Agriculture Adaptation Practices in South Asia

Case of India

Tirthankar Mandal

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South Asia Watch on Trade, Economics and Environment (SAWTEE)

26 Mamata Galli ♦ P.O. Box: 19366 ♦ Tukucha Marg

Baluwatar ♦ Kathmandu ♦ Nepal

Tel: 977-1-4444438 / 4424360

Fax: 977-1-4444570

Email: sawtee@sawtee.org

Web: www.sawtee.org

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Chapter 1: Overview of Agriculture Sector in India and threats due to climate change

According to the Intergovernmental Panel on Climate Change (IPCC), climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2001). Therefore, climate change is partly due to the natural variability and partly due to the human activity. An immediate increases in the temperature after 1970's can be attributed to human activities causing an increase in greenhouse gases (GHGs) into the atmosphere that are responsible for most of the warming of at least last 50 years (IPCC 2001). A majority of nations, particularly developing nations, have been affected by the impacts of climate change hence having a devastating effect on the economies of these countries. Evidences suggest that climate change is affecting a large number of people across South Asia in different ways. This includes increased variability in both monsoon and winter rainfall pattern; increase in average temperature, with warmer winters; increased salinity in coastal areas as a result of rising sea level and reduced discharge from major rivers; weakening ecosystems; the recession of glaciers in the Himalayas; and increased frequency and/or severity of extreme weather events (floods, cyclones, droughts). The region is particularly vulnerable to climate change owing to high population density and concentrated poverty, and existing climate variability. Hence climate change has the potential to compound the prevailing development problems and increase pressure on key resources needed to sustain growth in South Asia (Sterrett 2011; Abbas 2009).

Agriculture Food Security and Climate Change:

Like many countries of the region, agriculture is still the mainstay of livelihoods for India. Although the GDP contribution from the sector is continuously dropping, it still employs two-third of the national workforce. Most of these farmers are small land holders; a substantial number of them are even landless and depend on agriculture for subsistence.

In India, more than three-fifth of the area is rain-fed and hence the contribution of agriculture to the economy depends highly on rainfall. In the event of rain failure, the worst affected are the landless and the poor whose sole source of income is from agriculture and allied activities like forestry, lodging and fishing. Serving as a major livelihood resource in the country, agriculture plays a critical role in defining poverty levels across different states (TERI 2007). GDP contributions in other South Asian countries are also found to be similar to that in India barring Nepal where the dependence in agriculture is far higher. The sector is also the largest consumer of water in the region making it further sensitive to the consequences of changing climate. In India alone, more than 85 percent of the ground water is used for irrigation purposes.

The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2001) pointed out that climate change and its variability will exacerbate existing vulnerabilities to droughts and floods in Asia. The livelihoods and economic activities in South Asia are closely tied to the natural resource base, and are hence, highly sensitive to changes in the climate. In view of the findings of IPCC (2001), agriculture and aquaculture will be threatened by a combination of thermal and water stresses, sea level rise, increased flooding, and strong winds associated with intense tropical cyclones. Freshwater availability and biodiversity, which are already under pressure due to population growth and land use change, will be further impacted by climate change. Finally, warmer and wetter conditions will increase the potential for a higher incidence of heat-related and infectious diseases in South Asia (Kelkar and Bhadwal 2007).

It has been projected that due to the rise in temperature, India's wheat yields can go down by 2 percent in a pessimistic scenario (GoI 2004). Kavi Kumar and Parikh (2001) show that with a 2 degree rise in temperature, and mean precipitation increase of 7 percent, the net revenue from agriculture sector will reduce by 8.4 percent. Lal (2007) also shows that temperature rise is expected to lessen yield of important crops such as wheat and rice in parts of South Asia where they are cultivated close to their upper temperature threshold. Cereals production is expected to decline at least by 4-10 percent by the end of 21st century. Non-irrigated wheat and rice will be especially hard hit since a temperature increase of 2.2^{o} C may incur loss in net farm revenue between 9-25 percent. The major food grain producing regions of Haryana, Punjab and western Uttar Pradesh experience the most negative effects, along with the coastal districts of Tamil Nadu. Punjab and Haryana are significant from the perspective of food security in India, but they also face severe depletion of groundwater resources due to intensive cultivation techniques.

Impacts of Climate Change on Agriculture

Global climatic changes can affect agriculture through their direct and indirect effects on crops, soils, livestock and pest. The increase in temperature, depending upon the current ambient temperature, can reduce crop duration, increase crop respiration rates, alter photosynthate partitioning to economic products, affect the survival and distribution of pest populations, hasten nutrient mineralization in soils, decrease fertilizer use efficiencies and increase evapotranspiration rate.

Rise in mean temperature above threshold level will cause a reduction in yields. The yield of rice is expected to decline by 10 percent for each 1 degree rise in growing season minimum temperature above 32^{o} C (Pathak et al. 2012). The climate change impact on productivity of rice in Punjab has shown that with all other climatic variables remaining constant, temperature rise of 1 degree, 2 degree and 3 degree would reduce grain yield of rice by 5.4 percent, 7.4 percent, and 25.1 percent respectively (Aggarwal et al. 2009). A rise in temperature would result in increased water shortages and demand for irrigation water would rise in the country. Increase air temperature will lead to more evapotranspiration in areas of the country that are known for rice production (Aggarwal et al. 2009) and the projected water shortage would result in decline of rice yields by 20 percent in the country.

Indian agriculture is dependent on the onset, retreat and magnitude of monsoon precipitation. Despite increase in the net area of irrigation, droughts caused by inadequate and uneven distribution of rainfall continue to be the most important climatic aberrations, which greatly influence the agriculture productions of the country. Due to projected future rise in global temperature, the occurrence of more droughts would drastically affect the total agricultural productivity of the region. Temperature rise in the country will affect the rates of decomposition of organic matters and release of nutrients. At higher temperature, in the short run, the fertility will increase due to increased rates of decomposition, but in the long run, matter content will decrease, resulting in a decline of soil fertility.

At higher temperatures, insects and pests will also become more abundant. Due to a rise in temperature there will be an increase in migration of pests resulting in their increased population. Rise in temperature will also result in insect development and winter survival. The prediction of disease outbreaks for plants will become more difficult due to rapidly changing climate and unstable weather. Environmental instability would result in reduced effectiveness of pesticides on targeted pests and would cause more injury to beneficial organisms.

Strategies to address the Climate Change impacts: Role of technology and best practices:

Dealing with the impacts of climate change in the agriculture sector would mean: developing cultivars tolerant to heat and salinity stress and resistant to flood and drought, modifying crop management practices, improving water management, adopting new farm techniques such as resource conserving technologies, crop diversification, improving pest management, better weather forecasting, and harnessing indigenous technical knowledge of farmers.

India with its infrastructure of research institutes has been involved in developing new crop varieties with higher yield potential and resistance to multiple stresses. Germplasm research and their improvement is an important aspect of such programmes involved in the development of multiple stress resistant crops. In addition, improvements in water use and nitrogen efficiencies are also part of the research. Under the future climate change scenarios these research programmes become more crucial for addressing the adverse effects of climate change.

Diversification of crop and livestock varieties, including replacement of plant types, cultivars, hybrids and animal breeds with new varieties intended for higher drought or heat tolerance is being advocated as having potential to increase productivity in the face of temperature and moisture stresses. Diversification from rice-wheat towards high value commodities will increase income and result in reduced water and fertilizer use. A significant limitation of diversification is that it is costly in terms of income opportunities that farmers forego. So switching crop diversification can be costly and may be typically less profitable, especially in the short run.

Table 1.1: Examples of Various Measures for addressing climate change

Changes	**Sectors**	**Intervention Examples**
Increase in temperature	Agriculture	a) Introduction of short cropping varieties b) Diversification of crops c) Introduction of heat / moisture tolerant seed varieties d) Increase soil organic content / low tillage agriculture e) Water conservation crop management practices f) Tree planting to provide shade and fodder for livestock
	Water resources	a) Introduction of water storage methods b) Water conservation c) Monitoring and early warning systems for glacial lake outburst floods (GLOFs) d) Conservations of coastal mangroves and other vegetation.
Changes in rainfall patterns and / or seasonality	Agriculture	a) Appropriate, accessible, and reliable seasonal and weather forecasts b) Crop diversifications and crop mixing c) Livelihood diversification d) Crop insurance

		e) Floating gardens during times of inundation
	Water	a) Rainwater harvesting at household level b) Checks on dams, plantations c) Improved drainage d) Protected/raised food, water, and sanitation e) Community water management committees
Sea level rise	Coastal livelihoods/ resources	a) Introduction of salt tolerant crops / species b) Livelihood diversification c) Monitoring and early warning systems for cyclones and storm surges d) Sea defences e) Protected / raised food, water, and sanitation f) Mangrove rehabilitation
Source: Sterrett 2011		

In India, programmes carried out to promote resource conserving technologies (RCTs) are one of the important aspects of the country's preparedness towards climate impacts. Primarily in the country's system of rice intensification (SRI) techniques, and other input efficient methods of cultivation have immediate demonstrable benefits, through reduction of production costs and savings in terms of water, fuel and labour use. Zero tillage technology can allow farmer to sow wheat earlier after rice harvest. As the temperature of the region rises, early sowing will become more important for wheat. It has been observed that RCTs are being used by the farmers of the Indo-Gangetic Plain (IGP) basin more frequently.

Farmers of the country often offer a wealth of knowledge on range of measures that can help in developing technologies to overcome climate vulnerabilities. The current need is to harness and fine tune this resource to suit the modern needs. Traditional ecological knowledge that people have developed and practiced over time can provide insights and viable options for adaptive measures.

Anthropological and sociological studies have stressed upon the need for using these knowledge to enhance the climate preparedness of farmers as they are community based and have low transaction cost for transfer. In India, tribal and hill knowledge systems are rich in potential indigenous management, crop production, and plant protection techniques. Studies have shown that their understanding have been fairly developed in respect to earthquakes, droughts, and landslides (for hilly areas), and rainfall. Therefore, there is a need to take into account these knowledge systems while developing technocratic solutions towards climate change.

Short term weather forecasting has been one of the various ways used to minimize the effect of climate change in the agriculture sector. Early warning systems and hourly and daily weather forecast are important mechanisms that aid in minimizing the impacts of climate change in the region. The application of information and communication technology (ICT) in disseminating the information to the farmers in rural areas and villages are an important way to make farmers resilient to climate change. There have been number of studies and practices undertaken in the country to develop various models of ICT based weather dissemination programmes. The use of recent models of forecasting along with integrated modes of dissemination through local vernacular has been proven to be beneficial for the farmers. Further, there are some schemes[1] where the farmers can get the benefit of scientific solutions to particular problems they face during cultivations directly from the scientists on the roster. Although these projects are undertaken on a pilot basis, they have the potential to upscale and provide solutions to make farmers resilient towards adverse effects of climate change.

The country depends heavily on agriculture for food and livelihood security. Even in the current stage, maximum number of the rural population is dependent on agriculture for their livelihoods. To protect these farmers the country should invest more on the agricultural research programmes and work towards building effective dissemination sharing networks. This should involve both government and non-government actors. Given that the country is going to be severely affected by the impacts of climate change, these measures are important to address the adversities effectively. Also, being a leader in the region in agricultural research infrastructure[2], the country should disseminate these results to the neighbouring countries on a priority basis. The government should be capable of developing effective collaborative arrangements in this regard. In the current study we examine these aspects and provide some suggestions for developing effective partnerships within the

[1] CGIAR-CCAFS extension service, Extension Education Institutes GoI, National Institute of Agricultural Extension Management (MANAGE), State Extension Programmes for Extension Reforms (SSEPER) scheme etc.

[2] India has developed a good research and development infrastructure in agriculture. It has agro-climatic based research centres within the country. It also has developed partnerships with international organisations like ICRISAT and CGIAR to name a few. Further, India has established a agriculture modelling centre that will research on the impacts of climate change, hydro-metrological research.

countries based on the experiences and knowledge sharing mechanism for developing a climate resilient agriculture system in the South Asian region.

Chapter 2: Case Studies on Successful Adaptation in Agriculture

The case studies undertaken in the present study represent the fact that there have been many advances in addressing climate change impacts using a variety of efforts. These initiatives show the step forward in making the community and people resilient towards the effects of climate change in the country. Moreover, since these case studies are drawn from different aspects of adaptation preparedness, it also depicts the possible range where interventions can be made. Although these case studies are based on local efforts, there are some potential for their replication across the ecosystem. However, the current initiatives are all outside the government initiatives and some have been indirectly used in other countries in different ways.

Case Study 1: Integrated Agro Advisory Approach by CGIAR CCAFS

- #### Brief Description

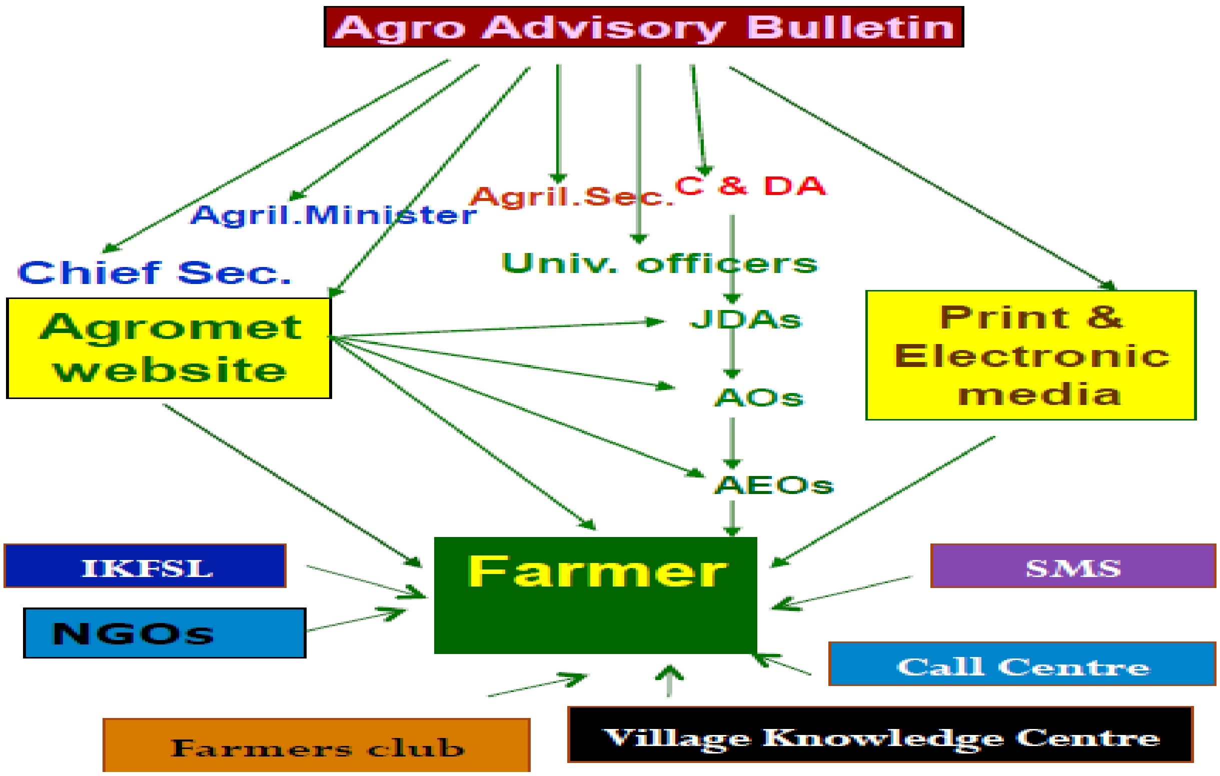
Agro advisory services provided under CGIAR's Climate Change, Agriculture and Food Security (CCAFS) project has been spread across the different agro ecological zones of India. They have been providing various information related to weather, crops, monsoon forecasts, extreme events forecast, and also providing solutions to farmers' queries through the use of mobile phone. In this regard, a number of private and public undertaking companies have joined hands with Indian Meteorological Department (IMD) and CGIAR to successfully run the project. Our case study tries to explain how this has been useful in Andhra Pradesh, which has been experiencing adversities of climate change for some time now.

- #### Districts covered under the project

Ranga Reddy, Medak, Mahbubnagar, Nalgonda, Karimnagar, Warangal, Kahammam, Wadilabad, Nizamabad, Vizag, Vizianagram, Srikakulam, Guntur, Krishna, Prakasham, East and West Godawari, Chittor, Nellore, Kadapa, Anantpur, Kurnool.

- #### The Working Structure of AAS

The service has been provided through SMS and other print and electronic media to the farmers on every Tuesday and Friday of the week. This information includes weather based agro-advisory, including water flows in the reservoir, forewarning of pest and disease based on crop simulation models.



Source: http://scalingup.iri.columbia.edu/uploads/1/5/8/6/15865360/gandla_andhra_pradesh_india.pdf.

- ### How it works?

It is an integrated process in which several types of information are passed on to the farmers in a user friendly manner. The e-Agromet project use the IMD based weather forecasts, and the scientists prepare agromet bulletin and services. These bulletins and messages are then passed on to the registered farmers on their SMS and through several other means like public address systems in the *gram panchayats*, display boards in the village common areas by the *gram panchayats* and local NGOs, and local cable TV bulletins (which are mandatory). As part of the integrated system, there are farmer-scientists interactions where the queries and problems of farmers are heard and resolved to the extent possible.

- ### Examples of Dissemination Methods Used under the AAS

This project has been successful in ensuring farmers to take appropriate measures before any abnormal weather situations come and also receive 72 hours and 48 hours periodic messages in specific time period of the year making them aware of the situation regarding heavy rainfall, cyclones etc.

Source: http://scalingup.iri.columbia.edu/uploads/1/5/8/6/15865360/gandla_andhra_pradesh_india.pdf.

- **Replicability to other regions of South Asia**

While the project has started under CGIAR in 2010, there are signs that some of the elements of the project are being replicated in a modified way in Bangladesh on the Community Service Radio systems in Amtali of Barashuna Taluk[3] undertaken through support from FAO, Bangladesh Agriculture Research Institute (BARI), and the NGO network of Bangladesh. The information about weather and other crop related issues are passed on to the listeners through the FM channel of 98.8 and the name of the service is Krishi Radio. While it is true that we do not find any examples of formal replication related linkages between the two, but they are based on the same principle of using ICT for farmers and providing solutions directly to the farmers.

Case Study 2: Integrated Farming for Climate Adaptation[4]

- **Brief Description**

Floods in Eastern Uttar Pradesh are a common phenomenon. Approximately 29 percent of this region of the Indo-Gangetic plain is considered to be flood prone. These floods take a huge toll on

[3] http://www.rcs.org.bd/index.php#.

[4] Contribution from Gorakhpur Environmental Action Group, UP, India.

agriculture which is the primary source of livelihood for the people living here. More than 80 percent of the farming community living in this region comprise of small and marginal farmers who have limited resources and are involved in subsistence farming. Hence, floods cause large-scale destruction of property and rural infrastructure leading to the disruption of lives of the local community. Torrential rains also cause severe water logging in the low lying areas.

Climate in this region is perceptibly changing, with natural hazards occurring with increased frequency and intensity. Farmers in the region have been able to perceive the changes as their lives revolve around it. On the one hand, the frequency of floods have increased in the last few decades and on the other, it is now normal for the temperatures to cross 45 degrees and remain so for extended periods during summer months. The unpredictable monsoons leave people unprepared for disasters leading to damage, destruction and disruption of lives. The rains have also become erratic with changes in volume, pattern and timing. The dry spells during monsoon season are also increasing as are hot winds during the winter months. Water logging periods have also increased.

Consequently, the crops are lost, increasing the vulnerability of those farmers whose farming practices are less diverse, mainly due to mono-cropping. This case study explains the situation of a small scaled woman farmer in the area where Gorakhpur Environmental Action Group (GEAG) has facilitated adoption of integrated and diversified farming as an adaptive measure.

- **Areas Covered**

Eastern Uttar Pradesh districts under the GEAG programme.

- **Diversification of cropping from monoculture**

After adopting such an integrated farming system, the income of small farmers has increased significantly. There was a time when paddy crop could not fetch profits and the yield was not enough to sustain the family year around. The situation has completely changed for farmers like Ramrati after learning new farming techniques from GEAG. It has better equipped her to deal with the climatic changes in an effective way, resulting in bigger returns from her farm products. She says, *"Paddy did not fetch me enough money. Now annually, I am able to make good money - approximately Rs.6000/- from selling maize, vegetable fetch me close to Rs.25,000/-, Rs.500 from selling eggs, Rs.3000/- from selling fishes. This way, I am able to make close to Rs. 40,000-*

50,000/- yearly from all my produce which was never the case before. Thanks to the trainings that I received in GEAG".

In GEAG, farmers learnt about integrated farming systems and crop diversity, mixed cropping systems, preparation of home-made organic manure, etc. Farmers have started growing more than 28 varieties of food and vegetable crops on their fields. Such crop diversification is an excellent mechanism to deal with the effects of climate change. Organically grown fresh vegetables are a good source of nutrition for the family, especially, women and children. In integrated farming system as this, even if one or two crops fail, the others will flourish thereby giving food, nutritional and income security to the small and marginal farmers.

Animal husbandry is another component of farm integration. Rearing of cows and buffaloes yield good money upon selling of milk and other by-products. For many farmers, their animals have been their saviour in times of floods.

Along with farming and animal husbandry, another dimension of integration which the farmers have adopted is the inclusion of fisheries and poultry in their farm ecosystem. A small pond is dug on the farm in which the fishes are reared. On the top of the pond, a bamboo platform is made like a *machan* and there is a cage inside which the poultry birds are reared. The droppings from the hens and cocks fall into the pond water which eventually becomes food for the fishes. Fisheries and poultry rearing have also helped the farmers to a great extent in the wake of the changing climate. Not only has it worked as an additional source of income for the family, it has also added to nutritional security of women and children, in particular.

Integrated farming system model has also reduced the dependencies of farmers on the external market. The entire farm ecosystem is managed in such a way that the output from one element becomes the input for another element and the cycle goes on.

- ### Replicability Potential

It has huge potential to be replicated in the whole of IGP Basin as most of the region has similar agro-climate and also most of the farmers are small landholders who will benefit the most.

Case Study 3: Shifting of cropping pattern in response to climate change[5]

- ### Brief Description

Significant climatic change and its impacts include increasing frequency of flash floods; dry spells during floods; flood timings (longer, delayed or early); increased duration and area of water-logging; and changes in time, volume, and pattern of rainfall. There has also been a significant change in the monsoon period. While August-September was the usual period of floods twenty years ago, at present it is unpredictable. In 2007, there were heavy rains in July causing sudden flooding whereas in 2008, rains began at the end of May. Heavy rainfall throughout June and July caused floods for which people were ill prepared, and had very little time to respond. Consequently there was considerable loss of life and property.

In the Himalayas land holdings are quite fragmented with more than 80 percent of farmers having less than one hectare of land. Therefore the main effect of floods and now climate change is on agriculture, and agriculture-based livelihoods.

- ### Areas Covered

The Himalayan foothills of the Nepal are prone to floods for centuries. In the last 60 years, however, their frequency has increased dramatically. People living in the region have slowly developed ways to cope with the floods.

- ### How it Works?

The multi-tier farming on one hand has intensified cropping and ensured higher production on smaller pieces of land and at the same time during floods and waterlogging periods even if the lower tier of crops get damaged the upper tiers are saved. Also the varieties used are flood and dry spell resilient and hence ensures mitigating losses in such situation.

This case study deals with example of one of several farmers who have shifted from a paddy centred mono cropping system to sugarcane based multi-tier farming which is helping the farmers to reduce the losses of floods and climate change uncertainties.

The shift from a paddy-based farming system to sugarcane-based farming system was done by Mr. Ram Niwas and his wife Subhawati Devi in *Rakhukhor* village of Campierganj block in Gorakhpur. This has been a paradigm shift in the nature of farming system for a small and marginal farmer like

[5] Contribution from Gorakhpur Environmental Action Group, UP, India.

him. This was purely done in the wake of changing climate which created uncertainties in rainfall patterns, flash floods and water-logging, sudden long dry-spells, etc.

Ram Niwas owns 6 acres of land, of which 4 acres are utilized for farming and the rest, include his house, kitchen garden, orchard, livestock shelter, etc. Paddy was the main crop that was grown by him ever since he started farming. Due to untimely rainfall and long dry-spells, he incurred big losses and his family was hit by food insecurity several times.

Since the last 3 years, Ram Niwas decided to change the cropping system completely. He resorted to sugarcane based farming on maximum land area of his farm. Sugarcane is a year-long crop in which the input cost is very low and it produces good outputs and benefits. It is also not a water-intensive crop and has the ability to stand dry spells. Apart from sugarcane, this year he also tried an early variety of paddy, *Shushk Samrat,* on a small piece of land which will be used for domestic consumption. *Shushk Samrat* is a new variety that consumes less amount of water and sustains better during dry spells. He also grows vegetables and largely follows mixed-cropping, inter-cropping farming systems which benefit him to a great extent. Ram Niwas's farm is undulated and not a flat piece of land. Hence, because of the land geography, he follows 3-tier cropping system which is also a way to mitigate climate change effects:

Tier-1 (low lying area): Late variety of paddy (*PBT-5204, Samba Masuri*) + groundnut + arhar (The low lying area gets inundated with water in case of rainfall which is good for paddy growth. In absence of rains and dry spells, the groundnut and arhar can survive)

Tier-2 (middle land): Late variety of paddy (*PBT-5204, Samba Masuri*)

Tier-3 (upland): Sugarcane in major part + early variety of Paddy (*Shushk Samrat*) (Both the crops do not require much water and can stand dry spells)

The sugarcane-based farming system definitely provides good yield and fetches better prices in the market. Apart from the above crops, Ram Niwas also grows vegetables which are mainly used for domestic consumption.

Case Study 4: Millet Cultivation through System of Rice Intensification Method[6]

- **Brief Description**

The study is undertaken in the semi-arid regions of Karnataka. The region is devoid of any irrigation facility and dominated by mainly the *adivasis* (tribal communities) and non-*adivasi* farming communities. Majority of the farmers are small and marginal farmers, and the region is classified as one of the most backward *taluks* (administrative units below the district) of the Karnataka. Due to the over emphasis of cash crops like sugarcane, ginger and BT Cotton (Genetically modified cotton), cultivation of food in the region has been severely affected and many farmers have leased out their land to meet the high costs of production of these cash crops. The *adivasis* have been displaced due to the Kabini dam construction and has been given fallow lands in the area as compensation from the government. Since they are not agriculturists, they fully depend on the public distribution system (PDS) from the government to meet their subsistence requirements, but these food products have very low calorie content leading to malnutrition.

Pipal Tree, a CSO based in Bangalore, started the current project in 2008 in the areas. Its objective is to promote the growth of crops that require less amount of water and are not heavily dependent on irrigation. Due to this reason and also because of its several nutritional benefits, millet has been identified as the most suitable crop for cultivation in the area.

- **Areas Covered**

H. D Kote Taluk, Mysore, Karnataka.

- **How it works?**

Millets can be grown in traditionally low fertile soils like the one in H D Kote Taluk. They require less water, and bio-fertilizers like vermicompost and farm manure are only used as supplements. Majority of millets varieties in India are also pest free resulting in minimum expenses on insecticide. Through SRI method the seedlings are grown in a nursery and are then transplanted in a distance of one foot each. These methods require less water as well as fewer amounts of seeds per hectare. It has been found that the SRI technique uses 1/10th the quantity of seeds than the traditional method. It has the same gestational period than the traditional method and ensures good growth and high yield like the traditional method. The varieties of millets are all traditional to the area and therefore this process has been able to revive these traditional varieties of crops that are drought resistant in the region.

Along with the SRI cultivations, to supplement the millet cultivations, vegetable gardens and kitchen gardens are grown in the area to meet the vegetable demands of the households; this is solely used for domestic purpose and thereby enhances food security of the region as well.

Promotion of traditional methods of storing seeds for the next round of cultivation was encouraged among the farmers. This not only ensures the quality of seeds but also aids in preserving the local

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[6] Contribution from Pipal Tree, Bangalore, Karnataka, India.

varieties from extinction. Further, the intervention has helped the *adivasis* in increased food and nutritional security by gradually getting involved in agriculture and reducing their dependency on the PDS system. The practice of seed banks[7] have also reduced the dependency on commercial seeds and reduced the cost of cultivation.

- **Replicability potential**

Currently this is undertaken in 5 other *panchyats* of Karnataka state in India.

Chapter 3: Status of Cooperation in Adaptation in Agriculture

South Asia is dominated by small landholder farmers who account for maximum of the labour force in the agriculture sector. In India, small and marginal farmers contribute to more than 50 percent of crop production and 85 percent of total labour force in agriculture (Sahai 2013). However, the current input intensive nature of agriculture practices is constrained by adverse impacts of climate change and is thus considered an unsustainable. In India and the rest of the world, this current model needs to be urgently replaced by a model that is climate resilient, environmentally and socially benign. The agriculture sector must adapt to the changing climate and produce minimum emission in order to keep the temperature limits within 2° C. Developing such climate resilient model of agriculture would imply developing efficient water use and conservation systems, maintaining genetic crop diversity, and minimizing mechanised agriculture. Consequently, this will convert the current input intensive agriculture systems to an input efficient one. In India there is a wide range of institutions that look into various agro-climatic zone based research. These research networks are also mostly involved in institutional cooperation and networking between different countries. In additional some top level multi-country research institutes that are present within the country to offer further collaborative research efforts.

Current Institutional Collaboration

In the case of institutional research one of the most successful themes has been the sharing of scientific and weather based information across the countries of the region and sometimes within specific regions like the Village Dynamics in South Asia (VDSA) programme of International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) between east India and Bangladesh, seed research programmes between the research institutes of countries, and also in developing various climate impact specific seed varieties of crops that are commonly used in the regions. Apart from

[7] Seed Banks: These are village level storage of seeds which is being collected from the villagers for use in the time of emergency.

these research collaborations there are regular training programmes and scientist exchange programmes which are also prominent ways of collaboration in agriculture. The current trend of these collaborative efforts shows that climate change impacts are being incorporated in these programmes.

India-Bangladesh Institutional Collaborative Efforts

In terms of developing stress tolerant varieties of crops within the region, both India and Bangladesh have been collaborating with each other through the Stress-Tolerant Rice for Africa and South Asia (STRASA)[8] in their Phase 2 Programme since 2011. Over the couple of years, the programme has been disseminating stress tolerant varieties of seeds among small landholder farmers in Bangladesh and India. For their future agenda, the STRASA programme undertook public-private partnership in seed marketing for both Bangladesh and India in 2012. Apart from these hardcore research activities, training programmes for scientists have been organized by the research institutes in India like Indian Agricultural Research Institute (IARI), Indian Council of Agricultural Research (ICAR) for their counterparts from Bangladesh Agricultural Research Institute (BARI), and Bangladesh Agriculture Research Council (BARC). ICRISAT is a prominent organisation in the region to carry out research across the geographical borders of the countries. Among the Indian centre of ICRISAT and BARI of Bangladesh, there is an established collaboration on pulses programme which has been running for three decades since the establishment of the centre in India. It is worthy to note that the current pulses development programme has a special focus on the development of drought tolerant varieties of pulses that are to be used between the two countries on a trial basis. Consultancies were undertaken by the Indian Agricultural scientists from the ICAR in various project based assignments with SAARC Agriculture Centre in Bangladesh, BARI and BARC. Thus we observe that at the institutional level, the collaboration ranges from joint development of stress tolerant varieties of crops, testing of these variants in both the countries, specific assignments based consultancies of research, and training programmes to address the impacts of climate change in the agriculture sector.

India-Nepal Collaborative Efforts

The mode of collaboration between India and Nepal has been mainly in the form of consultancies and training programmes for undertaking institutional research in addressing the impacts of climate change in agriculture. Impacts due to climate change have been recognised as the most prominent challenge to the agriculture sector (NARC 2010). It observed that the agriculture sector is vulnerable to landslides, hailstorms, floods, drought and fire; with the intensities of these events predicted to

8 http://irri.org/index.php?option=com_k2&view=item&id=12146:bangladesh-strong-partnerships-and-collective-efforts-emphasized-in-strasa-meeting&Itemid=100242&lang=en.

increase in the coming years. The cooperation has been strategically designed by the Nepal Agriculture Research Council's (NARC) vision document to effectively address these events through cooperation. Nepal and India has jointly developed some strategic partnerships to addressing some of these challenges. However, it must be observed that the cooperation does not cover most of the impacts that are mentioned in the vision document. Typically the elements of the cooperation are prioritised based on the impacts that have the potential to affect both these countries. The ongoing collaboration between the metrology department of India and Nepal on the Early Warning System (EWS) mechanism is the most important collaborative effort current underway. It is the result of a programme developed at the SAARC level for sharing of metrology data and information to develop robust EWS systems across vulnerable regions of the Himalayas. With the predicted increase of summer rainfall by 15 to 25 percent by 2030 (NARC 2010), the EWS will play an important role in addressing the vulnerability and increasing the resilient capacities. Most of the collaborations are currently through the regional arms of the international organisations like International Maize and Wheat Improvement Centre (CIMMYT), International Rice Research Institute (IRRI), ICRISAT which are located in India. However, there are very few Indo-Nepal partnerships in agriculture research to address the challenges of climate change in the sector. As part of the research on climate resilient agriculture, ICAR and NARC got into collaboration in 2009-10 to promote joint study visits, exchange scientists between India and Nepal for the better development of vegetable production technology and stress resilient seeds. Further, in order to study the Himalayan Glaciers melting and their effect on India and Nepal, International Centre for Integrated Mountain Development (ICIMOD) has been running a programme on generating robust data on the Himalayan glaciers—which the Indian government has supported financially since 2009. Apart from these programmes, CIMMYT office in India is currently collaborating with NARC on developing climate resilient maize variety. Further, there is a current ongoing programme on virology between India and Nepal on citrus fruits varieties. Thus we observe that the nature of collaboration under the institutional form between India and Nepal are mainly (a) developing robust data and sharing of information on Himalayan Glaciers, (b) bridging the data necessary on EWS, (c) developing stress tolerant varieties of crops.

India-Sri Lanka Institutional Cooperation

India and Sri Lanka have formed a partnership in plantation related research to make them resilient to climate change. In the recent years, these partnerships have integrated climate change impacts as one of the issues to be understood in a cooperative research framework, especially for providing training and capacity building on plantation research to Sri Lankan scientists. There are well established exchange programmes that ensure the students and scientists from Sri Lanka take part in specific research programmes in various agricultural research institutes in India.

International Institutes and Cooperation between India and South Asian Countries

The absence of a strong network of government level cooperation between the countries of South Asia and a high demand for such cooperation among the practitioners and scientists have opened up channels for the non-state actors to take up the challenges of cooperation. These cooperations mainly happen through ecosystems based approach or sometimes through agro-ecological zone based approach. Important institutions like UNEP, IRRI, ICRISAT, and CGIAR's special programme—Climate Change, Agriculture and Food Security (CCAFS), through various programmes, contributed to the development of cooperative research and testing of research outputs between South Asian countries. Some of these programmes are highlighted below. It is important to note here that these can be classified into mainly (a) research cooperation and knowledge sharing, (b) testing of results/new seed in specific geographical locations along the agro ecological zones, (c) using latest non-agricultural technologies for developing resilience, (d) training and capacity building. The main reason for developing such cooperative arrangements outside the government collaboration lies in the fact that the SAARC level cooperation is very weak which could have played a major role in such an effort across the region.

Table 3.1: Adaptation Related Cooperation (some important projects currently undertaken)

Name of programme	**Countries involved**	**Areas**	**Cooperating Entities/ Organisations**
Technology transfer	India-Nepal	Waste agro to biomass energy	Indian Technical and Economic Cooperation (IETC)and UNEP[9]
Knowledge and information sharing, conservation of species	India-Bangladesh-Bhutan	Agarwood plantation	Aga Khan Foundation, RED unit of BARC, AusAID, Canada government, Bill and Melinda Gates Foundation, Nike Foundation etc.[10]

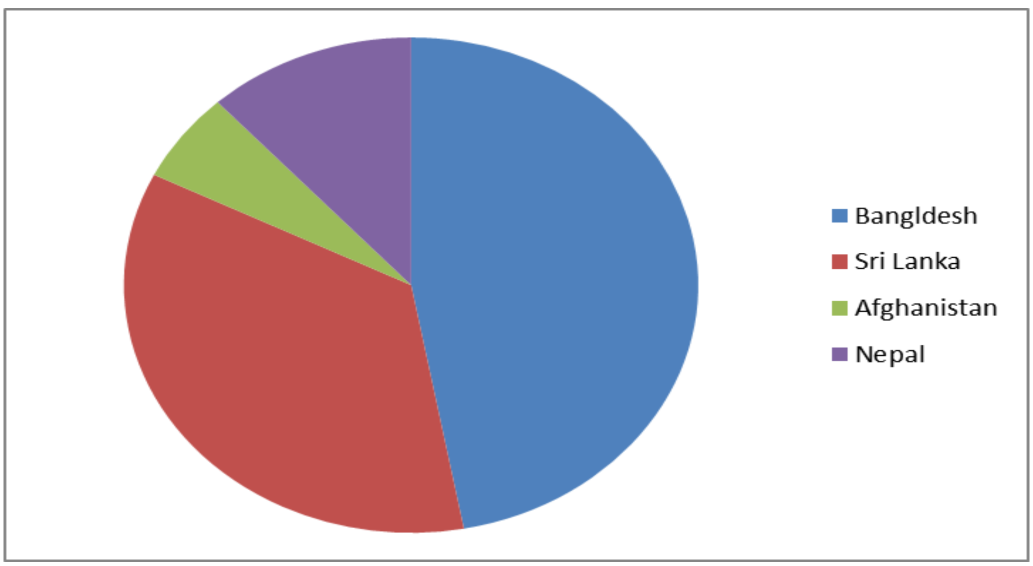
[9] UNEP South-South Cooperation Programme

[10] Akter and Neelim 2008.

Leveraging agriculture for nutrition in South Asia	India-Bangladesh-Pakistan	Nutrition, Agriculture	BARC, Collective for Social Science Research, Institute for Development Studies, International Food Policy Research Institute, M.S. Swaminathan Research Foundation
Rice seed industry	India-Bangladesh	Agriculture marketing, agro based industry	IRRI India, BARC Bangladesh, CORRA
Yield increase in pulses in dry areas	India-Bangladesh-Bhutan-Afghanistan-Nepal-Pakistan	Pulses research network among countries	ICARDA, Syria[11]

Source: Compiled by Author

Figure 3.1: Distribution of institutional collaborative projects, consultancies and training



Source: Compiled by Author from past SAARC Agriculture Reports

[11] BARI 1991.

Identification of Technology Cooperation

While discussing institutional cooperation it is observed that the cooperation is taking place at the levels of different programmes and research outputs are being shared through these programmes. These training programmes consists of substantial amount of such cooperation, but unfortunately there is very little sharing of actual research between India and other countries in South Asia at the institutional level. Consultancies carried out by various scientists show that the collaboration took place at the individual level.

Apart from the institutional programmes, various multilateral and bilateral organisation form coalitions to support and carry out cooperative activities around adaptation in agriculture. One such effort is UNEP's South-South Cooperation initiative focusing mainly on use of technology to convert agriculture waste into energy. There are also initiatives for development of specific drought tolerant crops. Most of these efforts are undertaken through a project based model and on an ecosystem based adaptation approach. In this regard it is to be noted that most of the collaboration are based on sharing of modern technological interventions. They have been mainly at the level of seeds development and dissemination practices. The traditional exchanges of technology and best practices have been relatively non-existent.

Examples of sharing: from India to other country

- ### CCFAS: Agro Advisory model:

This model is an extension service used by the CGIAR pilot programme in the states of Bihar and Haryana. The communities benefitted from various information related to monsoon forecasting and cropping solution services provided through mobile network services. The CGIAR model is applicable in the Indo-Gangetic Basin and therefore it has been upscaled to other parts of the IG basin. While upscaling, specific needs of the local people and communities have been kept in mind and local dialects have been used. While this is not a strict agriculture technology, it is a service which has benefitted the communities across the region. The innovation started in India and later was applied to other parts of the region covered by the project[12].

[12] Horil Singh, a farmer from Rajapakar village in Bihar says: "I almost quit farming in 2008. In the past two years, with proper support and information that we received, we have started afresh. Information that we receive on various topics is very useful. We are applying that information and knowledge to our farm." Today if a farmer needs any information, then they don't have to go out in search of agriculture experts. Most of the information is available on mobile phone right in their village. http://ccafs.cgiar.org/blog/help-through-participatory-videos-documenting-farmers-experiences-real-time

- ### System of Rice Intensification (SRI)

This technique falls under the best practice category of adaptation in agriculture. The idea of this practice involves efficient use of water, organic manures, and maintaining optimum distance between the plants for root intensification of rice crops which then ensure that the production is high. Due to systematic plantation of rice crops, the input cost becomes lower. This technique is being practiced all across the IGP basin through the CGIAR project. There are instances where this method is applied in Bangladesh with certain modifications of what has been followed in India. In India, the model that is followed has the following critical reasons identified for success. First, the space between the rice crops were maintained in such a way that allowed the highest growth of roots hence maximising the growth of grain carrying plants. Secondly, the fields have channels of water so as to reduce the water usage. Thirdly, the manures are all organic. A combination of all these three has resulted in the growth in productivity of the land, lessening of the inputs to 1/10th of the earlier ones. In Bangladesh also the same method has been followed except the fact that there were no channels being made, and there were phases of different water availability so that the roots were give shock treatment for their maximum growth. Through the SRI programme of CGIAR this technology co-evolved between Bangladesh and India[13]. One of the major characteristics of the SRI technology co-evolution is that both the countries have developed their own techniques keeping the broad parameters of SRI intact.

India as recipient of technology: Potential areas

India, having a strong and vibrant technological research infrastructure, has not been identified as recipient of adaptation technologies in agriculture. However, there have been very few cases of information sharing through SAARC metrological centre on developing robust EWS systems. But in general, examples of the country as recipient of technology have been very few.

- ### Floating Vegetable Garden

Bangladesh has a number of examples of successful technologies which can be beneficial for India; one of them is the floating vegetable garden which has been successfully developed in the submerged areas of the country. In India, floods often wreak havoc and result in a huge loss of assets and livelihood opportunities. In such cases floating vegetable gardens can provide alternative sources of livelihoods in the frequently flooded regions of India.

[13] CCAFS 2012.

- **Salinity resistant crops**

BARI has been successful in developing certain varieties of saline resistant rice varieties in Bangladesh. These can well be applicable in the saline regions of India especially in the coastal regions. Further, the Indian government during 2012 has entered into a joint programme for development of saline resistant crops between the two countries. The CSSRI of Karnal in India will be the representative institution from India while from Bangladesh it will be BARI.

From India to South Asian Countries

- **Developing Robust Climate Modelling Techniques for South Asia**

India has been involved with AusAid to develop regional crop modelling. This takes into account various sophisticated data and other crop related information. Often it has been observed that the results of the modelling are not up to the mark because of lack of data and information for all the parameters of modelling. In the current case there have been cooperative efforts made through various research entities to develop such a model that can then be implemented for forecasting in other countries of South Asia.

- **Support in developing Agricultural Research Infrastructure**

India has agreed to help develop the Agricultural University in Afghanistan. India will be providing support in terms of manpower, training the Afghan scientists, and also setting up required infrastructure at the University. It will also extend its support in the development of the curriculum.

Under the current situation it has been observed that the cooperation between India and other South Asian countries have been weak and mainly based on ad-hoc basis between the governments. There is no well thought out process of developing a strong agricultural science based research sharing network between India and other South Asian nations. Currently, the existing collaboration efforts are mainly from international non-governmental organizations either through ecosystem based approach or through agro-ecological approach. The governments of the region, while developing policies, need to incorporate cooperation in agriculture with the region as a core component in order to develop a climate resilient South Asia. Governments of the region will only be successful in doing so if the region has a strong and efficient cooperative strategy. India, being the most developed in terms of agriculture research infrastructure in the region, has to provide leadership in this regard in future.

Chapter 4: Impediments to Technology Cooperation: Assessment of Existing Gaps

South Asian countries rely on the governments and their support to address the veracity of the climate change in the agriculture sector. Given the range of impacts that are going to be faced by this region, both government and other stakeholders need to work in tandem to address various vulnerabilities in the agriculture sector. The technologies and the practices that are required for the sector should be sensitive to the agro-climatic requirements of the region. In many ways, management of knowledge in the sector plays a very vital role in adapting to the changing situations. This can be facilitated through adequate support by creating enabling environment through the removal of existing impediments that prevent the flow of such information and knowledge for making the sector climate resilient in future.

Broadly there are certain number of challenges that have been identified which explains the reason behind the low level of cooperation between India and other countries of the region. It has been observed that despite having very strong agricultural research infrastructure, the actual sharing of such research outputs has been very limited. To assess these limitations, the current study has categorised these limitations into some specific nature in order to better address them and also to develop robust cooperative arrangements in the future.

Institutional Barriers

- ### Lack of leadership role in SAARC

India being one of the vibrant economies and research infrastructure in the region has the capacity to lead the region in agricultural cooperation and research through developing programmes under SAARC. However, this has not been possible due to a multitude of factors, primarily due to the lack of dedicated funding commitments. In addition, the geo-politics of SAARC has also served as a barrier. The on-going tensions between Pakistan and India and its effect on the functioning of SAARC has hampered the progress of such collaborative research agenda in the agriculture sector.

- ### Weak bilateral cooperation

India's cooperation in agriculture research at the bilateral government level has been very weak over the decades, and has been limited to a few exchange programmes and trainings. There are very few dedicated research programmes that have taken place till date. Further, these attempts are made on an ad-hoc basis without any proper planning and goals to achieve it. For example, recently the CSSRI of Karnal in India signed a MoU in the presence of the agriculture minister of Bangladesh for cooperation on saline resistant crop varieties. The programme is an attempt for cooperation in agriculture and could have been developed in a larger form to ensure a holistic view to develop climate resistant crops between these countries, especially since these two countries contain vast knowledge on agriculture. However, such steps were not taken mainly due to the lack of foresight by policymakers. This is part of the larger problem where India seems to have a very weak preparation on the development of climate resilient agriculture programme for its own. The set up research infrastructure is currently at the very initial stage and the country is yet to integrate climate change aspects into all its programme of research in agriculture.

Role of non-State Actors

Non-State actors like the international donor organisations and research think tanks play crucial role in developing coherent cooperative research agenda in the region, including India. We have been witnessing the success of CGIAR CCAFS programme of climate resilient agriculture based on ecosystem approach. Even with these types of approaches, there are limitations as these programmes have been limited to the areas covered under specific projects and have not scaled up enough to have larger acceptability, in effect limiting the scope of benefits that could have been transpired between India and other country in the region. Further the programme under the ICRISAT and the IRRI have very limited climate change perspective. This is a problem because both these programmes have very robust cooperative component but they are yet to integrate climatic parameters based agricultural research programme in the region; currently limiting them to a low level project site specific ones.

Disconnect between Policy Think Tanks and Grassroots

One of the major reasons behind non-cooperation is that most of the think tanks and grassroots organisations in India and other countries of the region do not exchange their knowledge with each other in a cogent manner. There are instances of think tanks exchanges and networking between countries, but there are very few examples of think tanks mingling with the grassroots and taking up the demands and needs of the grassroots to the policy advocacy level. Due to this vacuum, the needs of the grassroots are weakly represented at the policymaking level which indirectly explains the way various potential cooperation attempts are neglected. Such an example is the lack of replication of same systems of cultivation of vegetable on submerged areas of Bangladesh in similar regions of India. Had there been a more coherent exchange of work, India could have easily incorporated these practices in the submerged region of the IGP basin.

We observe that India has not lived up to the potential as a leader in the region in terms of taking lead in the agriculture technology cooperation. Even if it boasts of research infrastructure, the outputs of the same are not shared among the countries in the region. Nor has it been able to adopt potentially good and robust outcomes that are practiced successful in the other countries. The agriculture research programme has to fully incorporate the climate change impacts that are potentially going to impact the sector in the future, thereby, putting it in a very interesting situation where despite having a strong infrastructure cannot contribute substantially to the development of technologies that are climate resilient. It has to rely on the other programmes that have been promoted by international institutions for climate resilient agriculture. The regional geo-politics within the SAARC plays a negative role in this regard as India lacks in getting political guidance for developing the result oriented agenda of technology development and research in agriculture for the region as well as creating an enabling environment for developing a climate resilient agriculture sector for future.

Chapter 5: Suggestions for a cooperative mechanism on agriculture technologies cooperation

Agriculture has been the most important sector in the South Asian region, due to its role in securing food and livelihoods for a large number of people. In the face of climate change, the uncertainties and vulnerabilities around the agriculture sector in South Asia has been predicted to be rising in almost every documented study in the recent past. One of the ways to address such a situation in the future is to increase the modes of cooperative actions between the countries of South Asia. Further, being a leader in development and research in agriculture sector, India needs to play a leadership role in developing cooperative programmes that addresses all aspects of uncertainties and vulnerabilities of agriculture sector.

Strengthening the SAARC

In the South Asian region, existing forms of institutional cooperation are fairly robust with the presence of SAARC and various regional centres covering particular theme of research and building the basis of cooperation between the countries. In India there are SAARC regional centres, but they have very little effect on developing effective cooperative mechanism. The SAARC Agriculture Centre (SAC) in Bangladesh have several programmes in agriculture and collaborate on various project based activities, but there are no institutional collaborative arrangements developed in adaptation and agriculture research. In a recent study undertaken by the SAC, it has been found that there are no formal collaborative arrangements present with research establishments of India and other countries. Despite having a strong infrastructure of research facilities in India, none of the agriculture research institutes and governments has established programmatic research with the Indian government. There is a lack of outreach towards neighbours by the Indian entities. The reason for this is the lack of political will among the policymakers.

In an interview related to the study, a principal scientist of a research institute has opined that the problem of not having such facilities lie in the lack of willingness of those in the leadership position to establish such cooperative arrangements. The scientist has in fact identified many areas of cooperation from which India could have benefitted had there been cooperation among the governments in sharing of such practices. Thus it is necessary that India creates an enabling environment of cooperation in research and knowledge sharing in agriculture with its neighbours and SAARC platform could be very important one to do so. In the current years India should take leadership in SAARC on climate change to create (a) a programme of agricultural research collaboration specific to agro climatic zones with all the agricultural research centres in the neighbouring countries, and (b) create a platform of scientists and policymakers in SAARC on agriculture and climate change to share knowledge and successful research in agriculture addressing specific agro-climatic zones that are not restricted to the political boundaries of countries.

Strengthening bilateral cooperation

It has been observed in the analysis that the cooperation with India and other countries in South Asia has been particularly lacking due to the weak bilateral ties among these countries. According to one of the senior agricultural scientist of NICRA, the bilateral cooperation has to originate from the top political level in India. Unless the governments jointly work on the issue of cooperation there is little opportunity to forge bilateral cooperation between the countries on important areas of research. Currently these collaborations are limited to student exchanges and young researcher exchange programmes. But the real fruit of such collaboration lie in joint research. Such types of collaboration through government initiatives are very minimal at this level. To increase such cooperation, the Indian government must extend its collaborative arm to the neighbouring countries. Jairam Ramesh, the former Minister of Environment and Forests, has declared some of the schemes at regional level[14] through Indian initiatives. But these initiatives are yet to be completely implemented. India should in future prioritise the implementation of such initiatives before declaring any new initiatives. Further, India can actually propose to form consortium of scientists or consortium of agriculture research institutes on specific ecosystem based issues. The opportunity and advantage of having robust climate analysis facilities at various research institutes and also within the nodal body of NICRA, should be shared between the countries of South Asia. Also, India can benefit from information it will receive through these collaborations when developing robust regional climate based cropping model of South Asia. The important point here is to open the gates of collaborations on research to make the region climate resilient in the agriculture sector.

Developing civil societies platforms and research networks

Civil societies and non-government organisations based in the region implement various pilot projects and are the store house of information and knowledge; also in many cases open up the routes for collaborative efforts. Currently the CGIAR-CCAFS programme on the IGP basin is an example of such initiative. Earlier, the UNEP's south-south programme has developed collaborative programme of climate resilient research in the agriculture sector. The civil society has the potential to fill up the existing gap and also put pressure on the governments of the region to develop collaborative research programmes. However, one of the major drawbacks of such initiatives is that they are often duplicated. Thus the civil society needs to undertake complementary efforts and extend the research outputs to the neighbouring countries of India. In the current analysis we have observed that these research programmes operate on an independent basis. In future, these programmes have to play a complementary role to each other and also there is a need to develop facilitative arrangements for cross learning between countries. Non-state actors from the region are involved in various interesting pilot projects in their own countries but there is very little formal collaboration. Even at the international multi country civil society and intergovernmental organisations, the collaboration is very limited. This needs to change and should be transformed towards more collaborative arrangements. In the analysis of case studies it has been observed that there are huge scopes of replication but due to lack of facilitative arrangements between the civil society organisations, it has not helped in building a collaborative mechanism. Thus, like the governments, the civil societies in India and other South Asian countries need to come together under a platform to develop common programmes of knowledge sharing and research. There are various networks already working in the interface of climate change, development issues and agriculture. These networks can come together to develop such collaborative programmes and facilities to better equip the region to address the impacts of climate change.

[14] Jairam Ramesh has declared a joint initiative on research on climate change adaptation in the region, Himalayan glacial research at the regional level, setting up intergovernmental marine, mountain, monsoon initiative (The Hindu, Nov 1, 2010).

Facilitating the replicability of projects

It has been observed that the pilot projects, even though developed for specific ecosystem, are often not replicated. For example, there have been many success stories of pilots in the IGP basin carried out through various organisations. But very often they are not replicated across the country border which also has the same ecosystem. In a climate constrained world with limited resources, there is little scope of duplication of efforts. Thus developing replicability programmes of successful projects can play a very vital role. Thus it is required that a compendium of successful projects is developed and potential of replication be identified. In this regard, the government, civil society and other think tanks should come together and build such facilities to ensure replication. In an analysis of the various technologies needs assessment it has been found that most of the countries in the South Asia has requested for input intensive technologies for making the sector climate resilient. While there have been numerous examples and research papers that cite organic based input efficient agriculture practice as best suited to address the climate impacts, these are yet to figure in the official technology needs documents for the countries. In this case, Indian facilities can play an important role by sharing the success stories of input efficient agriculture and the negative impacts of traditional green revolution based agriculture process. Further the creation of replication facilities between the countries would also address the scalability issue that is often being raised in developing a successful pilot project in the agriculture sector. Thus it is observed that the region has to develop a strong information and knowledge sharing platform which would foster replicability of pilot programmes and thereby ensure that these pilots are scaled up successfully to address particular challenges that climate change offers us.

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