 2013-14.

Through reviewing of the objectives of NICRA and NMSA it reveals that the research to develop varieties within these initiatives is in line with the reported need of the farm households to provide resilient to agriculture. This stresses the need to upgrade the strength of the agricultural research in India.

So, the third issue presents the status and the challenges of agricultural research and development (R&D) in India.

Investment on agricultural R&D in India

The agricultural research as defined by the Agricultural Science and Technology Indicators (ASTI) includes research on crops, livestock, forestry, fisheries, natural resources, and the socioeconomic aspects of primary agricultural production. It also included food-processing research. India has one of the largest and well coordinated agricultural R&D systems in the world which has been operated for more than a century and it is largely in the public sector domain and will continue to dominate India's agricultural R&D system (Pal *et al*. 2012).

The growing demand for agricultural products and the need to ensure food security are major factors introducing R&D growth and innovation in India (Kumar and Singh, 2014). The focus of agricultural research in India is widening and becoming more complex with the need to encompass issues such as sustainable natural resources, improving food quality and safety, increasing household food and nutritional security, and reducing poverty (Beintema *et al*. 2008; Pal *et al.* 2012). Therefore, the rising trend in Government funding for agricultural R&D, more resources will be needed to meet the needs of the growing population.

Amongst the various types of government spending foragriculture, agricultural R&D appears to be the most critical for augmenting farm yields and breeding for stress tolerant has been an important thrust area in agricultural research. Also research for developing tolerant varieties contributes to achieving adaptation

and mitigation targets. It is practical and development-oriented, aiming to support farmers, extension services, agricultural traders, politicians and Governments in creating innovations for the growth of agricultural sector (Fan *et al*. 2007; Birthal *et al*. 2014).

Dolan *et al*. (2001) noted that the investment into agricultural research and development represents a climate adaptation option by public agents where Government can encourage the development of new varieties of plants that are heat-tolerant and drought-tolerant, which primarily involves the investment in both public and private research and development.

Ford *et al*. (2011) reported that the most dominant stimulus that motivated to adapt was mainly due to the changes in precipitation. Hence, irrigation is another important factor that influences the adaptation decision of the farmer to a greater extent because access to water for irrigation increases the resilience of farmers to climate variability. Sahu and Mishra (2013) conducted a study in Orissa and suggested that irrigation investment needs should be reconsidered and water harvesting schemes need to be planned.

The research investment in Indian agriculture is channeled through Indian Council of Agricultural Research (ICAR), the apex organization, which has been credited for ushering the Green Revolution in India and which allocates resources for agricultural research, education and frontline extension through a vast network of research institutes and State Agricultural Universities (SAUs) (Joshi *et al*. 2005).

Table 1: Percentage share of total agriculture investment to that of total GDP

	Triennium averages				
TE ending year	**Public Investment (₹ billion)**	**Private investment (₹ billion)**	**Total Agri. investment (₹ billion)**	**Total GDP (₹ billion)**	**% share with total GDP**
1980-1983	117.96	116.72	201.35	1164.00	17.30
1983-1986	296.31	313.17	605.77	4470.11	13.55
1986-1989	259.83	327.52	587.35	6729.64	8.73
1989-1992	223.08	444.28	667.36	10345.04	6.45
1992-1995	196.36	490.33	686.69	16033.22	4.28
1995-1998	218.43	435.86	654.29	25190.07	2.60
1998-2002	192.16	653.26	845.43	37450.86	2.26
2002-2005	225.63	1064.37	1290.00	54372.86	2.37
2005-2008	426.47	1543.70	1970.19	77594.39	2.54
2008-2011	543.29	2322.04	2865.33	120199.88	2.38

Source: CSO, various estimates

Status of Agriculture investment in India

Agriculture investment in India is being undertaken by both the public and private sectors. During the early pre-reform period, 1980-83 public sector investment was higher to that of private sector investment, thereafter private investment picked up a momentum and the difference is more than 70% during the later phase of post-reform period i.e. 2002- 05 to 2008-11 (Table 1). The share of the total agricultural investment to that of the total GDP of the country shown double digits during the period 1980-86 and drastic decline was observed at the end of the 19th century. This presence a poor picture of the state of agriculture in India as public investment in agriculture play a vital role in promoting growth of agricultural output because it includes expenditures directed to agricultural infrastructure, research and development and education and training *etc.* On the other hand, the minimal share of agriculture investment to that of country's GDP poses a challenge to the Indian economy as investment is the road way for economic growth particularly for a mega sector like agriculture.

Status of irrigation investment in India

The investment on irrigation sector in India has increased in consecutive five year plans (Table 2). It was ₹ 4.41 billion during the first five year plan and has increased to ₹ 2200.60 billion during the eleven five year plan an increase of 99.79%. Even though, the financial allocation under this sector has increased, the percent share of the total plan expenditure has decline over every five year plans. It was found to be 22.54% during the first five year plan and decreased to merely 5.81% during the eleven five year plan (CWC, 2013). While analyzing the state wise expenditure on major and medium irrigation during Ten Plan, it is found that the maximum expenditure was made in Andhra Pradesh; followed by Gujarat, Maharashtra, Karnataka, Madhya Pradesh, Uttar Pradesh, Orissa, Bihar and Haryana as these states received more than 90% of the total investment made in this sector in India. As the impact of climate change particularly with the drifted monsoon many regions which enjoyed a bountiful monsoon shower has been declared as the rainfall deficit region. This calls upon the focus to initiate appropriate irrigation projects in these states.

Table 2: Plan wise investment on irrigation in India

Five Year plan	Investment (₹ billion)	% out of the total plan expenditure
I	4.41	22.54
II	5.41	11.59
III	10.17	11.89
IV	24.09	15.31
V	40.90	14.22
VI	115.28	10.55
VII	187.47	8.56
VIII	340.79	7.59
IX	628.09	6.70
X	1033.63	6.19
XI	2200.60	5.81

Source: CWC, 2013

Investment in crop research in India

Public investment on agricultural crop research in India has increased from ₹ 6.8 billion during 2002-03 to ₹ 21.1 billion during 2012-13 which is an increase of more than 67% and it further increased to ₹ 22.2 billion during 2014-15 (Fig. 1) (indiabudget.nic.in**)**. The impact of climate change is increasingly felt with the passage of time[1]; in India particularly the farming sector are more vulnerable to the change. Three national institutes were set up during the twelve year plans in India for addressing different loops facing the Indian agriculture which in a way might be a solution for climate change impact. With the objective to boost up agricultural productivity, the Indian Institute of Agricultural Biotechnology, Ranchi under the recommendation of Veerappa Moily Commitee (http://ilri.ernet.in/~iiab/genesis.html) and the Indian Agriculture Research Institute in Eastern India, Jharkhand were set up by the Indian Council of Agricultural Research (ICAR). National Institute of Biotic stress Management, Raipur was set up by the Department of Agriculture Research and Education, Ministry of Agriculture with the objective to develop cultivars tolerant to stress by taking up research and education in this perspective (http://www.nibsm.org.in/).

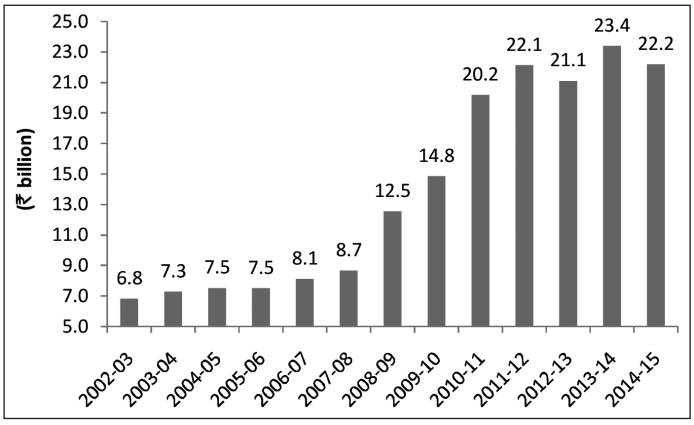

Fig. 1: Direct and indirect crop research in India*

Sources: Ministry of Agriculture, Department of Agricultural Research and Education

(**Exclusion:* Investment on agriculture Extension and Education, Economic Statistics and Management, Agricultural Engineering, ICAR Headquarter Administration, University, Animal Husbandry and Fisheries)

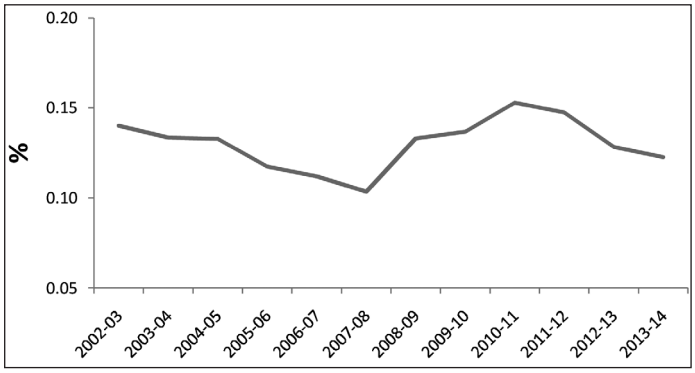

Fig. 2: Crop research investment per capita of Ag. GDP

Sources: Ministry of Agriculture, Department of Agricultural Research and Education CSO Advance Estimate

In India, the per capita crop research investment[2] to that of agricultural GDP is less than one% (Fig. 2). As the success of crop research investment through varietal development is important for sustainable productivity improvement; and this will be more important in the future than it has in the recent past, the challenge to broadened new research will directly require to boost up the investment cost. The budget of the Government for crop research investment hence needs to be projected up.

Conclusions

Adaptation to climate change is no longer the issue that can be handled by farming household alone although the first step is basically undertaken at the micro-level providing short term resilience to the impact, but the role of the Government is becoming more and more important as it is concerned to sustainability and food security of the country. The Government has initiated network project like NICRA and mission NMSA to combat climate change. Investment on irrigation projects has seen a quantum jump in the country as planned adaptation. Further, new research and educational institutes have been established during twelve year plan. On the other hand, though the investment on crop research has increased over the years but the per capita share in agricultural GDP is less than one % and also the percentage share of investment on irrigation to that of the total plan expenditure declined over the years. Hence it becomes imperative for the Government to upscale its investment particularly on crop research and irrigation infrastructure as it will provide long term resilience to Indian agriculture.

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Endnotes

1. Michael Segalov, conducted a study in 40 countries and reported that 46% of the world's population expressed climate change is the top threat faced by the humanity (ToI, 25th July, 2015)
2. Exclusion: Investment on agriculture Extension and Education, Economic Statistics and Management, Agricultural Engineering, ICAR Headquarter Administration, University, Animal Husbandry and Fisheries