FINAL REPORT for APN PROJECT
ARCP2009-08CMY-Iqbal

Assessment of Food and Water Security in South Asia under Changing Climate Scenario using Crop Simulation and Water Management Models and Identification of Appropriate Strategies to meet Future Demands

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Project Reference Number: ARCP2009-08CMY-Iqbal
Final Report submitted to APN

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OVERVIEW OF PROJECT WORK AND OUTCOMES

Minimum 2pages (maximum 4 pages)

Non-technical summary

Project was awarded for 2 years (2008-10) under its Annual Regional Call for Proposals Program (ARCP) with funding of US $ 70,000. Five South Asian countries (Bangladesh, India, Nepal, Pakistan and Sri Lanka) initially participated in the Project with Pakistan as the Lead Country. During the first year of the project, India and Nepal backed out due to one or the other reasons. The project which ended in 2013 played a significant role in sensitizing the food security and water scarcity issues in the wake of climate change. The hall mark of the project was use of crop simulation and water management models for assessing food and water security. The project helped in assessing the food insecurity hotspots in the participating countries under changing climatic and varying water availability scenarios and in identification of appropriate adaptation measures to counter the negative impacts of climate change. A total of four workshops to (i) initiate the project activities, (ii) build capacity, (iii) share preliminary research results, and (iv) final results, and three National Seminars for Policymakers and Planners in Bangladesh, Pakistan and Sri Lanka were organized to disseminate the research results. The project outcomes were highly appreciated by the participants who emphasized that economic valuation of the impacts also needs to be done.

Objectives

The main objectives of the project were:

1. To assess food and water security in South Asian Countries for sustainable development under changing climate using crop simulation and water management models
2. To synthesize the results at regional level in order to highlight the synergies of production systems in different agro-climatic regions
3. To identify appropriate adaptation strategies to meet the future demand and provide guidance to national planners/policy makers for introducing necessary adaptive measures.

Amount received and number years supported

The Grant awarded to this project comprised:

US$ 40,000 for Year1, 2008-2009

US$ 10,000 additional grant in 2009 for carrying out Capacity Building training of the participating countries (India and Sri Lanka) in operation/use of crop simulation models

US$ 30,000 for Year 2, 2009-2010

Activities undertaken

Activity 1: Project start-up meeting, Kathmandu, Nepal 12-15 August 2008 – To discuss and agree on detailed methodology and timelines.

Activity 2: Training Workshop on operation / use of crop simulation models, 16-10 March 2009, Kandy, Sri Lanka

Activity 3: Workshop on preliminary research results, 08-12 March 2010, Islamabad, Pakistan -To review the results, identify their shortcomings and requirements for additional work and to provide guidelines for future work.

Activity 4: Workshop on comprehensive research result, 15-18 Jan 2013, Islamabad, Pakistan – To discuss the results obtained by national teams, provide guidelines for finalizing the results and draft research papers/ technical reports

Activity 5: National Seminars for policy makers in the participating countries

Results

Research

Research activities were initiated and pursued in each participating country to assess the impact of climate change on major crops under changing future climate scenarios using crop simulation and water management models and to identify adaptation options to counter the adversities of climate change. Food security in all the three participating is at the risk of being disturbed as a result of global climate change and climatic variability. All study sites showed declining trends in crop yields which could have severe food insecurity concerns. National Planners and Policy makers can use this information to manage agricultural production and food security issues. The results have been discussed in detail in Section 3 of the report.

Capacity Building

Fifteen young scientists were trained in the use of crop Simulation models (DSSAT) and water management models (PODIUM) under this project.

Institutional Collaboration

Participating countries' intuitions which took part in these studies are now better equipped to work jointly as well as independently on future projects pertaining to food security, climate change and agricultural productivity.

Relevance to APN's Science Agenda and objectives

The goal of the project was to assess food and water security in South Asian countries for Sustainable development under changing climate and help national planners and policy makers to identify appropriate strategic measures. This is of direct relevance to APN Science Agenda, Item 4: "Use of resources, such as food, water, energy, materials, and pathways for sustainable development". Pre-calibrated models (used earlier in the APN CAPaBLE 2005-CRP1CMY-Khan Project carried out at GCISC) were used to address issues of food security in the local food secure/ vulnerable areas, to help guide the national planners on food security management and policy making issues.

Self-evaluation

Although there were inordinate delays in the project due to one or the other reasons including enhancing capacity needs of the participating countries, total lack of response or extremely delayed response by some countries, indecision about selecting the country counterpart (by Nepal), the Project succeeded in meeting its major objective of addressing the food security concerns in the participating countries. Three South Asian countries; Bangladesh, Pakistan and Sri Lanka participated in the project to the end. The climate change impact assessment studies helped assess the food security status of some vulnerable hotspots in the participating countries, and policy makers and national planners got awareness on how research-based modeling activities can provide input for policy making and enforcing actions for agricultural production and food security management.

Potential for further work

Using the framework designed for this project, further studies on impact assessment on food production can be organized in the disaster prone areas and relevant adaptation strategies can be identified to cope with the adverse impacts of climate change.
Sri Lanka and Bangladesh can evaluate the adaptation strategies, using crop simulation models, identified by them in the present project.

The present project focused only on the ‘Production’ aspect of the crop-based food system which is only a part of the whole food system. The food may be sufficient but due to some adverse prevailing conditions, such as disruption in rail/road network, spoilage due to improper storage, damages due to natural disasters, the food may not be available to the consumers in time. The studies, therefore, can be designed to focus on other aspects of the food system, e.g. storing, processing, packaging, transportation, marketing and consumption.

Quality of food is another characteristic which is drastically affected by changes in the climatic parameters. The milling and cooking quality of rice, taste, palatability of fodder crops etc may be affected by changes in humidity and temperature. This aspect deserves systematic studies.

Publications (please write the complete citation)

1. Iqbal, M. M., Goheer, M. A. and Khan, A. M. 2009. Climate Change Aspersions on Food Security of Pakistan. Science Vision. 15(1): 15-23.
2. Iqbal, M. M. and Goheer, M. A. 2011. Effect of increase in Carbon Dioxide Concentration on Agriculture. Proceedings National conference on Global Warming, Impact on Agriculture and Adaptation Strategies organized by Agriculture Foundation of Pakistan, 8th July 2010, Islamabd. Pages 24-37
3. Iqbal, M. M., Goheer, M. A. and Khan, A. M. 2011. Impact of Climate Change on Agriculture and Food Security in HKH Region. Background Paper prepared for International Centre for Integrated Mountain Development (ICIMOD), reported in the Report by Singh, SP; Bassignana-Khadka, I; Karky, BS; Sharma, E. (2011) Climate change in the Hindu Kush-Himalayas: The state of current knowledge. Kathmandu: ICIMOD
4. Punyawardena, B.V.R. S. Mehmood, A.K.Hettiarachchi, M.Iqbal, AS.H.S.A. De Silva and A. Goheer, 2012. Future climate of Sri Lanka: An approach through dynamic downscaling of ECHAM4 General Circulation Model (GCM). Tropical Agriculturist 161: 35-50.
5. Climate change - mediated food losses in Pakistan (Under Preparation)
6. Assessment of food security status of selected districts in Pakistan varying in moisture availability (Planned)

References

APN CAPaBLE 2005-CRP1CMY-Khan: Enhancement of National Capacities in the Application of Simulation Models for the Assessment of Climate Change and Its Impacts on Water Resources and Food and Agricultural Production

Acknowledgments

Acknowledgment to collaborating institutions, resource persons, etc., should be placed here

I would like to thank APN for its financial support to the project which made this useful work on an important issue of food security assessment having broader aim of saving the populace from hunger possible. GCISC (Global Change Impact Studies Centre, Islamabad) has a long history of good collaboration with APN dating back to 2004 when GCISC had been just established and APN awarded project under its CAPaBLE programme to GCISC. Since then, five projects including this one have been successfully completed, some are ongoing and three new projects have recently been initiated. The APN support has played a big and effective role in capacity building of young scientists of various institutions in the participating countries. Fifteen young scientists under this project alone were trained in the operation/use of DSSAT-based crop simulation models.

I would like to thank Dr. Amir Muhammad, APN SPG (Scientific Planning Group) Member from Pakistan, for taking keen interest and making useful constructive suggestions during currency of the project. Thanks are also due to Dr. Madan Lal Shrestha, SPG Member from Nepal and Dr. Giasuddin Miah, SPG Member from Bangladesh, for providing help on different matters whenever needed.

I am indebted to Dr. Arshad Muhammad Khan, Executive Director GCISC for initially suggesting formulating this project and later for providing guidance and useful suggestions at every stage of the project. He continued taking keen interest in outcomes of the project all along.

The efforts of participating Country Counterparts; Dr. Punyawardena from Sri Lanka and Dr. Ahmadul Hassan, Dr. Mozaharul Alam and Mr Aminur Rahman from Bangladesh, and their team members particularly Dr. Ajantha De Silva from Sri Lanka, are gratefully acknowledged for carrying out the project activities as per plan of the project and providing various reports and other necessary inputs whenever required. It is a pity that Nepal and India dropped out the project. Their absence was greatly felt.

Thanks are due to Dr. Gerrit Hoogenbom from Washington State University, USA, a developed country partner in the project, for imparting training on operation/use of DSSAT-based families of Crop Models to the young scientists from Sri Lanka and other participants in Kandy, Sri Lanka in 2009. He also provided useful suggestions and help for developing a common methodology and framework for the project during the Inception Workshop in Kathmandu, Nepal in 2008.

My GCISC colleague, Mr. Muhammad Arif Goheer, the Co-Principal Investigator in the Project, deserves special thanks for spearheading the logistic arrangements, both within and outside Pakistan, for organizations of various Workshops/ Seminars, and for help in preparing various reports, papers and Proceedings required under the project. I am thankful to other GCISC colleagues from the Agriculture, Climatology and Water Resources Sections, and the management of GCISC, for providing vital inputs to the project without which the project would not have achieved its objectives. Thanks are also due to the Resource Persons from GCISC and other organizations for their valuable inputs to various Workshops and Seminars held under the project.

TECHNICAL REPORT

Minimum 15-20 pages (excluding appendix)

Preface

South Asia is highly vulnerable to the adverse impacts of climate change due to high population, geographical location and low technological and resource base. The population of the region is increasing at a fast rate. This calls for increase in food production and assessment of food security situation. The economies of the region are primarily agrarian and hence climate-sensitive. The goal of the project was to understand challenges posed to food security by the changing climate and how to overcome these. The project has used simulation models to assess food and water demand and climate change impacts on production of staple crops, and identified some adaptive measures, in the three participating countries.

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Introduction

1.1 Background

South Asia region has the highest concentration of poor and undernourished and inhabits 40% of the world's hungry. The World Bank Agricultural Development Report (2007) ranked South Asia as the second most undernourished, malnourished and food insecure region in the world. Apart from the endemic poverty and poor nutritional status of the South Asian countries, there are signs of deterioration in the productive agricultural resources of the region.

The Fourth Assessment Report (2007) of the Intergovernmental Panel on Climate Change (IPCC) lists the consequences of climate change for the South Asian region. Existing level of water resources scarcity in the South Asian region will face more stress and uncertainty in the coming years. The melting of the Himalayan glaciers will lead to increased flooding and affect water resources within the next two to three decades. Crop yields could decrease by up to 30% in South Asia by the mid-21st century. This could hamper the achievement of many of the Millennium Development Goals (MDGs), including that of poverty eradication.

South Asia is one of the densely populated regions of the world with population growing in the countries at the rates of around 2%, calling for increase in food production in the coming decades to feed teeming millions. The economies of these countries are primarily agrarian and hence prone to vagaries of weather and changing climate. Climate change is expected to have severe socio-economic implications for the region. As three-fifth of the cropped area is rain fed, the economy of these countries hinges critically on the annual success of the monsoons. In the event of a failure, the worst affected are the landless and the poor whose sole source of income is from agriculture and allied activities. The productive resources of land and water in these countries are, however, limited rather dwindling due to urbanization, industrialization and global warming (IWMI, 2000). The rapid urbanization means loss of fertile land from agriculture to non-agricultural uses which has become an important phenomenon in South Asia. Besides, the water requirement of the municipal sector is also increasing as a result of urbanization and urban development. That means less water for agriculture. While the direct consequences of climate change are associated with rise in temperatures, the indirect impact will be felt in terms of water availability, changing status of soil moisture, and pest and disease incidence. The HDR (2006) has pointed out that most of the people living in this region will be affected by water stress and scarcity by the year 2050.

Relatively small changes in temperature and precipitation could cause relatively large changes in run-off. The arid and semi-arid regions will therefore be particularly sensitive to reduced rainfall and to increased evaporation and plant transpiration. Increased rainfall will lead to an increased likelihood of river flooding. Changes in seasonal patterns of rainfall may affect the regional distribution of both ground and surface water supplies. Hydrological regimes in mid latitude are often determined by monsoon rains and winter snowfall. Most climate models predict that global warming will reduce the amount of precipitation falling as snow in these regions, increasing the rate of water run-off and enhancing the likelihood of flooding. Changes in surface water availability and run-off will influence the recharging of groundwater supplies and, in the longer term, aquifers. Water quality may also respond to changes in the amount and timing of precipitation. Reduced water supplies would place additional stress on people, agriculture, food security and the environment. Regional water supplies will come under many stresses. Uncertainties regarding climate variability, water demand and the socio-economic and environmental effects of response measures all confound projections for future climate change impacts on water resource management and agriculture production in target regions.

Being the main driver of food production, the water availability will primarily affect issues like food security in the region. The components of food security: availability, accessibility and utilization will all be particularly affected changes in the water and agricultural resources availability in the region. A number of studies are available that investigated the impact of climate change on water resources and food production at regional scales, only a few of the studies portray the impact of climate change and have identified food insecurity hotspots and almost none holistically cross-verified the impact of water resources availability of the region on food security issues.

1.2 Country Contexts

Pakistan

The total geographic area of Pakistan is 79.61 million hectares (mha) with 22.7 mha as cultivated (28% of the total area). Of the total cultivated area, 19.12 mha (84% of the cultivated area) is irrigated and 3.67 mha (14% of the cultivated) is rainfed. Pakistan is basically an agricultural country with agriculture sector contributing 21.4% to the national GDP and over 47% of its population earning their livelihood from agriculture (GoP, 2013). The irrigated areas consume almost 90% of the fresh water resources and contribute >80% to the national production. The contribution of rainfed areas to national production is <30% but have potential to increased contribution of 50%, if managed properly. In the recent decades, climate change has come up to be a major factor which is exerting negative impacts on agricultural productivity.The effects of climate change are already being felt due to high temperatures and increased frequency of extreme events; the projected impacts include threats to its food security (through decrease in yield of staple food crops of rice and wheat in the irrigated and semi-arid plains), threat to its water security (through rapid melting of its glaciers, variability in magnitude and timing of monsoon rains affecting river flows); and threats to its energy security (through increased uncertainty in hydropower generation due to increased variability of river flows) (TFCC, 2010). These are likely to affect many sectors and ecosystems with particular adverse impacts on natural resources and the livelihoods they support. The vulnerability of Pakistan is due to its location, warm climate; preponderance of arid and semi-arid lands; and dependence of its rivers on the Hindukush-Karakoram-Himalayan (HKH) glaciers which are reported to be receding fast due to global warming. Under the influence of all these factors the Water Security, the Food Security and the Energy Security of the country are under serious threat (TFCC, 2010). The Agriculture Perspective and Policy (2004) has identified some plans regarding climate change and adaptation in agriculture, like: (1) Development of agricultural meteorology laboratories network for database forecasting, modelling and simulation of the effects of changing climate on crop yields/cropping patterns for development of early warning systems (2) Effect of global climate change on crop yields (3) Effect of global climate change on forests and rangelands (3) Greenhouse gas emissions from agricultural lands and animal farms quantification and control technologies. In 2002-03, Global Change Impact Studies Centre (GCISC) was established as a dedicated research centre for climate change studies in Pakistan, at the initiative of Dr. Ishfaq Ahmad, the then Special Advisor to the Chief Executive. Its programme includes, inter alia, impact assessment of climate change on important socio-economic sectors and identification of appropriate adaptation measures to counter the negative effects of climate change. The Centre is now functioning under Climate Change Division (CCD) as its research arm.

Bangladesh

Bangladesh is also an agrarian country. Agriculture is the single largest producing sector of the economy since it contributes 20% to the country's GDP (MoF, 2012) and employs around 44% of the total labour force (BBS, 2009). In Bangladesh, around 8.4 million hectare (around 58% of total land) area is cultivated (GOB, 2010) which is one of the highest percentages in Asia. The vast majority of population depends on agriculture for a large part of their food and income. Rice is the predominant crop in Bangladesh accounting for about 79 percent of agricultural land use. Other major crops include wheat (5.0%), jute (3.2%), pulses (3.4%), oilseed (3.0%), and sugarcane (1.2%). High value crops include vegetables, fruits, spices and potatoes, which account for only about 5 % of the total cropped area (GoB, 2010). Rice sector contributes half of the agricultural GDP and one-sixth of the national income in Bangladesh. In 1971-72, total rice production in Bangladesh was around 9.7 million metric ton which increased to 31.9 million metric ton in 2009-10 (BBS, 2010). This increased rice production has been possible largely due to the adoption of modern rice varieties on 66% of the rice land which contributes to 73% of the country's total rice production. In addition there are other factors that have contributed to increased yields like, development of flood control projects, application of fertilizer, and irrigation. Government of Bangladesh has identified 'food security' as one of the cornerstones for achieving sustainable development (Vision 2021: General Economics Division, GoB, 2012). It also emphasized achieving adequate capacity to mitigate the adverse impact of climate change. In this respect, GoB has also put 'food security' as the first thematic pillar in the Bangladesh Climate Change Strategy and Action Plan (Ministry of Environment and Forests (MoEF), 2009). The Government of Bangladesh has recently developed other policy documents such as Coastal Zone Policy, National Water Policy, and Poverty Reduction Strategy Paper (PRSP) to address climate change issues. National Adaptation Programme of Action (NAPA) and Bangladesh Climate Change Strategy and Action Plan (BCCSAP) were finalized in 2005 and in 2009 respectively. Food security stands listed as a priority area in these action plans.

Sri Lanka

Sri Lanka is a small island in the Indian Ocean, situated to the south-east of India. It has total land area of 64,000 sq. km. and a population of 19.5 million (Annual Report of the Central Bank of Sri Lanka, 2011). Sri Lanka has traditionally been an agricultural country; as such its economic situation depends heavily on the trends and the growth in the agriculture sector. Of the total cultivable land (2.9 m ha), 65% (1.9 m ha) is cultivated. The staple crop of rice occupies 40%, coconut 20%, tea 12%, rubber 7% and the remainder 21% accounts for all other crops (such as horticultural crops and export crops). Agriculture continues to be an important sector of the Sri Lankan economy in terms of contribution to GDP, employment and income. Presently agriculture contributes 12 % to the country's GDP. About one-third of the work force is employed in agriculture sector. In the Sri Lankan rural sector 60% of its population depends on agriculture for their livelihood. The production of food crops like paddy the staple diet and other field crops have been extremely important in terms of both employment and income of the rural population. The export oriented plantation crops; tea, coconut and rubber are other important crops in the country's economy. Spices, sugarcane, cashew and floriculture at present play a significant role and have been recognized as crops of great future potential. Animal husbandry and livestock production and inland fisheries are two important sectors in agriculture of Sri Lanka. Mahaweli river development programme commenced in 1976 contributed to the expansion of cultivated land extent.(Annual report of the Central Bank of Sri Lanka, 2010, Sri Lanka State of the Economy 2011, Institute of Policy Studies of Sri Lanka, 2011). In Sri Lanka there is a need to formulate a strong water policy geared to achieve a sustainable water/food security, and to maintain the ecosystems at a healthy level.

1.3 Objective of the Study

Bangladesh, Pakistan and Sri Lanka are among the poor countries in Asia where the implication of climate change on food security is anticipated to be the most in reference to other countries in the region.Overall goal of this project is to enhance and sustain the food security in the case study areas located in these countries. The main objective of this proposed project was to assess the impact of climate change on water resources availability and impact of water availability on food security to be used for adaptation strategy formulation.
The main objectives of the project were:

1. To assess food and water security in South Asian Countries for sustainable development under changing climate using crop simulation and water management models
2. To synthesize the results at regional level in order to highlight the synergies of production systems in different agro-climatic regions
3. To identify appropriate adaptation strategies to meet the future demand and provide guidance to national planners/policy makers for introducing necessary adaptive measures.

Three layers of output were generated from this study:

1. Policy level support: the outputs from the study, specifically the adaptation options will be used by the policy planners and adaptation practitioners to check the viability of replication in other parts of their respective countries. Output from this study will also be fed for mainstreaming climate change adaptation in relevant sectoral policies.
2. Strengthening the knowledge base: till to date, none of the research initiatives have been found which holistically address the impact of climate change on food security at national and sub-national level. Knowledge generated under this study will be used for effective and applicable adaptation options for minimizing uncertainties in our understanding on how the regional climate change will impact the food supply and demand in South Asia.
3. Institutional capacity building: Capacity building for each of the partner institutions will be achieved from joint research partnership. In addition to this, joint training for researchers involved in the study will also be initiated as a part of institutional capacity building.

2.0 Methodology

As per the Work plan, the Start-Up Workshop of the project was organized in Kathmandu, Nepal from 10-12 August, 2008. All the counterparts from the participating countries and the developed-country partner from USA attended the Workshop. In this Workshop, the current situation of food security in the participating countries was presented, and the common project methodology to be followed by the counterparts in their respective countries was discussed in detail. There was consensus that rice and wheat, the common staple crops of all the participating countries, will be studied. The study sites will be selected on the basis of any one or more of the following criteria:

- Most productive areas;
- Potentially food-insecure areas;
- Seasonally dry areas; Rainfed areas;
- Irrigated areas

A common project protocol for research, vetted by Dr. Gerrit Hoogenboom, was developed by Pakistan, the Lead Country, in the light of Kathmandu discussions which was agreed by the participating countries.

2.1 PROJECT PROTOCOL
APN-ARCP Project (ARCP2008-20NMY-Iqbal)

'Assessment of Food and Water Security in South-Asia under a Changing Climate Using Crop Simulation and Water Management Models, and Identification of Appropriate Strategies for Adaptation to Meet Future Demands'

Food security, in the context of the project, is defined as "Production of the required quantity of food, as determined by population growth and shifting patterns of food consumption, from the available amount of water under a changing climate". A framework on the Project Methodology is depicted below.

Site Selection:

The criteria were;

1. Agro-Ecological Zones
2. Potential food insecure districts
3. Most productive irrigated areas
4. Rainfed areas
5. All districts

Crops studied: Wheat, Rice

Time Horizons: Current/ Baseline (1961-1990), 2020, 2050, 2080,

Analytical Tools: Two models will be employed for food and water demand and supply at the selected sites. These include Decision Support System for Agrotechnology Transfer (DSSAT) and Policy Dialogue model (PODIUM)

DSSAT (CERES-Wheat & CERES-Rice)	**PODIUM**
Primary Input Data Weather (daily) Soil profile information	**Secondary data on:** Population Site crop yield

Crop and cultivar information Crop Management **Primary Field data (**for model calibration): Yield, yield components, and phenology, and associated crop management and environmental data) **Secondary data** (for model evaluation at site level): Crop yield and management Soil, Climate **Outputs** Yield and productivity Water use and water needs Season length Optimum planting and harvesting dates Required inputs Gross margins and economic returns	Proportion of cereal in food Present caloric intake Water availability in the selected site Calculate the present deficit/surplus between cereal demand and supply
Scenarios for DSSAT based CERES-Wheat and CERES-Rice Models • Climate change* + no technology improvement • Climate change + Improved Technology comprising; i) Increased N Fertilizer rates ii) Increased Seed rates iii) Irrigation Scheduling (deficit irrigation, application at critical growth stages) iv) Changes in planting dates The projections will give the maximum attainable yield at a particular site * based on Regional Climate Model outputs for 2020s, 2050s & 2080s	**Food Demand Scenarios** • Scenarios based on Population change, calorie status and dietary habit change These scenarios will help assess water requirements to produce the required quantity of food using PODIUM, and also help in adaptation strategies.

2.2 Study-Site Selection in the Participating Countries

Pakistan

Two districts in the Semi-arid areas (Faisalabad, Shiekhupura,)

Four districts in the arid areas (Bahawalpur, Multan, Badin, Hyderabad)

Two districts in the rainfed areas (Chakwal, Quetta)

Crops: Wheat (Inqilab-91), Rice (Basmati Super)

Time Horizons:

Baseline: (1961-1990)

2020s (2010-2039)

2050s (2040-2069)

2080s (2070-2099)

Scenarios: IPCC SRES A2 and B2

Fig. 2.1: Map Showing Study Sites in Pakistan

The agro-climatic characteristics of the study sites selected by Pakistan are presented in Table 2.1.

Table 2.1: Agro Climatic Characteristics of Study Sites in Pakistan

Site	Latitude	Longitude	Altitude (m)	T max (°C) (Mean Annual)	T min (°C) (Mean Annual)	Annual Rainfall (mm)
Faisalabad	31° 29 N	73° 06 E	184	30.9	16.9	367.3
Sheikhupura	32° 16 N	73° 31 E	236	29.7	16.1	655.2
Bahawalpur	29° 24 N	71° 47 E	117	33.1	18.2	172.8

Multan	30° 12 N	71° 26 E	123	32.6	17.9	186.8
Hyderabad	25° 23 N	68° 25 E	12	34.5	21.0	177.7
Badin	24° 38 N	68° 54 E	10	33.5	19.8	222.1
Chakwal	32° 56 N	73° 43 E	416	36.6	16.4	853.2
Quetta	30° 15 N	66° 53 E	1700	24.4	6.9	260.8

Bangladesh

Site: Rangpur District

(North western side of Bangldesh)

Crop: Rice, Aman (BR-11)

Time Horizons:

Baseline 1979-2008

2020s (2010-2039)

2050s (2040-2069)

Scenarios: IPCC SRES A2 and B1

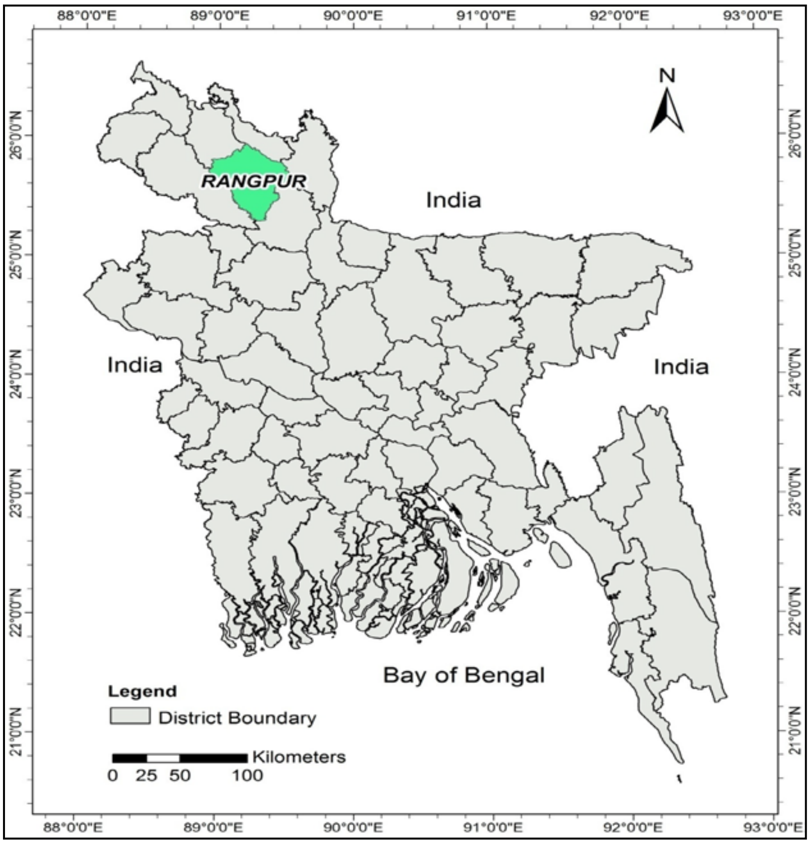


Fig 2.2: Map showing Study site in Bangladesh

Sri Lanka

Sites:

Aralaganwila - Galwewa series

Mahailluppallama – Aluthwewa series

Batalagoda- Batalagoda series

Crop: Rice (Yala and Maha)

Time Horizon: Baseline-1961-1990;

2020s, 2050s, 2050s

Scenarios: IPCC SRES A2 and B2

The climate change scenarios A2 and B2 for Time horizons 2020s, 2050s and 2080s for Pakistan and Sri Lanka were prepared by Global Change Impact Studies Centre (GCISC), Islamabad, by downscaling the Global Circulation Models (GCM) ECHAM-4 output using Regional Climate Model (RCM)-PRECIS. A detailed discussion is provided in Section 2.4. In Bangladesh, the SCENGEN Model was used to generate the temperature and rainfall scenarios for 2030s and 2050s for A2 and B1.

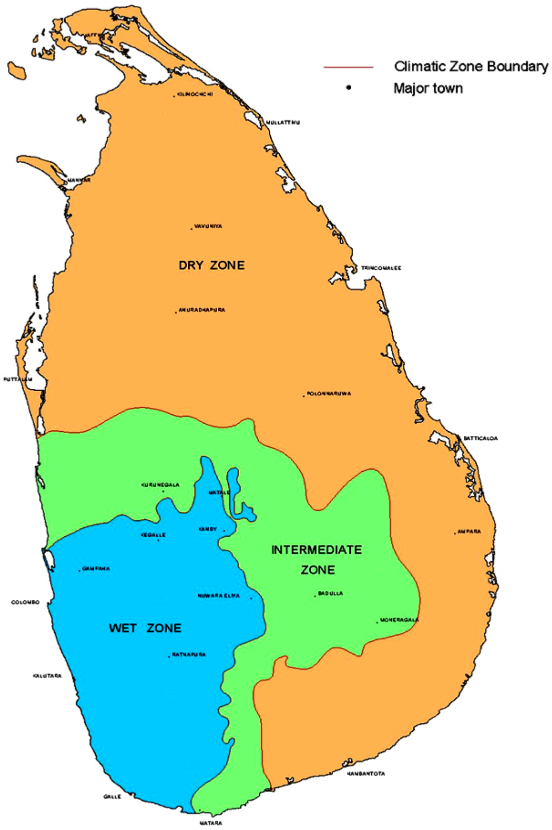


Fig 2.3: Map Showing Study Sites in Sri Lanka

2.3 Data Collection

Climate data: Historical daily climate data (from 1960 onwards) on Maximum and Minimum Temperatures, Rainfall and Solar Radiation was collected from the Meteorological departments in the respective countries.

Crop, soil and fertilizer data: These datasets were collected from the agricultural research institutes, academic institutions and the published statistical year books of Bureau of Statistics.

2.4 Downscaling of climate change scenarios

The assessment of global warming caused by enhanced greenhouse gas concentrations resulting from anthropogenic activities has increased the demand for high resolution climate change scenarios at regional scales to study more realistically the impact of climate change on various socio-economic sectors like agriculture, water resources, biodiversity etc. The starting point is the various SRES (IPCC Special Report on Emission Scenarios, 2000) global climate scenarios for future emissions of greenhouse gases, population growth, use of technology etc. These global scenarios are available from IPCC Data Distribution Centre in the form of outputs of Global Climate Models (GCMs), also known as General Circulation Models. These models are the most complex of climate models, since they attempt to represent the main components of the climate system in three dimensions. GCMs are able to simulate fairly well the most important mean climate variables, but at a coarse resolution (~ 300 km x 300 km). That's why they cannot capture the effects of local and regional forcings in the areas of complex surface physiography and provide information required for an impact assessment study at shorter distances. To overcome this problem, Regional Climate Models (RCMs) are developed having a higher resolution (around 50 km x 50 km) for assessing the climate of a particular region with greater details especially in the regions where forcings due to complex topography and land use are more important. RCMs are widely used to study the regional climate over different parts of the world for developing climate change scenarios.

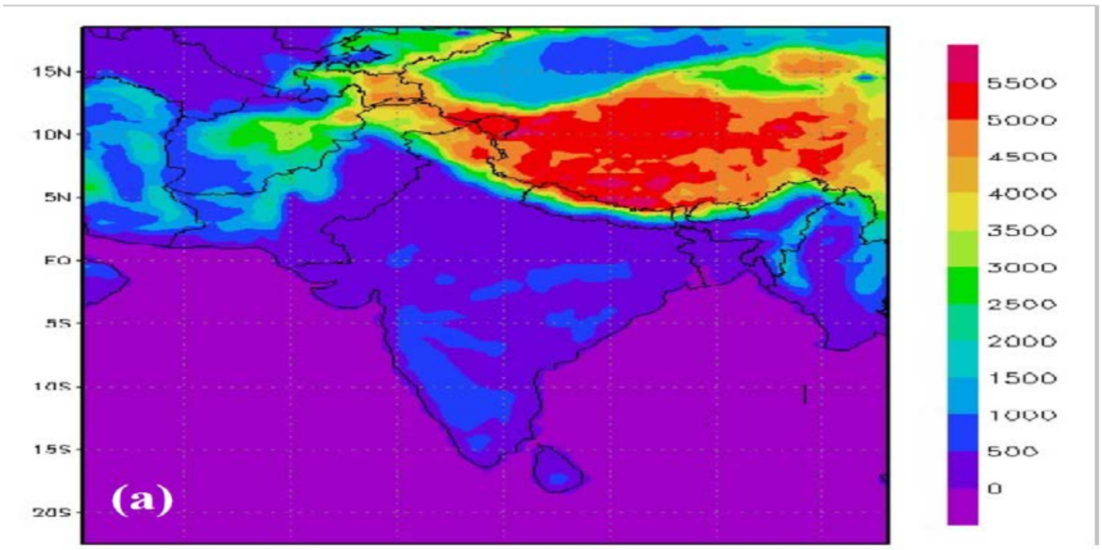


Fig 2.4: Model Domain showing topography of the South Asia region (color bar showing elevation in meters).

The high resolution climate change scenarios used in this project have been constructed by dynamically downscaling the output of Global Circulation Model (GCM) ECHAM4 for SRES A2 & B2 scenarios using the Regional Climate Model (RCM) PRECIS. ECHAM4 is the GCM developed by Max Plank Institute of Meteorology, Germany whereas PRECIS is a third-generation Regional Climate Model developed by Hadley Centre UK. The downscaling of climate change scenarios used in this study follows the methodology developed by the Hadley Centre (Jones et al. 2004). The horizontal resolution used for the simulations is taken to be 0.44° (~50 km) with the domain covering South Asia from 5°N to 50°N and 55°E to 100°E. The topography of the domain selected for scenario runs is shown in Fig. 2.5. As we go to the north of South Asia, the topography becomes more and more complex as the altitude reaches to 5000 m.

The simulations were performed for the base line 1961–1990 and three future periods of 2010–2039 (2020s), 2040-2069 (2050s) and 2070–2099 (2080s). A measure of the confidence to be placed in projections of climate change from a particular climate model (global or regional) comes in part from its ability to simulate recent climate which is called validation. The PRECIS model is validated by comparing its results with CRU data set (New et al, 1999).

For this project, for Pakistan, the projected changes in mean monthly temperature (Table 2.2) and precipitation (Table 2.3) have been prepared for use in the agriculture impact models. The analysis has been performed for the 8 districts in different agro-climatic zones of Pakistan. Similar climate profiles were prepared, by GCISC, for 30 individual grids covering whole of Sri Lanka (Table 2.4). The projected temperature and precipitation changes for Rangpur Saddar in Bangladesh have been shown In Table 2.5.

Table 2.2: Projected Temperature Changes for Specified Locations over Pakistan by PRECIS RCM in combination with ECHAM4 GCM for A2 & B2 Scenarios

Sr. No.	Locations	ECHAM4 - A2 ΔT (°C)			ECHAM4 - B2 ΔT (°C)		
		2020s	2050s	2080s	2020s	2050s	2080s
1	Faisalabad	1.14	2.38	4.39	0.70	2.00	3.23
2	Sheikhupura	0.99	2.21	4.04	0.69	1.97	2.92
3	Bahawalpur	1.68	3.22	5.28	1.15	2.65	3.89
4	Multan	1.33	2.62	4.71	0.87	2.19	3.49
5	Hyderabad	1.42	2.95	4.64	1.39	2.54	3.61
6	Badin	1.37	2.93	4.68	1.37	2.46	3.56
7	Chakwal	0.88	2.18	4.08	0.70	1.93	3.17
8	Quetta	1.65	3.26	5.43	1.25	2.47	3.81

Table 2.3: Projected Precipitation Changes for Specified Locations over Pakistan by PRECIS RCM in combination with ECHAM4 GCM for A2 & B2 Scenarios.

Sr. No.	Locations	ECHAM4 - A2 ΔP%			ECHAM4 - B2 ΔP %		
		2020s	2050s	2080s	2020s	2050s	2080s
1	Faisalabad	39	63	72	51	56	56
2	Sheikhupura	23	40	49	38	38	51
3	Bahawalpur	38	69	72	62	72	82
4	Multan	38	74	81	44	62	59
5	Hyderabad	90	51	92	82	94	106
6	Badin	103	58	81	84	119	112
7	Chakwal	36	54	64	40	53	50
8	Quetta	40	53	50	41	82	58

Table 2.4 Projected Precipitation Changes for Specified Locations over Sri Lanka by PRECIS RCM in combination with ECHAM4 GCM for A2 & B2 Scenarios

Grid No.	**Name of the Site**	**Grid Nos. (Location)**	**ECHAM-A2 ΔT (°C)**			**ECHAM-B2 ΔT (°C)**		
			2020s	**2050s**	**2080s**	**2020s**	**2050s**	**2080s**
20	Batalagoda	Grid No. 20 (80.75E:81.25E, 7.75N:8.25N)	0.93	2.33	4.08	1.10	2.10	3.02
21	Maha Illuppallama	Grid No. 21 (81.25E:81.75E, 7.75N:8.25N)	0.86	2.13	3.80	0.95	1.80	2.60
22	Aralaganwila 1	Grid No. 22 (79.75E:80.25E, 8.25N:8.75N)	0.71	1.70	2.95	0.97	1.81	2.63
23	Aralaganwila 2	Grid No. 23 (80.25E:80.75E, 8.25N:8.75N)	0.90	2.17	3.94	1.08	2.07	2.95

Table 2.5 Projected Temperature and Precipitation changes for Rangpur Saddar (Bangladesh)

Emission Scenario	**Temperature (Change in °C)**		**Precipitation (Percentage change)**	
	2030s	2050s	2030s	2050s
A2	0. 73	1.32	4.9	8.1
B1	0.78	1.62	6.3	8.4

2.5 Simulations on Yield and Growing Season length

The simulations on yield and growing season length were made using DSSAT-based crop models for cereals; CERES-Wheat and CERES-Rice. DSSAT modeling system is an advanced physiologically-based crop growth simulation model and has been widely applied for understanding the relationship between crop yields, growth, development phases and its environment (Tsuji *et al.* 1994). DSSAT incorporates models that can work independently but can be integrated for a simulation requirement and uses one set of code for simulating soil, water, nitrogen and carbon dynamics, while crop growth and development are simulated with other modules. DSSAT imitates the true scenarios at daily time steps and the aspect of variability related to change in daily weather and soil condition are integrated. Hence it demands a large amount of input data for the model to run (soil data, weather data, management data and crop growth parameters). According to Tsuji et al. 1994, the system DSSAT is an excellent example of a management tool that enables individual farmers to match the biological requirement of a crop to the physical characteristics of the land for achieving specified objectives. Hoogenboom *et al.* (2010) have provided a detailed description of the model. An overview of the DSSAT simulation model is presented in Figure 2.2.

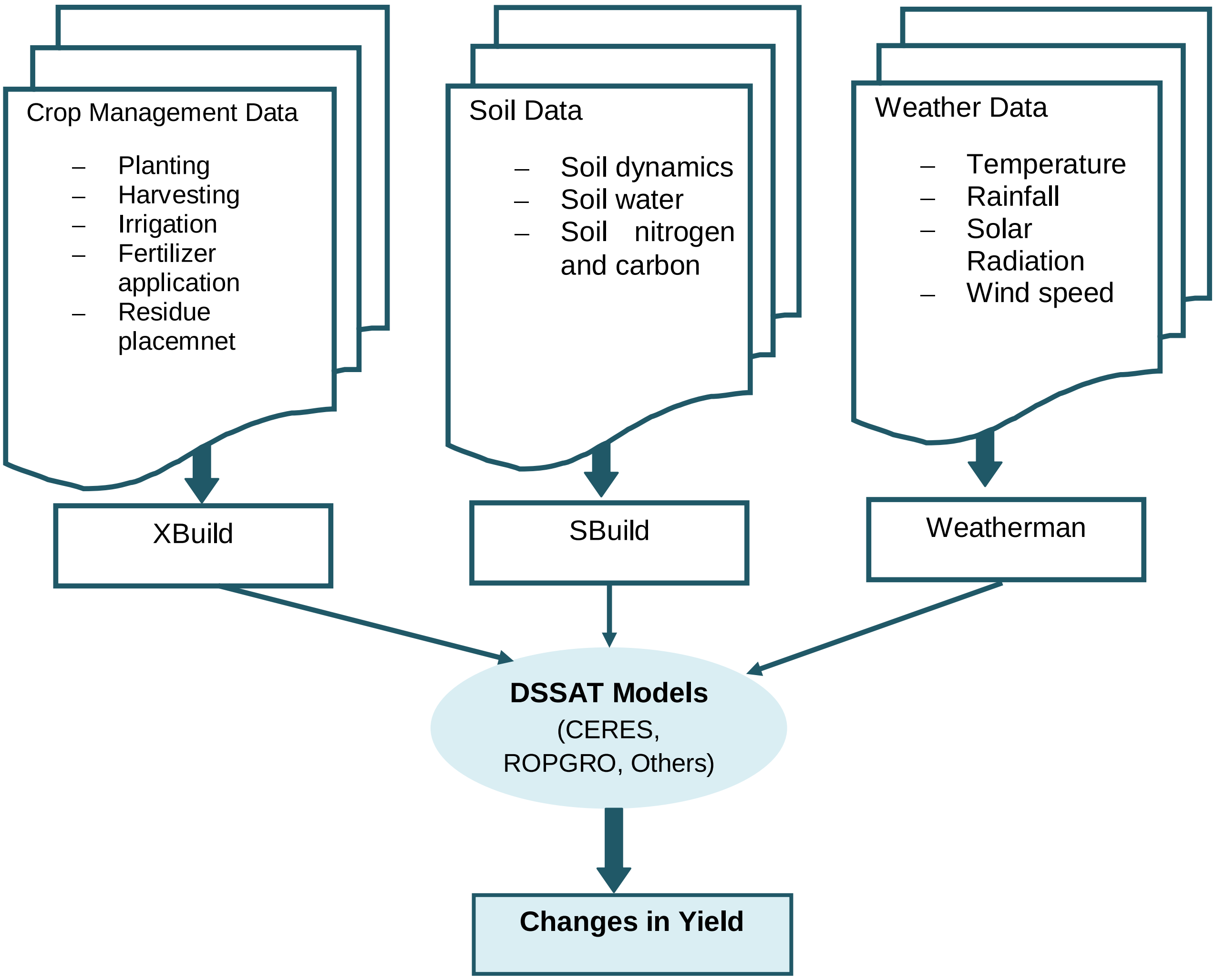


Fig 2.5: Description of DSSAT-based Crop Simulation Modeling Process.

Pre-calibrated crop simulations CERES-Wheat and CERES-Rice models were used in Pakistan (Iqbal *et al.* 2009, a and b) to assess the impact of climate change on crops under study in selected sites. PODIUM was used for the first time in Pakistan to assess the future food demand scenarios in the country.

In Sri Lanka, where no Crop Simulation modeling use capability existed prior to this project, a capacity building workshop was organized through the special funding by APN to enhance the capacity of the participating countries/organizations having no capacity to use of crop simulation models (viz. Sri Lanka and India). The workshop was organized in Kandy, Sri Lanka from 16-20 March 2009 and around 15 young researchers were trained. Developed country Partner Prof. Gerrit Hoogenboom provided this training to the participants. Crop and soil data used in the Training Course was collected from the field studies conducted by Department of Agricultural, Sri Lanka.

In Bangladesh, the climate scenarios used for this project were taken from the recent study (Yu *et al*. 2010) completed in Bangladesh. The Pre-calibrated model (CERES-Rice) was used for impact assessments and adaptation studies.

3.0 Results & Discussion

3.1 Impact Studies

3.1.1 *Bangladesh*

The result of future yield is shown as the % difference from base period yield. Here years-from 2004-2008 are considered as base year. The result from the simulation is given Table 3.1.

Table 3.1: Results on rice yield simulations for Bangladesh

Year	Yield (Mt/ha)	Yield reduction with respect to baseline (%)							
		A2				B1			
		2030		2050		2030		2050	
		(TP)	(TPC)	(TP)	(TPC)	(TP)	(TPC)	(TP)	(TPC)
2004	2.71	-32.93	-20.46	-40.34	-30.20	-29.24	-31.67	-61.43	-46.87
2005	2.59	5.24	9.10	-0.73	11.92	-3.36	0.27	-11.99	-7.64
2006	3.31	-8.67	-3.47	-21.54	-0.15	-4.23	0.42	-23.14	-8.25
2007	2.82	-7.90	-1.13	-12.11	2.94	-13.78	-10.02	-27.13	-24.30
2008	2.83	-11.41	-14.34	-24.47	-18.86	-16.38	-11.12	-36.72	-23.48
Av.	2.85	-11.14	-6.11	-20.05	-6.77	-13.13	-10.06	-31.88	-21.67

TP = Future Changes in Temperature and Precipitation considered

TPC = Future Changes in Temperature, Precipitation and CO_2 considered

From the simulation results, it is evident that in 2030, A2 scenario shows an 11% decrease in rice yield whereas B1 scenario gives a 13% decrease in yield (Figure 3.1). This is considering only the changes in rainfall and temperature in climate that are predicted to occur according to the climatic models used (SCENGEN). When changes in CO_2 are also considered, A2 scenario shows a 6% decrease and B1 scenario shows a 10% decrease in yield, by 2030. By 2050, the condition worsens more, with yield reduction of 20% and 31% in A2 and B1 scenario respectively when changes in temperature and rainfall are considered. When changes in CO_2 concentration are also considered, the yield reduction decreased to 7% and 22% for A2 and B1 scenario, respectively.

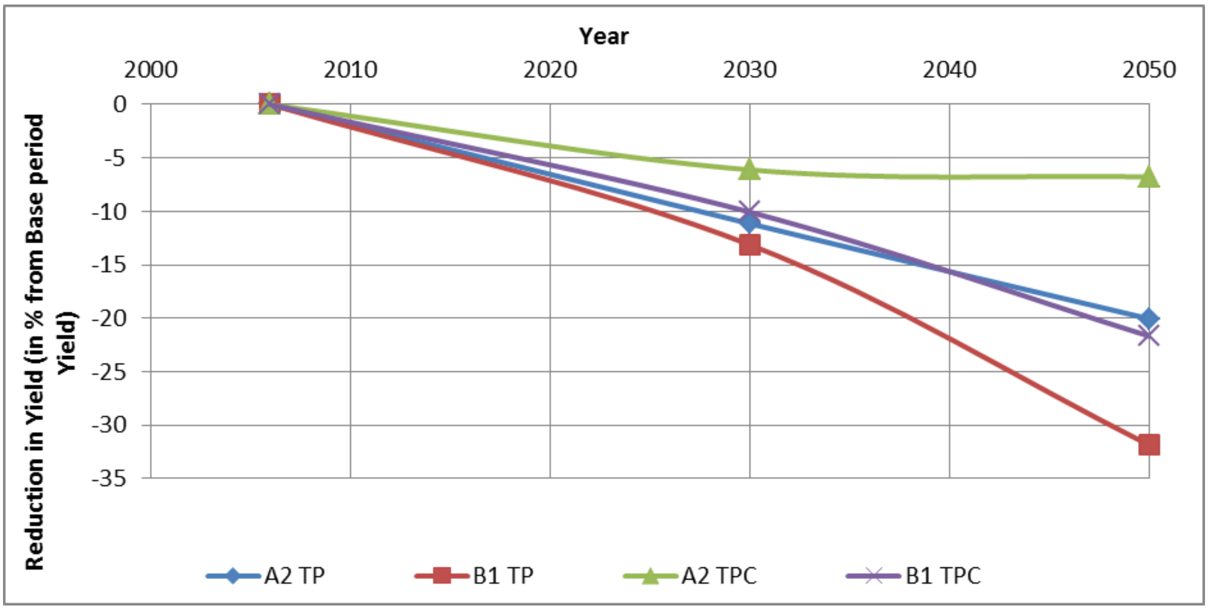


Figure 3.1: Changes in future yield under different climatic scenarios according to model simulations in Rangpur Sadar

The result shows that CO_2 has a positive impact on yield increase. Also, B1 scenario has higher yield reduction than A2, and 2050 will have higher yield reductions than 2030. This is due to the fact that temperature will be higher, as well as precipitation, in B1 scenario during 2050 than A2 scenario during 2030. Also, DSSAT employs constant multipliers for daily total crop biomass under elevated CO_2, equally applied to either stressed or unstressed growth conditions. The DSSAT response ratio for increases from 350 to 550 ppm CO_2 is 1.15. Elevated CO_2 alone increases plant photosynthesis, and thus increases crop yields (Kimball, 1983, Tubiello et al., 2000). But the predicted changes in temperature and precipitation might further affect crop yields, by hastening plant development, and by altering the water and nutrient budget in the fields, and modifying plant stress (Long, 1991, Tubiello *et al*, 1999). The drought condition of Aman rice in different emission scenarios in Rangpur Sadar considering changes in temperature, rainfall, and CO_2 is presented in Figure 3.2. The Figure 3.3 presents impacts considering only temperature and rainfall.

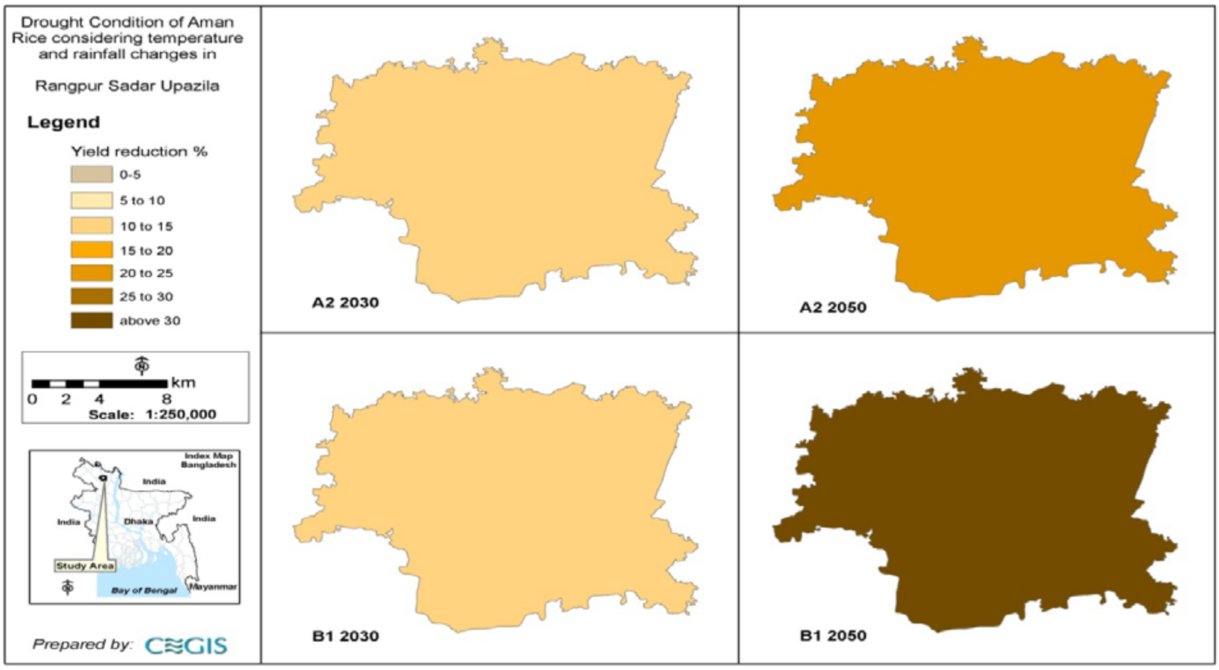


Figure 3.2: Drought condition of Aman rice in different emission scenarios in Rangpur Sadar considering changes in temperature and rainfall

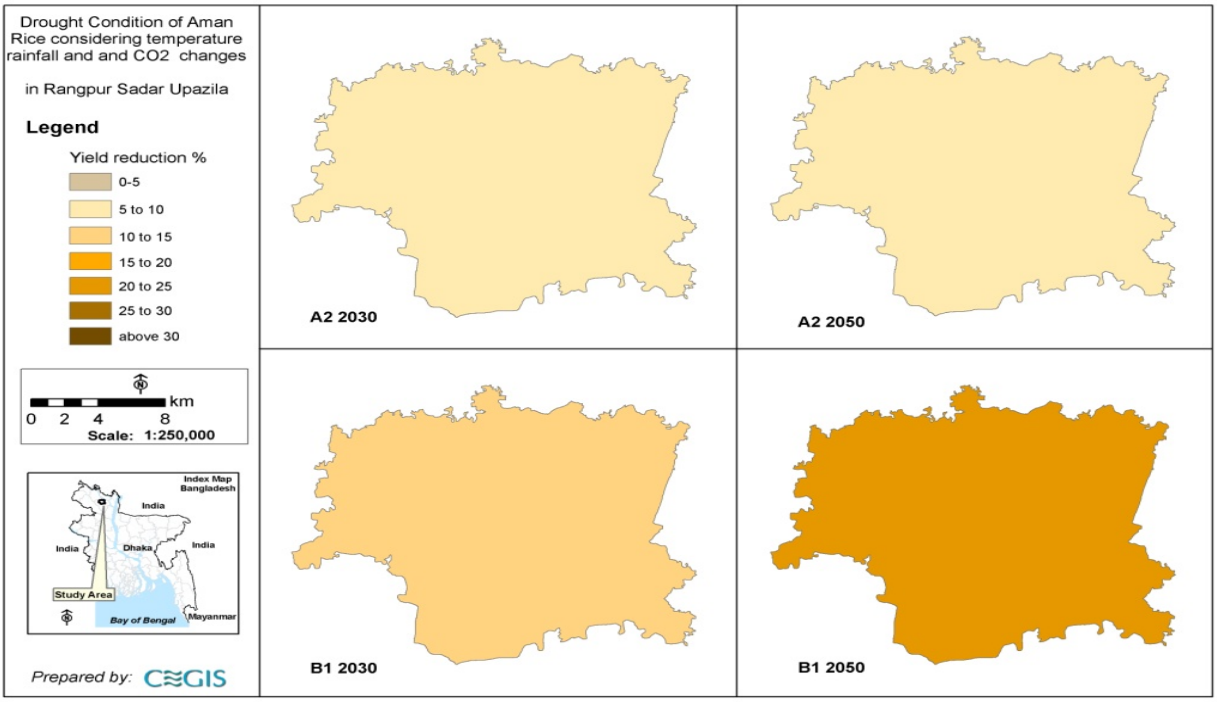


Figure 3.3: Drought condition of Aman rice in different emission scenarios in Rangpur Sadar considering changes in temperature, rainfall and CO2

3.1.2 Pakistan

The impact of climate change was studied on wheat and rice crops.

3.1.2.1 Wheat

Wheat is an important staple crop of Pakistan and a major determinant of food security. Previous studies show a significant impact of climate change on wheat yields in different agro-climatic zones of the country (Iqbal *et al.* 2009; Iqbal & Goheer, 2011)

a) Semi-arid Areas

The semi-arid areas occupy 11% of the total area of Pakistan. They normally receive annual rainfall of 250-500 mm and their Aridity Index (Thornthwaite, 1948) is 16-31. The major proportion of wheat production (around 40%) comes from the semi-arid areas. These areas have a significant role in national wheat production. Studies suggest that wheat yield will be declined both in Faisalabad and Sheikhupura in all of the three scenarios (2020s, 50s and 80s). The rate of decrease in yield is more in Faisalabad than at Sheikhupura (Table 3.2). This may be due to the slightly higher temperatures in Faisalabad. Further, the rate of decline in yield will be more in A2 scenarios than in B2 scenarios. This may be due to anticipated higher temperatures under the more globalized/ industrialized scenarios A2.

Table 3.2: Impact of climate change on wheat yield in Semi-arid areas of Pakistan.

Stations	**Baseline**	**2020's**		**2050's**		**2080's**	
	1961-1990	A2	B2	A2	B2	A2	B2
Faisalabad	4410	4198	4239	3986	4023	3857	3947
% Change		-4.8	-3.9	-9.6	-8.8	-12.5	-10.5
Sheikhupura	4523	4316	4361	4098	4160	3958	4069
% Change		-4.6	-3.6	-9.4	-8.1	-12.2	-10.1

Growing Season Length (GSL) of wheat was also found to be reduced from 148 days to 120 days in Faisalabad and from 152 days to 123 days in Sheikhupura (Table 3.3). The low growing duration leads to significant yield reduction of wheat because the metabolic activities of plants are hastened at higher temperatures and plant cultivar cannot express its normal genetic yield potential.

Table 3.3: Impact of climate change on wheat Growing Season Length (GSL) in Semi-arid areas of Pakistan.

Stations	**Baseline**	**2020's**		**2050's**		**2080's**	
	1961-1990	A2	B2	A2	B2	A2	B2
Faisalabad	148	140	137	131	132	120	124
% Change		-5.4	-7.4	-11.5	-10.8	-18.9	-16.2
Sheikhupura	152	143	141	133	135	123	127
% Change		-5.9	-7.2	-12.4	-11.2	-19.1	-16.4

b) Arid areas

The arid areas including hyper-arid areas comprise 48% of the total area of Pakistan. The arid areas normally receive annual rainfall of 150-250 mm and hyper-arid areas of <150 mm. The Aridity Index of arid areas is 8-16 and of hyper-arid areas <8. Arid areas are the second major contributor to wheat production in the country. Wheat yields are likely to reduce in all the four districts under study in these areas from 3.7% to 14.9% under A2 and B2 scenarios for the low, medium and high time scales (Table 3.4).

Table 3.4: Impact of climate change on wheat yield in the arid areas of Pakistan.

Stations	**Baseline**	**2020's**		**2050's**		**2080's**	
	1961-1990	A2	B2	A2	B2	A2	B2
Bahawalpur	4283	4057	4117	3794	3868	3683	3764
% Change		-5.3	-3.9	-11.4	-9.7	-14.0	-12.1
Multan	4306	4099	4146	3841	3923	3716	3832
% Change		-4.8	-3.7	-10.8	-8.9	-13.7	-11.0
Badin	3128	2968	3003	2781	2837	2685	2725
% Change		-5.1	-4.0	-11.1	-9.4	-14.1	-12.8
Hyderabad	3353	3185	3223	2963	3014	2853	2911
% Change		-5.0	-3.9	-11.6	-10.1	-14.9	-13.2

Wheat growing season length is also projected to decrease in all the study sites in these areas with consequent yield reductions (Table 3.5).

Table 3.5: Impact of climate change on wheat Growing Season Length (GSL) in the Arid areas of Pakistan.

Stations	**Baseline**	**2020's**		**2050's**		**2080's**	
	1961-1990	A2	B2	A2	B2	A2	B2
Bhawalpur	138	130	132	121	122	115	117
% Change		-5.8	-4.3	-12.2	-11.8	-16.7	-15.2
Multan	140	132	130	126	127	117	120
% Change		-5.7	-7.1	-10.0	-9.3	-16.4	-14.3
Badin	135	127	129	117	118	110	113
% Change		-5.9	-4.4	-13.3	-12.6	-18.5	-16.4
Hyderabad	134	125	127	113	114	108	113
% Change		-6.7	-5.2	-15.7	-14.9	-19.4	-15.7

c) Rainfed areas

Although not a major contributor to national wheat production, the Rainfed areas are important from subsistence and livelihood point of view. The study districts (Chakwal and Quetta) will suffer a decline in yield to the tune of 13% (Table 3.6). Reduction in growing season length in these areas, like semiarid and arid areas, could have serious implications for food security (Table 3.7)

Table 3.6: Impact of climate change on wheat yield in Rainfed areas of Pakistan.

Stations	**Baseline**	**2020's**		**2050's**		**2080's**	
	1961-1990	A2	B2	A2	B2	A2	B2
Chakwal	3271	3114	3144	2882	3038	2844	2990
% Change		-4.8	-3.9	-12.2	-7.1	-13.1	-8.6
Quetta	3067	2920	2948	2702	2868	2760	2822
% Change		-5.1	-3.8	-11.9	-6.5	-10.0	-8.0

Table 3.7: Impact of climate change on wheat Growing Season Length (GSL) in Rainfed areas of Pakistan.

Stations	**Baseline**	**2020's**		**2050's**		**2080's**	
	1961-1990	A2	B2	A2	B2	A2	B2
Chakwal	164	151	153	143	141	139	141
% Change		-7.9	-6.7	-12.8	-14.0	-15.2	-14.0
Quetta	169	150	152	142	144	134	138
% Change		-11.2	-10.1	-16.0	-14.8	-20.7	-18.3

3.1.2.2 Rice

Basmati Super rice yield will decline by 11% (by 2020s) to 21 % (by 2080s) both in Faisalabad and Sheikhupura (Table 3.8). The crop growing season length will also be curtailed to 96 days from 109 days in Faisalabad and 98 days from 111 days in Sheikhupura (Table 3.9). These results are in line with the previous findings (Iqbal *et al.* 2009).

Table 3.8: Impact of climate change on Rice yield in Semi-arid areas under A2 scenarios in Pakistan.

Stations	Baseline (1961-90)	**2020's**	**2050's**	**2080's**
Faisalabad	4210	3738	3507	3305
% Change		-11.21	-16.69	-21.49
Sheikhupura	4445	4316	4098	3958
% Change		-11.14	-15.80	-20.50

Table 3.9: Impact of climate change on Rice Growing Season Length (GSL) in semi-arid areas under A2 Scenario in Pakistan.

Stations	Baseline (1961-90)	**2020's**	**2050's**	**2080's**
Faisalabad	109	106	99	96
% Change		-2.8	-9.2	-11.9
Sheikhupura	111	108	101	98
% Change		-2.7	-9.0	-20.50

3.1.2.3 Food Requirements and Water Availability

Policy Dialogue Model (PODIUM) developed by International Water Management Institute (IWMI) was used to assess the future food (wheat and Rice) requirement under increasing population and reducing water availability trends. It is anticipated that there will be an overall shortfall of 31 MAF by 2025 (GoP, 2001). Since agriculture is the major user (around 96%) of water (Asian Development Bank, 2007) and Net Irrigation Requirements are likely to increase from 3 to 7% under 0.9^{0}C and 1.8^0 C temperature rise (Ahmad, 2010), agricultural production is expected to suffer drastically. Considering production constraint, both with and without water by 2025, wheat deficit will be 11.42 and 1.27 million metric Ton, whereas Rice deficit will be 1.80 and 1.07 MMT by 2025 (Table 3.10).

Table 3.10: Food Grain Situation in Pakistan by 2025

Food Item	Food Grain Consumption (MMT)	Production with no water constraint (MMT)	Production with water constraint (MMT)	Deficit with no water constraint (MMT)	Deficit with water constraint (MMT)
Wheat	38.97	37.70	27.55	-1.27	-11.42
Rice	5.27	4.2	3.47	-1.07	-1.80

3.1.3 Sri Lanka

Assessment of impact of climate change on food security was carried out by DSSAT-based crop growth model CERES-Rice with three popular rice varieties under A2 and B2 scenarios. The varieties BG-300, BG-357 and BG-358 were used in the study. These varieties cover more than 90% of the total rice area every year. These three varieties were tested under three rice eco-systems, namely, Major irrigation schemes, minor irrigation schemes and rainfed systems as shown in Table 3.11. Model calibration for those varieties was carried out using data available at Rice Research and Development Institute, Batalagoda, Sri Lanka.

3.11 The crop data used to calculate crop coefficients in Sri Lanka.

a) Crop data used under major irrigation schemes at Aralaganwila

Year/Location	Variety	Date of planting	Days to heading	Days to maturity	Yield (t/ha)
2011 Yala	**BG-300**	20/05/2011	69	96	5.89
	BG-357				
	BG-358	10/5/2011	80	112	4.98
2010/11 Maha	**BG-300**	12/11/2010	73	109	3.94
	BG-357	4/11/2010	75	111	4.98
	BG-358	4/11/2010	75	111	3.29
2010 Yala	**BG-300**	3/6/2010	67	102	6.55
	BG-357	25/05/2010	71	111	7.13
	BG-358	25/05/2010	75	105	5.54
2009/2010 Maha	**BG-300**	20/11/2009	67	96	5.15
	BG-357	18/11/2009	64	94	5.39
	BG-358	18/11/2009	65	95	5.18

b) Crop data used under minor irrigation schemes at Maha-Illuppalama

	Variety	Date of planting	Days to heading	Days to maturity	Yield (t/ha)
2010/11 Maha	**BG-300**	16/11/2010	70	96	3.04
	BG-357	12/11/2010	74	101	3.83
	BG-358	12/11/2010	79	100	3.59
2010 Yala	**BG-300**	10/6/2010	74	103	2.76
	BG-357	8/6/2010	81	106	2.54
	BG-358	8/6/2010	91	119	2.23
2009/2010 Maha	**BG-300**	2/12/2009	65	103	5.81
	BG-357	4/12/2009	68	100	4.655
	BG-358	4/12/2009	68	108	6.021

c) Crop data used under rainfed schemes at Batalagoda

Year/Location	Variety	Date of planting	Days to heading	Days to maturity	Yield (t/ha)
2010/11 Maha	**BG-300**	26/10/2010	61	102	3.33
	BG-357	10/10/2010	65	111	3.13
	BG-358	10/10/2010	65	107	2.78
2010 Yala	**BG-300**	13/05/2010	61	95	5.21

	BG-357	13/05/2010	61	90	6.21
	BG-358	13/05/2010	63	105	3.92
2009/2010 Maha	**BG-300**	19/11/2009	62	96	3.668
	BG-357	11/11/2009	69	101	4.291
	BG-358	11/11/2009	67	100	3.918

Weather data collected at each station were used to compile the weather file for the DSSAT software. Following soil data collected from each site was used as the soil inputs for the CERES-Rice model (Table 3.12).

Table 3.12. The soil data used as input to the CERES-Rice model in Sri Lanka.

a) Aralaganwila - Galwewa series

Moderately deep, imperfectly drained soil.

Colour : Surface- Dark grayish brown; Sub surface – Brownish yellow; Texture – Loamy sand

Horizon	**Depth (cm)**	**Sand %**	**Silt %**	**Clay %**	**Bulk density (Mg/m^3)**	**Saturated hydraulic conductivity ($cm\ h^{-1}$)**
Surface	0-20	93	2	5	1.4	52.6
Sub surface	20-110	98 -95	1-3	4-8	1.5	16-20

	pH	EC	CEC	Base saturation	Organic carbon %	Available P (mg/kg)
Surface	5.6	0.2	2. 8	100	0.4	0.4
Sub surface	6 – 6.2	0.05	1.6 - 3	81 -100	0.01-0.2	0.1-0.2

b) Mahailluppallama – Aluthwewa series

Reddish brown earth soil, well drained.

Colour: Surface – Dark brown to brown; Sub surface – Reddish brown to red; Texture – Sandy loam

Horizon	**Depth (cm)**	**Sand %**	**Silt %**	**Clay %**	**Bulk density (Mg/m^3)**	**Saturated hydraulic conductivity ($cm\ h^{-1}$)**
Surface	0-25	72	15.7	12	1.4	33.1
Sub surface	25-140	54-67	11-15	19-32	1.4-1.6	3-11

	pH	EC	CEC	Base saturation	Organic carbon %	Available P (mg/kg)

Surface	6.5	0.09	10. 8	99	0.2	5.5
Sub surface	7	0.06-0.1	12-17	68-78	0.5-1.5	0.0-8.5

c) Batalagoda- Batalagoda series

Low humic gley soil

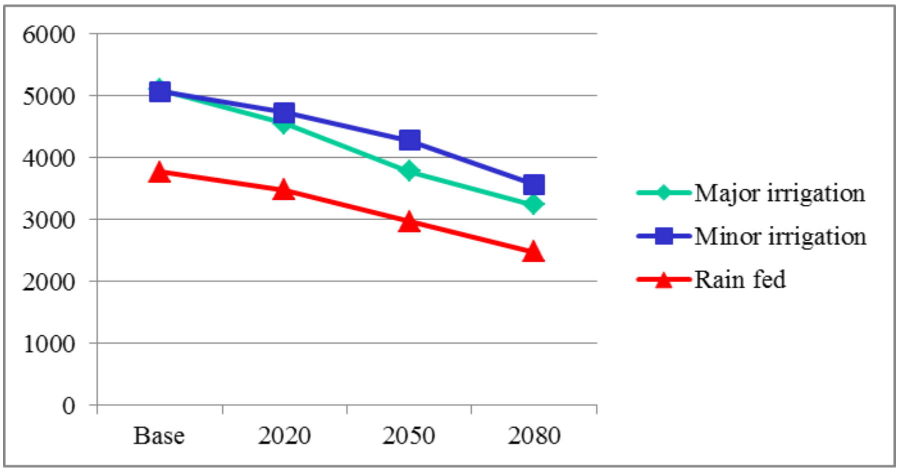
Colour: Surface- Grey

Latitude – 7.52, Longitude –8 0. 45

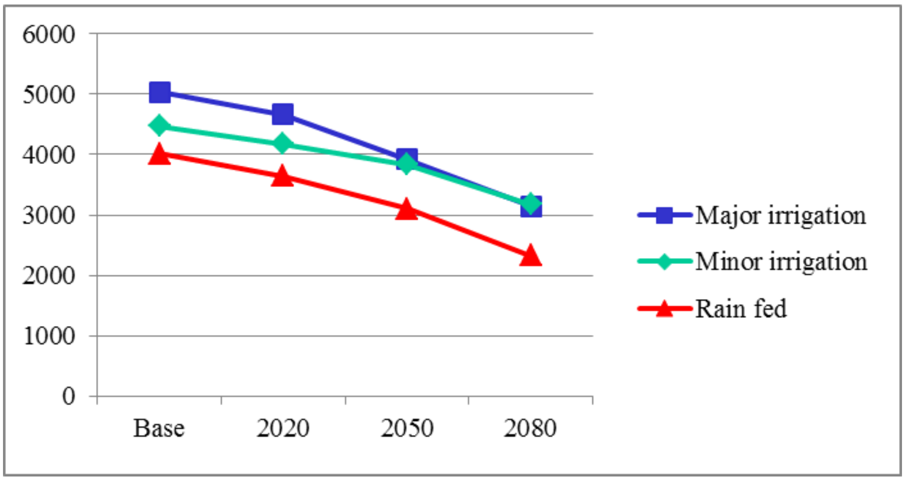
Horizon	**Depth (cm)**	**Silt %**	**Clay %**	**Organic carbon %**	**Total N (%)**	**pH**	**CEC**
Surface	0-19	14	16	0.68	0.1	6.1	11.4
Sub surface	19-40	13.3	16.1	1.91	0.05	6.6	10.9
	40-77	13.7	20. 8	0.94	0.06	6.4	13.2

The following figures show trends of rice yield of three rice varieties used in the study during the two major rice growing seasons in Sri Lanka, namely, Maha season and Yala season. Results have been shown for A2 and B2 scenarios independently.

a) BG-300



b) BG-357



c) ***BG-358***

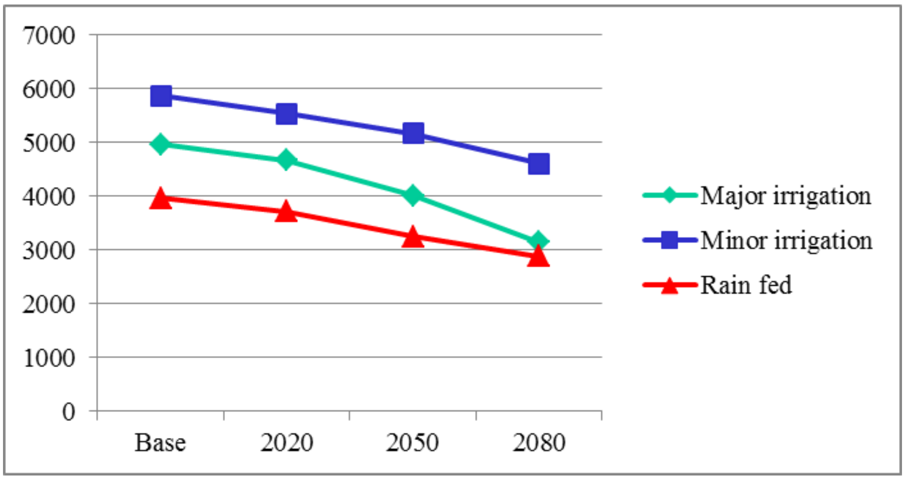
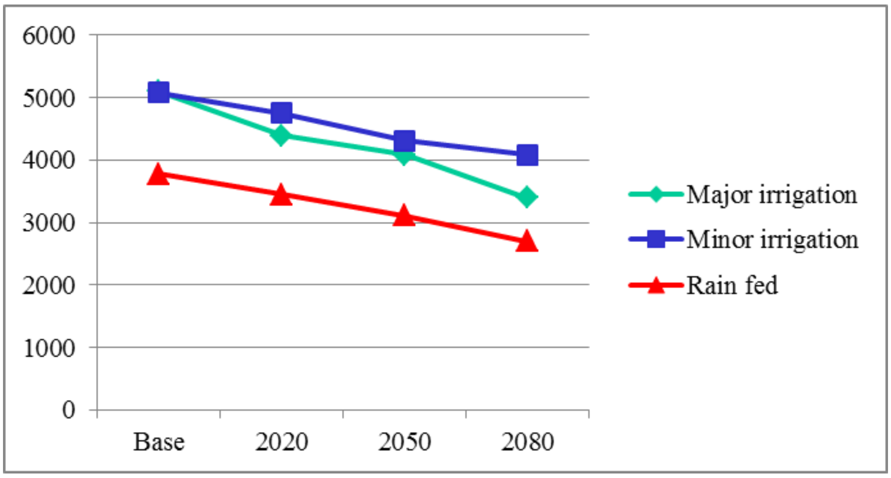
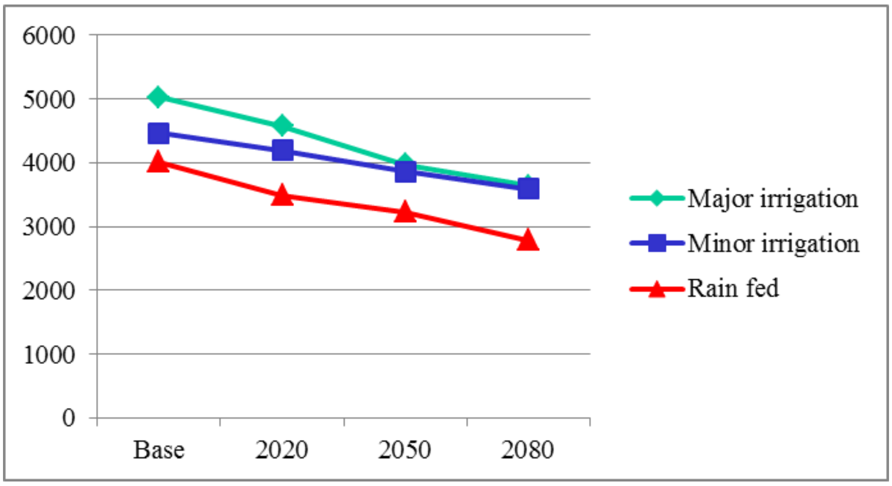


Fig. 3.4. Rice yield (kg/ha) under A2 scenario in different rice eco systems in Maha season in Sri Lanka.

a) ***BG-300***



b) BG-357



c) BG-358

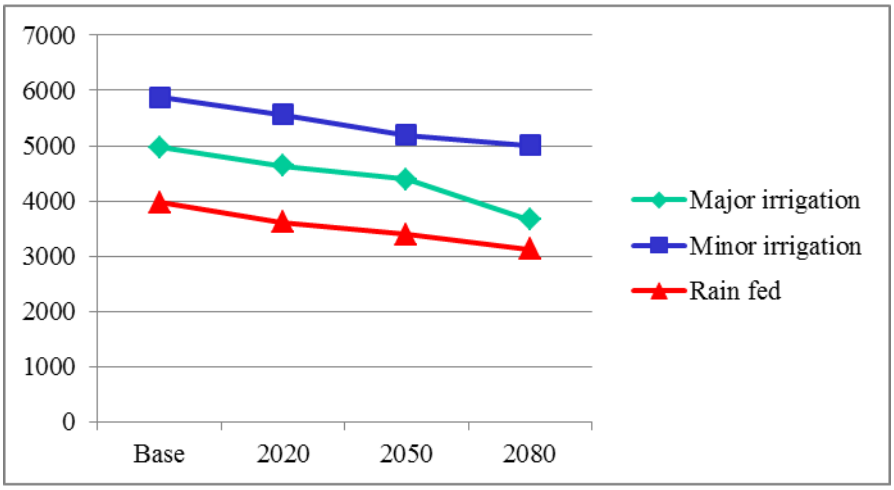


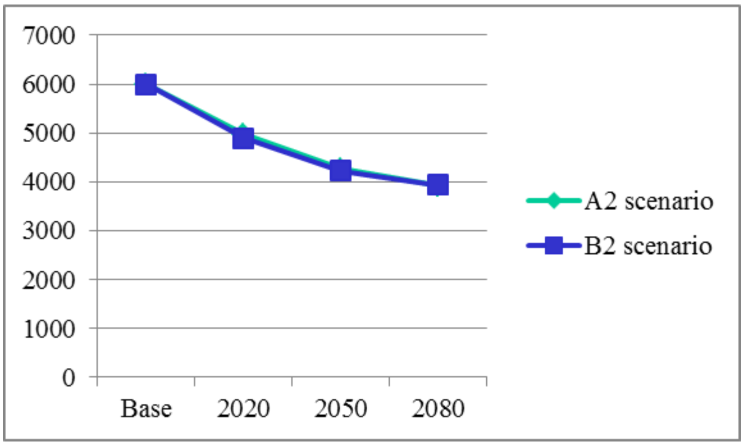
Fig. 3.5. Rice yield (kg/ha) under B2 scenario in different eco systems in Maha season in Sri Lanka.

As observed in the fields as well as model simulations, the rainfed rice cultivation gave the lowest yields than major and minor irrigation systems. With the climate change under A2 and B2 scenarios yield is likely to reduce gradually from 2020 to 2080. It was interesting to note that when the 3-month variety was considered, the performance was similar under both climate scenarios until 2050s. With B2 scenario, rice under major irrigation schemes will be more resilient to climate change. Results further reveal that yield reduction of 3.5-month varieties (BG-357 and BG-358) is greater than that of 3-month varieties (BG-300). Moreover, BG-358 performs better than BG-357 under changing climate.

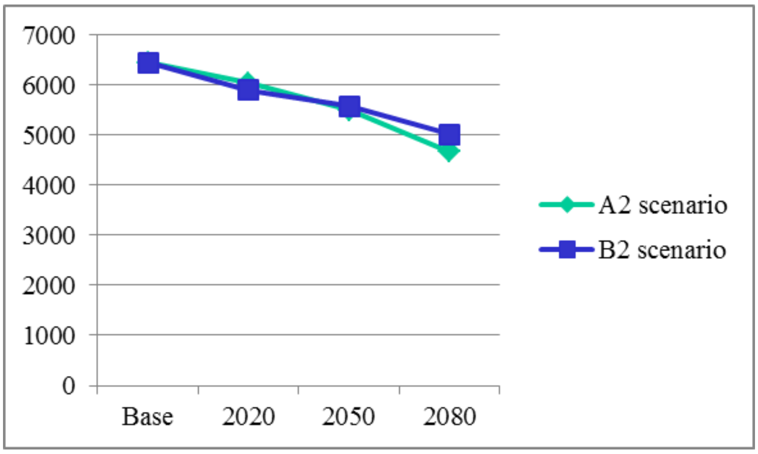
3.1.3.4 Rice yield (kg/ha) in Yala season under A2 and B2 climate scenarios

During Yala season (minor rainy season), rice is not cultivated under rainfed system in any part of the Dry zone of Sri Lanka. Therefore, field trials were conducted only under Major and minor irrigation schemes. Results on yield under Major irrigation system are presented in Fig. 3.6 and under Minor irrigation schemes in Fig. 3.7.

a) BG-300



b) BG-357



c) BG-358

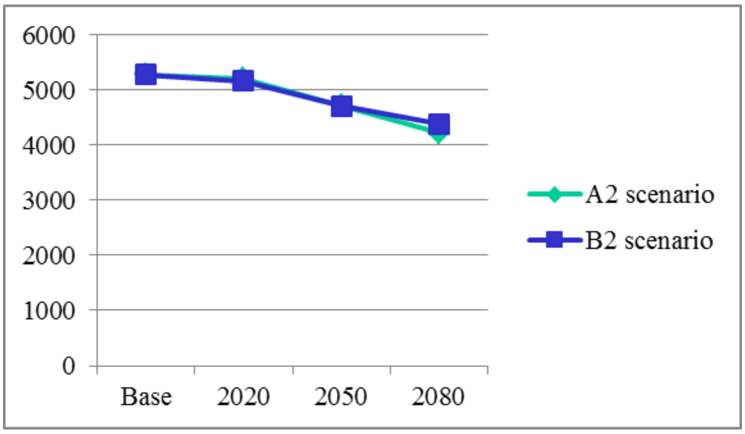
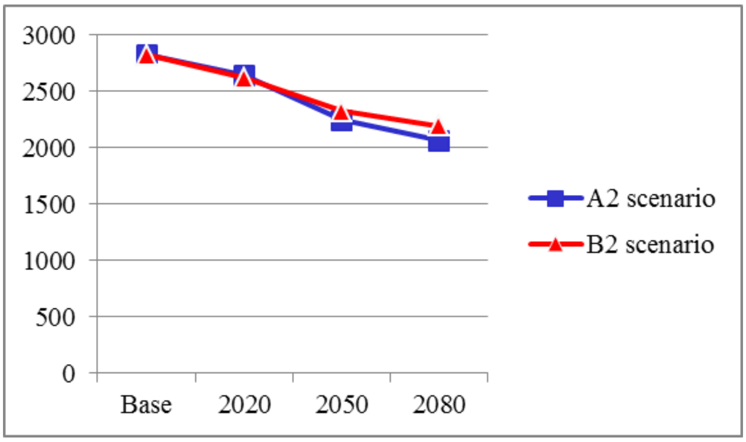


Fig. 3.6. Rice yield (kg/ha) in Yala season under Major irrigation schemes in Sri Lanka.

a)   BG-300



b)   B- 357

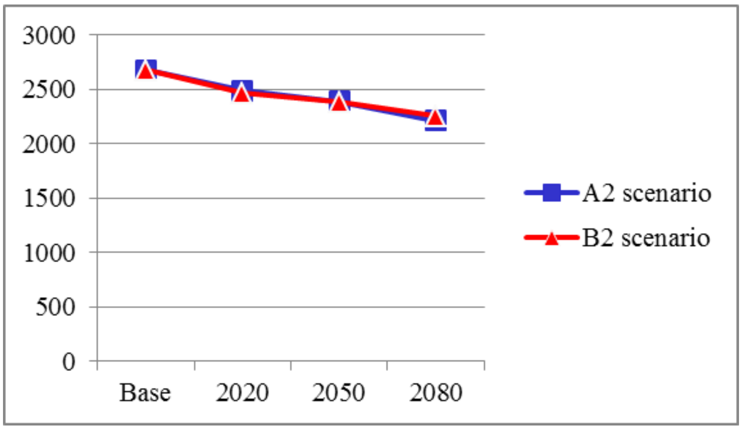


Fig. 3.7. Rice yield (kg/ha) din Yala season under Minor irrigation schemes in Sri Lanka.

Results revealed that in Yala season, yields are higher than in Maha season for all varieties under study. This is mainly attributed to higher solar irradiance during Yala seaaason compared to Maha season where cloud cover limits the solar irradiance. Moreover, there was no difference between A2 and B2 climate scenarios during Yala season with any of the tested varities. Both 3-month (BG-300) and 3.5 month varieties (BG-357 and BG-358) show a gradual reduction in yield under climate change.

3.2 Adaptation Studies

The results obtained under this Project in Pakistan, Bangladesh and Sri Lanka amply show that climate change is likely to depress grain yields of wheat and rice in the main growing areas of these countries. The literature including IPCC reports and the papers published from the region and from other tropical/subtropical countries in the international journals also corroborate the negative impacts of climate change on the yield of major food crops. Such yield losses when combined with increasing population pose serious risk to food security of the region particularly of South Asia. This points to the need for adaptation measures, that is, how to cope with the negative impacts or how to make farming practices resilient to climate change. Some of the adaptive measures proposed/evaluated by the participating countries are described below:

3.2.1 *Bangladesh*

No specific adaptation studies were conducted. Instead based on the results obtained on impact assessment of climate change on yield of rice, the following adaptation options were proposed for the researchers and policy makers:

- Adoption of new varieties and species of crops with increased resistance to heat stress, shock and drought.
- In case of seasonal shift of monsoon, the consequent shift in planting date may be considered. For this, at least 20 days forecast will be required to know the onset of monsoon in order to inform the farmers in time for seedbed preparation and raising seedlings for Aman rice.
- Modification of crop calendars, i.e., timing or location of cropping activities according to water stress (with due consideration to livelihood adaptation)
- Mulching to decrease evaporation from the soil surface.
- Conservation tillage on top soil (to avoid land cracks of topsoil)
- Developing climate resilient cropping patterns suited to different regions, by conducting field trials on climate compatible cropping patterns and associated water management systems

In addition to the farm level measures, the government should also take some initiatives to help farmers to withstand the losses. Government can take the following measures:

- Support to farmers from Government in case of major crop failures by appropriate price subsidies, food for work program, credit and saving schemes at least until the harvest of the follow up crops
- Government may give support to the farmers in case of exceptional drought years; normally 1 out of 5 or 1 out of 10 years, with drought relief or introducing crop insurance
- Building food reserves is a planning level adaptation option which needs to be executed and managed by the government so that in extreme drought years, people do not die of hunger in the vulnerable areas
- Implementation of seasonal climate forecasting by different government organizations so that timely warning is given to the farmers is also an important measure that might be taken by the government
- Additional adaptation strategies may involve land-use changes that take advantage of modified agro climatic conditions. Land type selection can be done from planning level by identifying agro-economic zones vulnerable to climate change
- Development of organized seed production and supply system and extension mechanism needs to be considered
- Provision of appropriate law to protect specific users' rights in extreme cases is needed.

3.2.2 *Pakistan*

Some adaptive measures were identified, as per the project plan of work, and evaluated using crop simulation models CERES-Wheat and CERES-Rice. Increasing the crop fertilizer application rate, splitting of fertilizer application, change in sowing dates, use of increased seed rates and improved irrigation scheduling in case of wheat and dry sowing in case of Rice were tried as adaptation strategies. For adaptation studies, the yield of respective districts in the study zones were averaged out and used as the baseline yield. The results obtained are briefly described below:

- **Increasing the rate fertilizer application**: The recommended rate of nitrogenous fertilizer application to wheat is 150 kg N/ha (NARC, 2010) but most of the farmers apply 125 kg N/ha due to various reasons, e.g. non-availability or late availability of fertilizer, low financial resources of farmers. The increased rate of fertilizer application at 175 and 200 kg N/ha were studied as an adaptation measure to protect/increase the yield. The rate of 175kg N/ha was able to sustain the baseline yields by 2020s and 2050 under both A2 and B2 scenarios (Table 3.13)

Table 3.13: Effect of change in Nitrogenous Fertilizer application Rates on yield of wheat in different areas of Pakistan.

Study Sites	Baseline	Fertilizer application Rate (kg N/ha)	2020s	2050s	2080s
Semi-arid	4466	175	4439	4111	3950
		200	4510	4220	4012
Arid	3757	175	3711	3329	3123
		200	3805	3432	3196
Rainfed	3169	175	3014	2717	2535
		200	3116	2813	2695

- **Split application of fertilizer**: The normal practice of farmers is to apply the fertilizer amount either as a whole at the time of sowing or in two splits at sowing plus at first irrigation. The application in 3 splits (at sowing, first irrigation and tillering) was compared with the conventional 2 splits (at sowing and first irrigation). The 3-split application increased the yield only under 2020s scenario and not for the later period (Table 3.14)

Table 3.14: Wheat yield as affected by 3-split application of nitrogenous fertilizer in Pakistan.

Study sites	Baseline (2 splits)	2020s	2050s	2080s
Semi-arid	4466	4510	4235	4019
Arid	3757	3694	3432	3139
Rainfed	3169	-	-	-

- **Shift in the sowing window of wheat**: Change in the sowing time to escape the heat shock to seedlings/plants at the sensitive growth stages, seems to be a good short term strategy to cope with the negative impacts of climate change. In this study (Table 3.15), both the sowing dates (2nd week of October and 2nd week of December) gave lower yields than the recommended date of 2nd week of November; the yield reduction was, however, lesser in the December sowing. In an earlier study also (Sultana *et al*, 2009) sowing of wheat in the cooler months gave better results.

Table3.15: Impact of shift in the sowing date on yield of wheat in the agro-climatic zones of Pakistan.

Study Sites	**Baseline (2nd week of November)**	**Sowing Date**	**2020s**	**2050s**	**2080s**
Semi-arid	4446	2nd Week of October	4487	4321	3860
		2nd week of December	4390	4200	3911
Arid	3757	2nd Week of October	3716	3364	2988
		2nd week of December	3786	3809	3544
Rainfed	3169	2nd Week of October	3195	2835	2763
		2nd week of December	3014	2618	2192

- **Use of higher seed rate**: Application of higher seed rate (150 kg/ha instead of 125 kg/ha) showed promise to sustain the baseline yields upto 2020s under A2 and B2 scenarios both in the arid and semi arid areas (Table 3.16).

Table 3.16: Effect of change in seed rate on wheat yield in the three areas under study in Pakistan.

Study Sites	**Baseline**	**Seed Rate kg/ha**	**2020s**	**2050s**	**2080s**
Semi-arid	4466	125	4423	4019	3853
		150	4512	4211	3919
Arid	3757	125	3721	3222	3029
		150	3819	3346	3107
Rainfed	3169	125	2989	2609	2521
		150	3027	2718	2539

Irrigation scheduling of wheat: Under the scenario of shortage of water supplies in the arid and semi-arid areas, the option of increasing the number of irrigations without increasing the total quantity of irrigation water during the growing season, i.e., 225 mm, was tested. The results are presented in Table 3.17. Increasing the number of irrigations to five (45 mm water per irrigation) at crown root initiation, tillering, late jointing, flowering and dough stages instead of three (75 mm water per irrigation) at crown root initiation, tillering and flowering stages had positive impact on wheat yield. The yield was improved (upto 38%) under B2 scenario (Table 3.17).

Table 3.17: Effect of applying the same amount of irrigation water in five irrigations rather than three on yield of wheat in Pakistan.

Scenario	Baseline Yield (Kg/ha)	A2			B2		
		2020s	2050s	2080s	2020s	2050s	2080s
Semi Arid	4446	4441	4096	3715	5077	4699	4294
Arid	3757	3467	3133	2816	4159	3783	3435

- **Direct seeding of rice**: Rice is a high delta crop hence sensitive to declining water availability. With increasing water scarcity, alternate methods of establishing rice that require less labor and water without sacrificing yield are needed. The feasibility of dry/direct seeding under the semi arid conditions was assessed by comparing its yield with the yield of transplanted rice. By Direct seeding of rice water use efficiency was increased with non-significant reduction in crop yield (Table 3.18).

Table 3.18: Water use efficiency as influenced by 'Direct Seeded' and 'Transplanted Rice' in Pakistan.

Locations	**Water Use Efficiency of Transplanted rice (kg/m^3) (17irrigations)**	**Water Use Efficiency for Direct seeded rice (kg/m^3) (13irrigations)**
Faisalabad	2.91	3.68
Sheikhupura	3.10	3.82

Agronomic adaptation strategies of adjustments in the sowing dates and change in irrigation frequency were effective in sustaining the baseline yields under 2020s climate change scenarios, and in some cases for 2050s, whereas for longer term scenarios (2080s) the adaptation strategies investigated were not sufficient to maintain yields, suggesting that additional technological practices, such as changes of cultivar traits and/or of cropping systems may be required to further minimize risk.

3.2.3 Sri Lanka

No adaptation studies were conducted as such, however, based on the modeling studies' results of reduction in yield and future drier picture of the country under changing climate, it is proposed that rice varieties that have low water requirement and can tolerate the temperature extremes may be developed.

4.0 Conclusions

4.1 Bangladesh

The major objective of this study was to assess food and water security in Bangladesh under different climate change scenarios using a crop simulation model. DSSAT was used for rice yield simulations in Rangpur Sadar upazila of Rangpur district. The DSSAT was applied to assess the drought impact on Aman (monsoon rice) in the selected site. The simulation has been carried out for SRES Emission scenarios A2 and B1 and for the periods 2030 and 2050, while 2004-2008 period was taken as the base period. The model results showed that the rice yield will be reduced both by 2030s and 2050s; the reduction will be higher in B1 scenarios than A2. The results showed further that yield reduction will be higher when only the impact of temperature and precipitation was considered. The yield losses will be lower when the change in CO_2 was also considered in addition to changes in temperature and precipitation. This is due to carbon fertilization impact. Future yield reduction will have profound impact on the food security situation of the country where almost 32% of the population is still food insecure. At the same time, population is increasing very rapidly and cultivable land area is decreasing due to huge population pressure. Therefore the country needs more food to feed the ever increasing population. In such a situation climate change will be an additional threat to the food security of the country. However, to minimize the climate change impact on agriculture, adequate and appropriate adaptive measures should be taken at both farm levels as well at Government planning level. Shifting of the planting date, modification of crop calendar and development of climate resilient cropping pattern could be very efficient adaptive measures to withstand the impact of drought. In addition Government can also take several measures like credit support, agricultural subsidies to the farmers which can help farmers to minimize the losses from drought due to changing climate scenarios.

4.2 Pakistan

Wheat: In the semi-arid irrigated areas (Faisalabad and Sheikhupura), the yield will be reduced by 3.4 -12.5%, under both A2 and B2 scenarios towards the end of 21^{st} century. The GSL will also be reduced from 148 to 120 days in Faisalabad and from 152 to 123 days in Sheikhupura. In the arid areas (Multan & Bahawalpur, Badin and Hayderabad), the yield is likely to be reduced by 3.8 -14% under A2 & B2 scenarios from up to 2080s whereas GSL will be reduced from 134 days to 113days. In the rainfed areas (Chakwal and Quetta), the yield is likely to be reduced up to 16% under A2 scenario by 2080s.

Rice: In the Basmati rice tract, the yield is expected to be reduced by 10.4%, 16.5% and 17.8% under B2 scenario by 2020s, 2050s and 2080s, respectively. Under A2 scenario, the yield is expected to decline by 11.4%, 15.8% and 21.5 %, respectively by 2020s, 2050s and 2080s.The growing season length will also be curtailed from 110 days to 98 days resulting in significant decline in yield.

In general***,*** an increase in temperature will lead to shortening of Growing Season Length (GSL) for wheat and rice crops in all the selected wheat growing districts and Basmati rice tract of the country. The results suggest that the aggregate impact of climatic parameters i.e, changes in temperature and rainfall exerted an overall negative impact on cereal crop yields, given that the management practices and use of technology remain unchanged.

4.3 Sri Lanka

The study revealed that the average annual temperature of Sri Lanka will increase by 2.5 – 4.5 ^{0}C under A2 scenario 2.5 – 3.5 ^{0}C under B2 scenario by the year 2080. In terms of future rainfall regime of Sri Lanka, projections with A2 scenario reveal that Dry zone will become drier while the Wet zone and Intermediate zones will become wetter than at present as we reach the end of this century. The results revealed that rice yield of 3.5-month varieties may decrease by 26% by the year 2080 compared to the base period. The yield reduction in the 3-month varieties would be about 31% by the year 2080. Of the two major growing seasons, Maha season rainfed rice eco-system is the most vulnerable to the adverse impacts of climate change.

4.4 *General Conclusions*

The studies conducted in Pakistan, Bangladesh and Sri Lanka reveal that climate change, manifested by increase in temperature in the main cereal crop growing areas of these countries, will negatively affect the yield of staple crops of wheat and rice thereby posing threat to food security of this densely populated region. In Pakistan the wheat yield will be reduced by 3 to 15% and the rice yield by 11 to 21% under both A2 and B2 scenario by the end of the century. In Bangladesh, rice yield will be reduced to a greater extent under B1 than A2 scenario. Also, the reduction will be higher when only temperature and precipitation are taken into account; the yield reduction will be lesser when CO_2 is also considered, due to the fertilization effect of CO_2. In Sri Lanka, the rice yield of medium duration 3.5-month varieties will decrease by 26% while those of short duration 3-month varieties by 31% by 2080s.

Such likely yield reductions call for adaptation measures to protect/increase the yield. Some adaptation measures like increased rate of fertilizer application, use of higher seed rate, 3-split application of fertilizer, change in sowing window, improved scheduling of irrigation and dry sowing of rice have been evaluated and have shown promise to maintain/increase yield.

5.0 Future Directions

Based on the results obtained under the project, further studies can be designed on the following lines:

- The present project focused only on the 'Production' aspect of the crop-based food system which is only a part of the whole food system. The food may be sufficient but due to some adverse prevailing conditions, such as disruption in communication infrastructure, spoilage due to improper storage, damages due to natural disasters, it may not be available to the consumers in time or in sufficient quantities. The studies, therefore, can be designed to focus on other aspects of the food system, e.g. storing, processing, packaging, transportation, marketing and consumption.
- Quality of food is another characteristic which is drastically affected by changes in the climatic parameters. The milling and cooking quality of rice, taste, palatability of fodder crops etc may be affected by changes in humidity and temperature. This aspect of food system deserves systematic studies.
- Evaluation of relevant adaptation strategies to cope with the adverse impacts of climate change. Sri Lanka and Bangladesh can evaluate the adaptation strategies, identified by them in the present project, using crop simulation models.
- Assessment of impacts of natural disasters on food production in the disaster prone areas. The disasters lead to transient or permanent hunger, malnutrition or poverty in some sections of the population.
- Satellite imagery has come up as the latest tool for spatial and temporal assessment of food security. Projects can be designed to assess food security status using Remote Sensing and Geographic Information System techniques.
- Impact assessment of climate change on natural productive resources, e.g. impacts on land degradation, crop water use efficiency.
- Vulnerability assessment of fragile ecosystems, e.g. mountainous areas, coastal areas, deltaic areas.
- Socio-economic impacts of climate change including impacts on poverty, livelihood and income.

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APPENDICES

Appendix – I

Activities organized under APN ARCP2009-08CMY-Iqbal

Workshops

- **a)** Project start-up meeting, 12-15 August 2008, Kathmandu, Nepal
- **b)** Training Workshop on operation / use of crop simulation models, 16-10 March 2009, Kandy, Sri Lanka
- **c)** Workshop on preliminary research results, 08-12 March 2010, Islamabad, Pakistan
- **d)** Workshop on comprehensive research result, 15-18 Jan 2013, Islamabad, Pakistan

Seminars

- **e)** National Seminar for policy makers and Planners, 08 July, 2013, Islamabad, Pakistan
- **f)** National Seminar for Policy makers and Planners, 10 July, 2013, Dhaka, Bangladesh
- **g)** National Seminar for Policy makers and Planners, 11 July, 2013,Maha-Illupplallama, Sri Lanka

a) APN Startup Workshop

Program

APN ARCP Start-up Workshop on

Assessment of Food and Water Security in South-Asia under a Changing Climate Using Crop Simulation and Water Management Models, and Identification of Appropriate Strategies for Adaptation to Meet Future Demands

Kathmandu, Nepal
August 10-12, 2008

Day 1	**Sunday, August 10, 2008**
0830-0930	Registration
0930-0940	Welcome address by Dr. Madan Lal Shresta, Academician, Nepal Academy of Science and Technology, Kathmandu, Nepal
0940-0950	Opening speech by Project Leader, Dr. M. Mohsin Iqbal, Head Agriculture, Global Change Impact Studies Centre (GCISC), Islamabad, Pakistan
0950-1000	Introductions of the participants
1000-1030	Aims and Objectives of the Project – Dr. M. Mohsin Iqbal
1030-1045	Tea/Coffee Break
1045-1245	**Country Presentations**
1045-1105	Bangladesh (Mozahar ul Alam)
1105-1130	India (Kamal Vatta)
1130-1155	Nepal (Ajaya Dixit)
1155-1220	Pakistan (Arif Goheer)
1220-1245	Sri Lanka (P. Batugedara)
1245-1300	Discussion
1300-1430	**Lunch**
1430-1515	Water- A finite resource (Sarfraz Ahmad)

1515-1600	Role of crop simulation models (Gerrit Hoogenboom)
1600-1615	**Tea/Coffee Break**
1600-1645	Food Security and challenges of Climate Change (Arif Goheer)
1645-1700	Discussion
2000-2130	**Reception Dinner**
Day 2	**Monday, August 11, 2008**
0900-1030	Setting the foundation for Studies -Discussion (Moderator-Mohsin Iqbal)
1030-1045	Tea/Coffee Break
1045-1145	DSSAT Capabilities in assessing the impact of climate change on crop productivity (Gerrit Hoogenboom)
1145-1245	Use of PODIUM(Policy Dialogue Model) in Food and Water security studies (Arif Goheer)
1245-1415	Lunch
1415-1515	Scenario Development (climate change + water + Food consumption) (Shahbaz Mehmood and Arif Goheer)
1515-1700	Learning from the past experiences, GECAFS and IGP Studies, problems and opportunities) + Working Tea/Coffee (Moderator – Rajinder Sidhu))
1800-	Excursion activity
Day 3	**Tuesday, 12, 2008**
0900-1030	Integrating Scenarios for policy options - Discussion (Moderator- Gerrit Hoogenboom)
1030-1045	Tea/Coffee Break
1045-1300	Concluding session & Way Forward (Moderator – Mohsin Iqbal)
1300-1430	Lunch

Workshop closed

APN ARCP Start-up Workshop on

Assessment of Food and Water Security in South-Asia under a Changing Climate Using Crop Simulation and Water Management Models, and Identification of Appropriate Strategies for Adaptation to Meet Future Demands
Kathmandu, 10-12 August, 2008

List of Participants and detail address

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USA [Resource Persons]			
21	Dr. Gerrit Hoogenboom, Professor and Coordinator of Research, Extension and Instruction	Department of Biological and Agricultural Engineering, University of Georgia, Griffin, Georgia 30223-1797, USA	gerrit@uga.edu +00-1-770-2293438

b) **Regional Training Workshop on Crop Simulation Modeling**

APN ICASA

Assessment of Food and Water Security in South-Asia under Changing Climate using Crop Simulation and Water Management Models, and Identification of Appropriate Strategies to Meet Future demands

A Training Program on DSSAT Version 4.5

Assessing Crop Production, Nutrient Management, Climatic Risk and Environmental Sustainability with Simulation Models

March 16 – 20, 2009

Royal Garden Mall Hotel
Kandy, Sri Lanka

International Consortium for Agricultural Systems Applications (ICASA)
Asia-Pacific Network for Global Change Research (APN)
Global Change Impact Studies Centre, Islamabad, Pakistan
Natural Resources Management Center, Department of Agriculture, Sri Lanka
The University of Georgia, Griffin, Georgia, USA

The University of Georgia

Introduction

Day	Hour	Activity	Responsibility
Monday March 16			
	0830	Registration	
	0900	Welcome address	Dr. Punyawardena
	0905	Lightning of the traditional oil lamp	
	0910	Objectives of the workshop	Dr. Mohsin Iqbal
	0920	Opening address	Dr. Kudagamage
	0930	Tea	
	1000	Goals, Course Outline, Schedule	G. Hoogenboom
	1030	History of ICASA	G. Hoogenboom
Reading/Reference:		*Uehara and Tsuji Chapter in Kluwer book, pp. 1-7* *Jones et al. Chapter in Kluwer book, pp. 157-178*	
	1130	DSSAT Applications	G. Hoogenboom
	1230	Lunch	
	1330	Installation of DSSAT Version 4.5 Software Overview of DSSAT	G. Hoogenboom
Reading/Reference		*DSSAT V4 Volume 1* *Readme and Install files on CD*	
	1430	Exercises: Running Crop Models	G. Hoogenboom
	1500	Tea	
	1515	Exercises: Running Crop Models	G. Hoogenboom
	1630	Adjourn	
	1900	Reception and dinner	

Potential Production & Weather

Day	Hour	Activity	Responsibility
Tuesday March 17			
	0900	**Simulating Basic Growth and Development Processes: Phenological Development**	G. Hoogenboom
Reading/Reference		*Boote et al. chapter in Kluwer book, pp. 99-128*	
		Simulating Basic Growth and Development Processes: C Balance & Growth (CROPGRO)	G. Hoogenboom
Reading/Reference		*Boote et al. chapter in Kluwer book. pp. 99-128*	
Reading/Reference		*Ritchie et al. chapter in Kluwer book. pp. 79-98* *Jones et al., Eur. J. Agron. 18(2003):235-265*	
	1030	**Tea**	
	1045	**Creating FileX: Potential Production**	G. Hoogenboom
Reading/Reference		*DSSAT V3.5 Volume 2-1, pp. 1-93* *DSSAT V3.5 Volume 1-4, pp. 111-143* *DSSAT V4.0 Volume 2, XBuild User's Guide*	
	1230	**Lunch**	
	1300	**Exercises: Simulating Potential Production**	G. Hoogenboom
	1500	**Tea**	
	1530	**Weather Data Inputs and Utilities**	G. Hoogenboom
Reading/Reference		*DSSAT v3.5 Volume 3-3*	
	1600	**Exercises: Weather Data Files**	G. Hoogenboom
	1700	**Adjourn**	

Water Limited Production & Soils

Day Hour	Activity	Responsibility
Wednesday March 18		
0900	**Simulating Water Limited Production**	G. Hoogenboom
Reading/Reference	*Ritchie chapter in Kluwer book, pp. 41-54*	
1030	**Tea**	
1100	**Soil Data Inputs and Utilities**	G. Hoogenboom
Reading/Reference	*DSSAT V3.5 Volume 1-3, pp. 49-90* *DSSAT V4.0 Volume 2* *Gijsman et al., Eur. J. Agron. (2002):75-105*	
1130	**Exercises: Soil Data Files**	G. Hoogenboom
1230	**Lunch**	
1330	**Creating FileX: Water Balance On**	G. Hoogenboom
1330	**Exercises: Water Limited Production**	G. Hoogenboom
1500	**Tea**	
1530	**Exercises: Water Limited Production**	G. Hoogenboom
1700	**Adjourn**	

Nitrogen Limited Production
Experimental Data Collection

Day Hour	Activity	Responsibility
Thursday March 19		
0900	**Simulating Nitrogen Limited Production Processes in the Soil**	G. Hoogenboom
Reading/Reference	*Godwin and Singh chapter in Kluwer book, pp. 55-78* *Gijsman et al., Agron. J. 94(2002):462-474*	
1030	**Tea**	
1030	**Simulating Nitrogen Limited Production Processes in the Plant**	G. Hoogenboom
Reading/Reference	*Bowen et al. chapter in Kluwer book, pp. 189-204*	
1130	**Creating FileX: Water and N Balance On**	G. Hoogenboom
Reading/Reference	*DSSAT V3.5 Volume 2-1, pp. 1-93* *DSSAT V3.5 Volume 1-4, pp. 111-143* *DSSAT V4.0 Volume 2, XBuild User's Guide*	
1200	**Exercises: Nitrogen Limited Production**	G. Hoogenboom
1230	**Lunch**	
1330	**Exercises: Nitrogen Limited Production - Continued**	G. Hoogenboom
1500	**Tea**	
1530	**Experimental Data Collection --Model Evaluation**	G. Hoogenboom
Reading/Reference	*DSSAT V3.5 Volume 4-7 & 4-8, pp. 203-233*	
1600	**Experimental Data Files and Utilities**	G. Hoogenboom
Reading/Reference	*Bostick et al., Agron. J. 96(2004):853-856* *Hunt et al., Agric. Systems 70(2001):477-492*	
1630	**Exercises: Experimental Data Files**	G.Hoogenboom
1700	**Adjourn**	

Genetic Coefficients for Growth and Development
Model Calibration and Evaluation
Evaluating Risk and Sustainability

Day	Hour	Activity	Responsibility
Friday March 20			
	0900	**Genetic Coefficients – CERES**	G. Hoogenboom
Reading/Reference		*Ritchie et al. chapter in Kluwer book, pp. 79-98*	
	0945	**Estimating Genetic Coefficients, Concepts**	G. Hoogenboom
Reading/Reference		*Mavromatis et al., Crop Science 42(2002):76-89* *Pathak et al., Trans ASABE 50(2007):2295-2302*	
	1015	**Exercises: Cultivar Coefficient Calibration**	G. Hoogenboom
	1030	**Tea**	
	1100	**Uncertainty, Risk, BMPs, and Sustainability**	G. Hoogenboom
Reading/Reference		*DSSATV3.5 Volume 3-1, pp. 1-66* *Thornton and Wilkens chapter in Kluwer book, pp. 329-345* *Bowen et al. chapter in Kluwer book, pp. 313-327* *Tojo Soler et al., Europ. J. Agronomy 27(2007:165-177*	
	1130	**Creating FileX: Seasonal Analysis**	G. Hoogenboom
Reading/Reference		*DSSAT V3.5 Volume 2-1, pp. 1-93* *DSSAT V3.5 Volume 1-4, pp. 111-143*	
	1200	**Exercises: Seasonal Analysis**	G. Hoogenboom
	1300	**Lunch**	
	1400	**Closing ceremony**	
	1500	**Adjourn**	

Regional Training Workshop on Crop Simulation & Modeling, Royal Garden Mall Hotel, Kandy, March 16-20, 2009

Name	March 16	March 17	March 18	March 19	March 20
USA					
Dr. Gerrit Hoogenboom					
Pakistan					
Dr. Moshin Iqbal					
Dr. Arif Goheer					
India					
Dr. Rajendar Sidhu					
Dr. Kamal Vatta					
Sri Lanka					
Dr. W.M.A.D.B. Wickramasingha					
Ms. R.D. Chitranayana					
Dr. W.M. Weerakoon					
Ms. U. Ratnayaka					
* Dr. J.D.H. Wijewardena					
Ms. Deepa Weerasooriya					
Mr. M.S. Nijamudeen					
Mr. Chamila Perera					
Mr. L.H. Kulathunga					
Dr. S.H.S.A. De Silva					
Dr. B.V.R. Punyawardena					
* A.C.M. Mazeen					

c) Regional Workshop on Preliminary Research Results

APN Regional Workshop on Preliminary Research Results

"Assessment of Food and Water Security in South-Asia under a Changing Climate Using Crop Simulation and Water Management Models, and Identification of Appropriate Strategies for Adaptation to Meet Future Demands"

March 08-12, 2010

Hotel Crown Plaza, Islamabad, Pakistan

Workshop Programme

Day -1	**Monday, March 08, 2010**	
0900-1000	Registration	
	Inaugural Session	**Chairperson- Dr. Arshad M. Khan**
1000-1015	Welcome Note	M. Mohsin Iqbal
1015-1030	Opening Remarks	Arshad M. Khan Executive Director, GCISC
1030-1100	Project Overview	M. Mohsin Iqbal
1100-1130	Food Security-Climate Change Linkages and Implications: A Regional Perspective	Wajid Pirzada Former Chief WTO, PARC/MINFA
1130-1200	Tea Break	
1200-1245	Food Security and Climate Change in major agro-ecological zones of Pakistan	Syed Sajidin Hussain, National Expert on Climate Change
1245-1330	Climate Change and Water Resources of Pakistan	Ghazanfar Ali, Head, Water Resources, GCISC
1330- 1430	Lunch	
1430-1515	Ensuring Food Production on degraded lands: Saline Agriculture	Zahoor Aslam Director, National Bio-Saline Program
1515-1600	Climate Change and Water Management: Regional Food Security Perspective	Mohsin Hafeez Charles Sturt University Australia
1600-1615	Tea/ Coffee	

1615-1700	Use of Models for Climate-Agricultural Decisions	Arif Goheer
Day – 2	**Tuesday, March 09, 2010**	**Chairperson- M. Mohsin Iqbal**
0900-1000	Project Framework	M. Mohsin Iqbal
1000-1030	Elements of Food Security	Kashif Majeed
1030-1100	Impact of climate change on Food situation in Pakistan	Dr. Aslam Gill Commissioner, Minor Crops, MINFA
1100-1130	Tea/Coffee	
1130-1200	Climate Change Scenarios	Shahbaz Mehmood
	Presentation of Research Results	
1200-1230	Bangladesh	Aminur Rehman
1230-1300	Discussion	
1300-1430	Lunch Break	
1430-1500	Vulnerability of Wheat Producing districts of Pakistan to climate change	Muhammad Ijaz
1500-1600	Assessing the impact of climate change on Rice Production in the selected districts of Pakistan	Nuzba Shaheen
1600-1615	Tea/Coffee	
1615-1645	Sri Lanka	Punyawardena
1645-1700	Discussion	
1930-2030	**Reception Dinner**	
Day -3	**Wednesday, March 10, 2010**	**Chairperson- Punyawardena**
0900-0930	Bangladesh	Rabi Uzzaman
0930-1000	Sri Lanka	Ajantha DeSilva
1000-1030	Discussion	
1030-1100	Coping Climate Change – Increasing Crop Production through Technological Improvement - I	Arif Goheer
1100-1130	Tea/Coffee	
1130-1200	Coping Climate Change – Increasing Crop Production through Technological Improvement - II	Arif Goheer
1200-1230	Assessment of Food Security of different socio-economic	Bushra Aslam

	groups in Gujrat District	
1230-1300	Discussion	
1300-1430	Lunch Break	
1430-1600	PODIUM – its operational requirements (hands-on session)	Arif Goheer
1600-1615	Tea/Coffee	
1615-1700	Discussion	Moderator- Mohsin Iqbal
Day – 4	**Thursday, March 11, 2010**	**Chairperson – Ajantha DeSilva**
0900-1000	Food demand under varying scenarios of population, caloric intake and changing food patterns	M. Mohsin Iqbal
1000-1030	Assessing future water requirement for required food production	Arif Goheer
1030-1100	Climate change stresses on Production of Food	Kashif Majeed
1100-1130	Tea/Coffee	
1215-1300	Impediments in Research Progress – Round Table Discussion	M. Mohsin Iqbal
1300-1430	Lunch Break	
1430-1700	Visit to GCISC/ NCP	
Day -5	**Friday, March 12, 2010**	
0900-1100	Future Line of Research in the light of Project Framework - Discussion	Moderator Dr. Mohsin Iqbal
1100-1130	Tea/ Coffee	
1130-1200	Way Forward	Mohsin Iqbal & Arif Goheer
1245-1300	Concluding Session	Dr. M. Mohsin Iqbal Dr. Punyawardena Mr. Aminur Rehman Dr. Arshad M. Khan Dr. Amir Muhammad
1300-1430	Lunch	
	Workshop closed	

APN Regional Workshop on Preliminary Research Results

Assessment of Food and Water Security in South-Asia under a Changing Climate Using Crop Simulation and Water Management Models, and Identification of Appropriate Strategies for Adaptation to Meet Future Demands

Islamabad, 08-12 March 2010

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d) Regional Workshop on Final Research Results

APN Regional Workshop on Final Research Results

"Assessment of Food and Water Security in South-Asia under a Changing Climate Using Crop Simulation and Water Management Models, and Identification of Appropriate Strategies for Adaptation to Meet Future Demands"

Hotel Shalimar, Rawalpindi, Pakistan

January 15-18, 2013

Day - I		
1030-1130	Registration	
1130-1215	Welcome Note	M. Mohsin Iqbal
1215-1245	Opening Remarks	Punya Batugedara (Sri Lanka) Abdul Hamid (Bangladesh)
1245-1315	Project Overview	Mohsin Iqbal Project Leader
1315-1330	Views of the Guest of Honour	Arshad Muhammad Khan Executive Director, GCISC
1330- 1430	*Lunch*	
1430-1515	Managing Food Security under Climate Hazards	Syed Sajidin Hussain Consultant CC/DRM
1515-1600	Climate Change in Pakistan: Historical Trend Analysis	Sheikh Muhammad Munir GCISC
1600-1645	Modeling Crop Responses to Changes in Climate and Management	Arif Goheer GCISC
1645-1700	*Tea/ Coffee*	
Day - II		
0900-0945	Project Plan and Framework	M. Mohsin Iqbal Project Leader
0945-1030	Climate Change Scenarios	Shahbaz Mehmood GCISC
1030-1130	Impact of Climate Change on Food Production in Bangladesh	Abdul Hamid Syed Ahsanul Haque
1130-1200	*Tea/ Coffee*	
1200-1245	Integrated Food Security Phase Classification (IPC) for periodic food security analysis and mapping	Krishna Pahari World Food Programme

1245-1330	Assessment of Food and Water Security under changing climate using RS/GIS Techniques	Mobushir Riaz Khan CIIT
1330- 1430	*Lunch*	
1430-1530	Impact of Climate Change on Cereal Production in Pakistan	Muhammad Ijaz Nuzba Shaheen
1530-1630	Impact of Climate Change on Food Security in Sri Lanka	B. V. R. Punyawardena
1630-1700	*Tea/ Coffee*	
Day - III		
0900-0945	Climate Change and Dwindling Water Resources: A threat to food security in South Asia	Ghazanfar Ali GCISC
0945-1030	Adapting to Climate Change – Wheat and Rice Research Results	Arif Goheer GCISC
1030-1115	Adaption strategies to minimize the adverse effects of climate change on food security in Sri Lanka	S.H.S.A. De Silva
1115-1145	*Tea/ Coffee*	
1145-1230	Adaptation of Bangladesh's Agriculture to Climate Change	Abdul HAmid Syed Ahsanul Haque
1230-1330	Assessment of Future Food and Water Requirements under changing Climatic Scenarios	Arif Goheer GCISC
1330- 1430	*Lunch*	
1430-1630	Discussion (Sharing the experiences -Good practices on Adaptations to Agriculture in Participating Countries)	Moderated by Mohsin Iqbal & Arif Goheer
1630-1700	*Tea/ Coffee*	
Day - IV		
0900-1030	Way Forward: • National Seminar for Planners and Policy Makers in each participating country • Possible Research Publications • Format of the final Report • Possibilities of future collaboration	Mohsin Iqbal & Arif Goheer
1030-1100	*Tea/ Coffee*	
	Closing Session	
1100-1110	Welcome	Arshad M. Khan Executive Director
1110-1130	Summary of Workshop Proceedings	Mohsin Iqbal Project Leader
1130-1150	Views of Participants	Punya Batugedara (Sri Lanka) Abdul Hamid (Bangladesh) Arif Goheer (Pakistan)
1210-1225	Remarks by Chief Guest	Joint Secretary, Ministry of Climate Change
1225-1230	Vote of Thanks	Mohsin Iqbal Head, Agriculture Section
1230- 1400	*Lunch*	
Workshop Closed		

APN Regional Workshop on Final Research Results

Assessment of Food and Water Security in South-Asia under a Changing Climate Using Crop Simulation and Water Management Models, and Identification of Appropriate Strategies for Adaptation to Meet Future Demands

January 15-18, 2013

~~Hotel Crown Plaza, Islamabad~~, Pakistan

Shalimar Hotel, Rawalpindi, Pakistan.

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2

e) National Seminar on Food Security in Pakistan under Changing Climate

National Seminar on Food Security in Pakistan under Changing Climate

Under APN (Asia Pacific Network for Global Change Research) Project

"Assessment of Food and Water Security under Changing Climate using Crop Simulation and Water Management Models, and Identification of Appropriate Measures to Meet Future Demand" (ARCP2009-08CMY-Iqbal Project)

Hotel Crown Plaza, Blue Area, Islamabad

July 8, 2013

Programme

9.00 –10.00 am Registration of the participants

10.00 –10.05 am Recitation from Holy Quran

10.05– 10.20 am Welcome address – Dr. M. Mohsin Iqbal, Project Leader

1020 – 10.35 am Opening Remarks – Dr. Arshad M. Khan, Executive Director, GCISC

10.35- 10.50 am Remarks by the Chief Guest (Mr. M. Asif Shuja, DG Pak-EPA/DG (Envt)

10.50 – 11.15 am **Tea**

11.15 – 11.45 am **Climate Change and Food Security: Policy Development**

Dr. Muhammad Aslam Gill, Ministry of Food Security & Research, GoP.

11.45 – 12.15 am **Food Security Analysis and Mapping in Pakistan.**

Mr. Krishna Pahari, WFP, Islamabad.

12.15 – 12.45 am **Food Security under changing Climate in Pakistan- Outcomes of the Project**

Dr. M. Mohsin Iqbal, GCISC

12.45 –13.15 pm – **The State of Food Security in Pakistan: Future Challenges and Coping Strategies**

Dr. Umar Farooq, PARC

13.15 – 13.45 pm **Assessment of Food and Water Security through Simulation Modeling**

Mr. M. Arif Goheer, GCISC

13.45– 13.55 pm **Distribution of Shields to the Invited Speakers**

13.55 -14.00 pm **Vote of Thanks** – Mr. M. Arif Goheer

14.00– **Lunch**

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National Seminar on Food Security in Pakistan under Climate Change

Assessment of Food and Water Security in South-Asia under a Changing Climate Using Crop Simulation and Water Management Models, and Identification of Appropriate Strategies for Adaptation to Meet Future Demands

July 08, 2013
Hotel Crown Plaza, Islamabad, Pakistan

REGISTRATION

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Appendix - II

Funding Sources outside the APN

No direct funding for this project was received from sources other than APN. However, in-kind support was provided by each of the four participating organizations (GCISC and IWMI from Pakistan, CEGIS from Bangladesh and Department of Agriculture from Sri Lanka) in terms of office space and time cost of their scientific staff, use of institutional facilities, logistics support during organization of the Regional Workshops, and other administrative support, as and when required.

In-kind support was also provided by the developed country partner (Prof. Gerrit Hoogenboom) in terms of time he devoted to the project activities and served as Resource Person in the Project Workshops, without any fee, and provided technical advice and guidance to the project members whenever required.

GCISC served as the Secretariat for the Project and coordinated with Country Counterparts in the participating countries. The project funds were held by GCISC which were transferred to the participating countries as per the approved plan of the Project, with due approval of the Institutional Head of GCISC (Executive Director).

Appendix -III

List of Young Scientists Involved in the Project

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23	R.D.Chitranayana	*-do-*	*Not known*

Appendix - IV

Glossary of Terms

ADB	Asian Development Bank
APN	Asia Pacific Network for Global Change Research
ARCP	Annual Regional Call for Proposals
AR4	IPCC Fourth Assessment Report (2007)
CEGIS	Centre for Environment and Geographic Information System
DSSAT	Decision Support System for Agro-Technology Transfer
GCISC	Global Change Impact Studies Centre
GCM	Global Circulation Model
GSL	Growing Season Length
IPCC	Intergovernmental Panel on Climate Change
MAF	Million Acre Feet
MMT	Million Metric Tonnes
Ppm	Parts per Million
PRECIS	Providing Regional Climate for Impact Studies (RCM)
RCM	Regional Climate Models
SCEGEN	Scenario GENerator
SRES	Special report on Emission Scenarios
SERES	Special report on Emission Scenarios
WB	World Bank

Appendix - V

Interim Report for ARCP Project
ARCP2008-20NMY-Iqbal

Part One (350 words)

1. **Project Reference Number and Title**
   ARCP2008-20NMY-Iqbal
   Assessment of Food and Water Security in South-Asia under Changing Climate Scenario Using Crop Simulation and Water Management Models, and Identification of Appropriate Strategies to Meet Future Demands

2. **Project Leader Details: Name, Institution, Email Address, Website**

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3. **Collaborating Countries**
   Pakistan, Bangladesh, India, Nepal, Sri Lank, USA

4. **Non-technical summary**
   The project was approved on June 24, 2008 with the total funding of US $ 70,000 ($ 40,000 for Year-I and 30,000 for Year-II). The first installment of $ 32,000 was received on July 23, 2008 which cleared the way to organize the Start-Up workshop in Nepal on August 10-12, 2008. In the Workshop, the project framework and the common methodology to be followed by participating countries during the next two years was discussed. After the Workshop, Pakistan formulated the project framework and sent to the participating countries for preparing their own plans of work, in the light of common framework. The Kathmandu Workshop revealed that Indian and Sri Lankan counterparts lacked the ability to operate/use Crop Simulation Models; hence APN was requested to provide additional funds for their capacity building. The APN now has very kindly agreed to provide upto US $ 10,000 for this activity.

Part Two

5. **Project Objectives**
   - To assess food and water security in South Asian countries for sustainable development under changing climate using crop simulation and water management models
   - To synthesize the results at regional level in order to highlight synergies of production systems in different agroclimatic regions
   - To identify appropriate strategies to meet the future demand and provide guidance to national planners/policy makers for introducing necessary adaptive measures
   -

6. **Amount of Funding Received for 2008/2009**
   32,000 US $ (80% of the total amount allocated for the Year-I)

7. **Relevance to the APN's Science and Policy Agendas**

The objective of assessing the food and water security of South Asian countries for sustainable development under changing climate is of direct relevance to the APN Science Agenda, Item 4 (Use of resources, such as food, water, energy, materials, and pathways for sustainable development).

8. **Work undertaken and results to date** (please comment on progress against your project timeline as well as any problems you have encountered)
As per the Work plan, the Start-Up Workshop of the project was organized in Kathmandu, Nepal from 10-12 August, 2008. All the counterparts from the participating countries and the developed-country partner from USA attended the Workshop. In this Workshop, the current situation of food security in the participating countries was presented, and the common project methodology to be followed by the counterparts in their respective countries was discussed in detail. There was consensus that rice and wheat, the common staple crops of all the participating countries, will be studied. The study sites will be selected on the basis of any one or more of the following criteria: Most productive areas; Potentially food-insecure areas; Seasonally dry areas; Rainfed areas; Irrigated areas. The introductory presentations on the use/operation of DSSAT and PODIUM models were delivered during the Workshop.

Later on, a common project protocol for research, vetted by Dr. Gerrit Hoogenboom, was developed by Pakistan, the Lead Country, in the light of Kathmnandu discussions (copy attached) and sent to the counterparts with the request to prepare project frameworks for their respective countries based on the common protocol, and send back to us for release of amounts earmarked in the main project proposal for data collection and survey. To date, the project protocols from two participating countries are still awaited.
During Kathmandu discussions, it transpired that Indian and Sri Lankan counterparts had no ability in operation or application of DSSAT-based Crop Growth Simulation Model CERES (which is to be used in the project for making food projections at different time slots towards end of this century as a function of climate change scenarios). In view of this, APN was requested to provide additional funds to organize a Training Workshop in Sri Lanka for capacity building of Indian and Sri Lankan counterparts in Crop Growth Simulation Modelling. The APN has very kindly agreed to provide upto US $ 10,000 for organizing this activity.

9. **Self evaluation against project objectives**
The project has so far progressed satisfactorily. As per the objectives/timeline, the Start-Up Workshop has been organized, common project framework has been developed and the secondary data collection is in progress. The greatest difficulty experienced, however, is that some of the counterparts are very lax and slow in responding. Two of them have still not provided the project framework for their respective study sites, even the names of sites, despite our repeated reminders. This has kept us from release of the amounts earmarked for survey and data collection ($ 1,000 per country).

10. **Publications** (to date and/or pending)
Power Point Presentation made by Dr. M. Mohsin Iqbal on "Climate Change and Food Security Nexus in Pakistan" at 11th International Sustainable Development Conference, organized by Sustainable Development Policy Institute, Islamabad, December 01-03, 2008. The full paper (for publishing in SDPI Anthology) is being prepared.

11. **Acknowledgments**
The funding provided by APN for the main Project and additional funding approved/pledged for organizing the Training Workshop on Operation/Use of Crop Growth Simulation Model in Sri Lanka is gratefully acknowledged.

12. **Appendix:** Photographs, Diagrams, Graphs for APN (website) dissemination

Appendix - VI

Report of National Seminars for Planners and Policy Makers

Under APN Project "Assessment of Food and Water Security in South Asia under Changing Climate using Crop Simulation and Water Management Models, and Identification of Appropriate Strategies for Adaptation to Meet Future Demand" (APN ARCP2009-08CMY-Iqbal)

Pakistan

GCISC organized the National Seminar on 8th July 2013. About 50-60, out of 100 invited participants including planners, academicians, researchers, government officials from federal ministries and NGOs participated. The Chief Guest was Mr. Muhammad Asif Shuja, Director General, Pakistan Environmental Protection Agency/Director General (Environment), Ministry of Climate Change. Dr. M. Mohsin Iqbal, the Project Leader welcomed the audience and gave a brief run down on the high vulnerability of South Asia to the adverse impacts of climate change due to high population, low resource and technological base and degrading natural productive resources. Dr. Arshad Muhammad Khan, Executive Director GCISC appreciated the research efforts under the project and acknowledged the support and contribution of APN in capacity building of the region, particularly of Pakistan. He said that since inception of GCISC in 2003, six APN project have been under study or successfully completed which opened a new chapter in simulation modeling in Pakistan. The Chief Guest elaborated that Pakistan was classified as an arid country as 80% of the land depended on rainfall. The water resources are likely to decrease in future due to climate change, so ensuring food security under these conditions was an important task.

The Technical Session was chaired by Dr. Aamir Irshad, Chief, Agriculture & Food Section, Planning and Development Division, Government of Pakistan, Islamabad. Five presentations were made in this session. Each presentation was followed by a question-answer session for 10-15 minutes. Dr. Muhammad Aslam Gill, Commissioner Food Security, Ministry of Food security & Research, dilated upon food security status and Government of Pakistan initiatives in this regard. He said that various federal and provincial organizations were at work in relation to food production. The focus of newly created Ministry of Food Security & Research (after devolution of Ministry of Food & Agriculture to provinces, as a result of passage of 18th Amendment to the Constitution of Pakistan) was agricultural research to develop appropriate technologies to eliminate hunger and ensure food security under changing climate. The organizations working on climate change in Pakistan were: PMD (Pakistan Meteorological Department), GCISC, PARC (Pakistan Agricultural Research council), PCRWR (Pakistan Council of Research in Water Resources), PFI (Pakistan Forests Institute), PINSTECH (Pakistan Institute of Nuclear Science & Technology), PIEAS (Pakistan Institute of Engineering & Applied Sciences), UNIDO (United Nations Industrial & Development Organization), UNEP (United Nations Environmental program), etc. Dr. Mohsin Iqbal gave a detailed account of the research results obtained under the project. The grain yield of staple crops of wheat and rice was likely to decrease in all the districts under study In the semi-arid and arid areas towards the end of this century due to climate change. The reduction was to be more in the semi-arid areas than in the arid areas. He outlined some coping strategies, such as improved crop nutrition, improved crop water use, improved seedrate, etc evaluated through crop simulation modeling, to meet the future demand.

Seated (from left to right): Dr. M. Mohsin Iqbal, Mr. Asif Shuja, Dr. Arshad M. Khan. Mr. Arif Goheer is on the rostrum.

Mr. Krishna Pahari, from World Food Program-Pakistan, spoke on food security analysis and mapping in Pakistan. He said some myths exist which need to be clarified. For example, Good national production is important, but this is not enough to achieve food security. Economic growth is important, but it does not guarantee food security at household level. Good production and economic growth are important, but they are not enough for food security; sanitation, care practices for population, food habits and stability are important. For this, food security has to be measured. There are different ways for assessing food security, such as Global Unger Index, % of population undernourished, % of household expenditure on food, Food consumption score, Dietary diversity, Malnutrition Indicators (Stunting, Underweight, Wasting), Coping analysis, etc. According to him, >50% of population in Pakistan was food insecure, the Global Acute Malnutrition rate was 15%, a value above 15% is considered by WHO an emergency level. Dr. Umar Farooq, from Pakistan Agricultural Research Council summarized the research findings of past few years carried out at PARC, especially their economic aspects. Mr. Arif Goheer, the Co-PI of the Project explained the use of simulation modeling in food security studies which is the core tool for assessment of food security in the present project. He emphasized the need for effectively utilizing the research findings in national food policy formulation process.

The audience took great interest in each presentation and asked a number of questions mostly directed towards the current status of food security vis-à-vis the increased frequency of natural disasters (floods, landslides, sea storms, etc) in the past few years. These disasters are one of the primary causes of food security in some regions of Pakistan. The Chief Guest remarked in the inaugural session as well in a separate email that the Seminar was very informative; he would suggest its findings to be widely disseminated to the parliamentarians and policy makers in simple wordings to visualize future scenario and need for serious measures.

The Seminar was closed 3.00 pm with a vote of thanks by Mr. Arif Goheer, followed by lunch.

Sri Lanka

The seminar was held in the Auditorium of Field Crop Research & Development Institute, Department of Agriculture, Maha-Illupplallama, Sri Lanka on July 11, 2913. The objective was to disseminate information generated by the above multi-country project funded by the APN upon its completion. It was attended by 73 participants representing full cross section of the stakeholders of the entire agriculture value chain (scientists, extensionists, academia, economists and policy makers, etc) out of 120 invited persons. The seminar was digitally covered by the official photographer.After the welcome address by the co-investigator of the project, there were two presentations made by the eminent scientists of the Department of Agriculture, followed bya brainstorming session on impacts of climate change on rice production in Sri Lanka. They session was then opened for a general discussion. Major points surfaced duringthe general discussion were:

- What are the most vulnerable rice growing regions of the island for climate change?
- What kinds of yield changes are expected?
- If any reduction in rice yield occurs, would it be due to increasing temperature or irrigation water scarcity?
- How modeling can be used to increase the resilience of the farming community?

The discussion went on for about 15 minutes and was so interesting that it provided the correct platform to Country Co-coordinator of the project to deliver his presentation without much effort. After an hour-long presentation, the session was again opened for discussion. One of the major concerns of the participants was as to why the project did not focus on wetter part of the island (the so called Wet zone) where about 15-20% of country's rice production is concentrated. There was anxiety that it is the same area where floods, increasing temperature and sea level rise are likely to exert significant impacts on rice crop in the future due to climate change. The coordinator and other resource persons explained the technical and financial constraints of the project that deprived the Wet zone being dropped. It was their consensus that as the capacity has been developed by the project by giving an in-country training to the departmental officers on DSSAT software at the very beginning of this initiative, time has come to undertake similar studies for the Wet Zone of Sri Lanka under the general research programme of the organization. This was highly taken by the Director in-charge who chaired the seminar.

The presentation on economics perspectives of rice production under changing climatic conditions was also an eye-opener with a kind of alarming message that there is a possibility of yield reduction of rice by 28% in Sri Lanka in 50 years time unless corrective measures are adopted. This presentation was based on a recent economic modeling carried out with DSSAT software in Sri Lanka.

In the general, the discussion which spanned over 20 minutes brought up some potential adaptive measures to reduce the impact of climate change on agriculture of Sri Lanka. Some novel points of these suggestions are given below:

- Identify, recognize and promote the use of traditional knowledge and community-based practices in good water management (use of cascade systems as water storage and groundwater recharge mechanisms);
- Support groundwater management, including recharge of groundwater, and correct land use planning as a sustainable mechanism for water resources management;
- Establish a good weather and climate forecast linked to need-based advice from agricultural extension services/farmers as a necessary practical tool for adapting to changes in seasonality and more extreme weather patterns;
- Promote crop-animal integrated farming systems as a priority best practice for adaptation to climate change in the agriculture related development programs;
- Promote agriculture and livestock insurance as a means of safeguarding the livelihood of farmers under a changing and variable climate;
- Recognize and recommend an appropriate mixture of traditional and modern technologies as a coping mechanism for adverse impacts of climate change;
- Review the existing agriculture subsidies in the context of adaptation to climate change variability;

Audience was also inquisitive about the regional situation of rice production under a changing climate as it will have a significant bearing on the market price of the rice in Sri Lanka under a crisis situation. The national coordinator informed the learned audience that the final report of this multi-country project will be made available on the web for public. The seminar was adjourned at 4.40 p.m. with the vote of thanks.

Bangladesh

CEGIS organized the National seminar for planners & policy makers on 10 July, 2013 in Hotel Quality Inn, Dhaka. Twenty five professionals from different government organization and twenty one participants from different international and national NGOs and research organizations attended the seminar. The objective of the seminar was to present/discuss the results of project- related research work with the relevant stakeholders and incorporate the concerns and valuable comments of the experts.

Mr Shaikh Altaf Ali, Senior Secretary, Ministry of Water Resources graced the seminar as the Chief Guest and Mr. Md Azizul Haque, Director General, Bangladesh Water Development Board, attended the seminar as the Special Guest. Engr. Md Waji Ullah, Executive Director, CEGIS chair the seminar. Dr Maminul Haque Sarker, Deputy Executive Director of CEGIS, Dr M. A Matin, Professor, Water Resources Department, Bangladesh University of Engineering and Technology (BUET) and Mr Md Shahidur Rahman, Director General, Water Resources Planning Organization (WARPO) were the designated discussants of the seminar.

Engr. Md Waji Ullah, Executive Director, CEGIS delivered a presentation on overview of the project and Dr Ahmadul Hassan, Director, Research, Development and Training Division, CEGIS presented the keynote paper in the seminar.

Engr. Md Waji Ullah, Executive Director, CEGIS delivering his presentation. Seated (from left to right) are: Dr Maminul Haque Sarker, Deputy Executive Director, CEGIS, Dr. M. A Matin, Professor, Water Resources Department, BUET, Mr. Md Azizul Haque, Director General, Bangladesh Water Development Board, Mr Shaikh Altaf Ali, Senior Secretary, Ministry of Water Resources, Mr Md Shahidur Rahman, Director General, Water Resources Planning Organization and Dr Ahmadul Hassan, Director, Research, Development and Training Division, CEGIS.

The discussants and the participants of the seminar appreciated the research initiative and acknowledged the support of APN in research studies in South Asian countries. The participants expressed their opinion and valuable comments on the output and suggested strategies to address the future concerns which are summarized below:

- This research assesses the drought impact on T. Aman rice under changing climate change scenarios which is much needed. However, due to climate change there will be other impacts on agriculture like flooding, erosion which also need to be assessed. Therefore future follow up studies need to have a clear and realistic understanding of climate change impact on agriculture.

- The participants suggested that only one Upazila of the country is not sufficient to represent the vulnerability of the country. Moreover, Rangpur is located in severe drought prone region of the country. Obviously damage due to drought will be higher in Rangpur compared to other less risky areas of the country. Therefore this study should replicate in other parts of the country which should include area from other moderate risk zones also.

- As under this research, CEGIS does not apply any water management model to assess water security. Therefore, the planners suggested to apply water management models in future studies to have clear picture on future water security situation of the country.

- The experts also suggested that though rice is the staple food of Bangladesh, still we have to know what will be the impact of climate change on other important cereals like wheat and potato which demands are expected to increase in future.

- Moreover, it also comes out from the workshop that the model can only reflect the availability of food grain in future. However there are other dimensions of food security like, accessibility and appropriate utilization of food which cannot be identified from this model. In addition to modeling, other approaches should take simultaneously to have a clear concept on the other two dimensions of food security.

- The participants also emphasized for changing the food habit of the population because Bangladesh people are mainly depending on rice as the major sources of dietary energy supply. As a result people are suffering from different micronutrient deficiencies. Therefore food habit needs to change to improve the food security situation of the country.

- The experts also suggested for different adaptation strategies, both for demand management as well as supply management. And some zone wise specific strategies should be undertaken which are more effective to address specific issues.