Final Activity Report for APN Project

"Climate variability and rice-wheat productivity in the Indo-Gangetic Plains" 2002-10 (APN 2002-03)

Rice-Wheat Consortium for the Indo-Gangetic Plains

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Abstract

The sustainability of rice-wheat systems are at most important with their importance as they govern the food security, economic and political stability in the south Asian nations including Bangladesh, China, India, Nepal, and Pakistan. Among these nations, Indo-Gangetic Plains takes lion's share of rice-wheat area in the continent. With the scenario like human induced climate change gaining importance, the fears of such changes affecting the sustainability of this important system is considered prime concern. Having said that, the impact of the rice-wheat system on climate and climate change is also a matter of important study.

The Rice-Wheat Consortium for the Indo Gangetic Plains(RWC) is the lead player in the IGP with sustainability of rice-wheat systems as its main mandate, it has taken initiative, as a part of larger global dialogue going on climate change lead by GECAFS, to deliberate on the pertinent issues of climate change and rice-wheat systems as a result of which a work plan is envisaged with the financial support of APN.

A planning workshop was organised by the RWC in New Delhi from October 8-10, 2002. This brought together regional and international scientists to review the current state and to develop a collaborative research programme whereby new and existing agronomic data and rice-wheat cropping system models could be better utilised to determine so the likely effects of climate change variability and investigate management strategies to improve the productivity and sustainability of the system. The workshop concluded that the main areas for future development include geo-referenced data management; cropping system model development; scientific capacity building for model use and interpretation; and developing client-oriented applications. The modelling needs to be closely coupled with field experimentation. A full proposal for developing systems analysis capability for the rice-wheat rotational systems and targeted field research will be formulated to aim at a number of agencies representing both global change science donors (e.g. APN, national research councils) and other development agencies.

Project Information

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List of Collaborating APN Approved Countries:

Australia, Bangladesh, Canada , Germany , India , Japan , Nepal , New Zealand , Philippines , United Kingdom, USA,

Introduction

Rice-Wheat Systems are critical to South Asian food security. More than 150 million people depend on growing rice in rotation with wheat. The sustainability of these systems is under the threat on several fronts. Climate change and increasing climate variability have raised widespread concern, although the implications of these trends are not well understood.

Recognizing the complications that climate change and variability could bring to rice-wheat productivity, the Rice-Wheat Consortium for the Indo-Gangetic Plains has identified a number of researchable issues directly related to improving agronomic management in response to changed climate variability which could be critically examine by developing a “systems analysis” modelling approach which would then be used to conduct scenario based quantitative “yield gap” analysis of changed climate and management. RWC in collaboration with APN has organized a Research Planning Workshop aimed at developing the systems analysis approach. The workshop, involved about 20 researchers from the IGP and about 15 from other countries, which was being hosted by the RWC in New Delhi in October 2002.

Questions need to be answered:

The ensued workshop has deliberated on following questions:

Q1: What is the potential productivity of the rice-wheat rotational system across the IGP?

Q2: How are yield declines in the rice-wheat cropping system apportioned between variations in seasonal weather, planting date and/or other management aspects?

Q3: How can we quantify and map potential yield losses across the region due to increased climate variability and consequent changes in planting date and other management aspects?

Q4: What are the strategies that will improve the system productivity and sustainability, thereby improving food security, and how would these strategies need to be adjusted in response to changing climate variability?

It was commonly agreed that the system analysis modelling can solve these questions affectively. Hence, a workshop was conducted with the following goals:

Short term workshop goals

- to develop a dialogue between local agronomists, agricultural policy advisors and crop scientists on key issues relating climate variability and the productivity of the rice-wheat cropping system;
- to strengthen regional crop modelling research capability and developing links with international crop modelling groups;
- to collate to international standards and evaluate existing crop, soil and climate data for modelling the rice-wheat system; and

- to evaluate rice, wheat and rice-wheat cropping-system models of the IGBP-GCTE Crop Networks with local data, in collaboration with the originators of the experimental studies.

Longer-term Workshop goals

- To identify regional and international research groups who can collaborate to develop and implement the 3-5 year research project; and
- to work towards a mechanism for linking the envisaged research with other disciplines within the Global Environmental Change and Food Systems[1] (GECAFS) framework. This will allow the fuller analysis of impacts of changed climate variability on IGP livelihoods and the consequences of adaptation strategies.

Relationship to Priority Topics in the APN Research Framework

This proposal relates directly to the APN theme “Climate Change & Variability”. It will develop an interdisciplinary, collaborative 3-5 year research effort to develop tools to assess the impacts of climate variability on the region’s major cropping system by bringing together local agronomists, agricultural policy advisors and crop physiologists and modellers. It relates indirectly to the APN theme “The Human Dimensions of Global Change” as research from the study will contribute to the envisioned regional study on climate variability and the rice-wheat food system to be developed under the auspices of GECAFS.

It also relates to synthesis and analysis of existing research by bringing together datasets and models to develop new analytical tools for modelling the rice-wheat system thereby adding value to earlier research investment; and to capacity building and networking by linking researchers with different skills and from different disciplines and countries to mutual benefit.

The systems nature of the longer-term proposal means it has relevance to a wide range of cropping systems that are still within the scope of the APN priority themes and, in principle, could be extended to them.

Regional Collaboration

The RWC already coordinates agronomic research between the four countries sharing the IGP, and links this with research in the CGIAR. A particular emphasis will be on developing links with the nascent CGIAR’s Global Challenge Programme on Climate Change (via links with the CGIAR Inter-Center Working Group on Climate Change who will be invited to the Workshop), and with on going CLIMAG projects in the region. This proposal will further extend collaboration to several other APN countries (Japan, Australia, New Zealand and USA; see Appendix 1) who can contribute skills in crop modelling, scenario development and GIS for the follow-up activities. It will also be relevant to other regions where the rice-wheat rotation is practiced, e.g. China; and in the improvement of modelling studies for other rotational systems worldwide.

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[1] Global Environmental Change and Food Systems (GECAFS; http://gecafs.org) is a joint project of IGBP, IHDP and WCRP with the objective “*to determine strategies to cope with the impacts of Global Environmental Change on food provision systems and to analyse the environmental and socioeconomic consequences of adaptation*”.

Capacity Building

The workshop is the first step in the development of a new research effort. It will include detailed discussion between experimenters and modellers jointly to develop further research. It will also define the criteria for data needs and gauge the availability and evaluate the suitability of existing data for model development and testing. Preliminary discussions on scenario development will help establish the range of skills needed to undertake the longer-term project.

The envisioned 3-5 year project will offer wide-ranging scope for capacity building in the APN region, including formal training workshops. Skills will be shared in data quality-assessment and formatting (the international standards developed by ICASA/GCTE will be adopted); scenario development; crop modelling and interpretation; and GIS. The preparation of the overall research proposal will in itself provide opportunities for improving skills in problem identification, draftsmanship and liaison with the donor community.

Links to Policy

The Questions raised by the RWC came about through discussion with both the national research communities and with local and regional policy makers. It is clear that local and regional agricultural policy formulation regarding response to climate variability needs to be developed on robust, scenario-based modelling tools in which decision makers have confidence. The envisioned project will develop these tools, and, through links with other GEC research projects working at higher levels on integration (e.g. CLIMAG and GECAFS), will aim to develop them to help decision-making at a range of spatial and temporal levels. The Workshop provides an initial forum to identify the key issues agronomists and policy makers need to address, and the follow-up project can ensure iterative interaction between the groups to help build confidence in the product – and raise awareness of its potential limitations.

Relationship to Global Change Research Programmes

The objectives of the Workshop are directly in line with the recently-developed Implementation Plan of GCTE Activity 3.4 "Production Systems" (http://mwnta.nmw.ac.uk/GCTEFocus3/). This has identified the rice-wheat system as an initial case study to help integrate research between individual GCTE Networks (i.e. rice, wheat, soil organic matter). GCTE Focus 3 results would be combined with other research groups with different disciplinary foci. The Workshop would therefore be jointly sponsored by the RWC and GCTE. There is also a strong interest in developing a close link between the follow-up GECAFS which will place the research within a broader Global Change context.

Related Research Work

The proposal would build upon field surveys and long-term experiments across the IGP conducted by regional scientists over the last couple of decades and link this to the GCTE-led international research in crop model development. Models for single-season, monocrop rice and wheat have been extensively evaluated by international research groups such as GCTE and IBSNAT/ICASA, but there has been little work on evaluating dynamically-coupled rice-wheat models for both short and long-term simulations of farming system productivity and sustainability. The successful development of such "combined" models will require close collaboration between the crop modellers and the regional experimenters as interpretation of the experimental results will be critical. The Workshop, and envisaged follow-up project would therefore add considerable value to existing datasets and model development.

Activities Conducted

Activity 1: Field visit to rice-wheat plots:

RWC organised a field trip to 3 villages in Uttar Pradesh, India on 6th October, 2002 for showing to the multidisciplinary participants from various countries the resource conserving technologies (RCTs) being practised by the farmers. During the field visit the delegates interacted with the farmers and the consortium scientists. The participants were shown the new tillage and crop establishment options co-evolving with the Agents for change in system ecology perspectives. These experiments related to site-specific nutrient management, tillage and crop establishment options, competitive cultivars for weed management, DSR rice, crop residue management, and crop diversification. This helped in better understanding the relevance of the RCTs with climate change and water issues.

Activity 2: The workshop:

The planning workshop was held in New Delhi from October 8-10, 2002, and brought together regional and international scientists to develop a collaborative research program whereby new and existing agronomic data and RW cropping system models could be better utilised to determine so the likely effects of climate change variability and investigate management strategies to improve the productivity and sustainability of the system.

Key note speakers highlighting existing regional and international efforts included Drs J.R. Porter, P.K. Aggarwal, and J.K. Ladha. A number of senior agronomists from India, Bangladesh and Nepal presented overviews of regional problems and data availability, whilst many of the world's most prominent systems modelling groups (e.g. DSSAT, APSIM, DNDC, SIRIUS) were represented and outlined the capacity of existing models to simulate RW systems and data requirements. These workshop presentations are available on a CD-ROM from the RWC office (see contact details below). The last day of the workshop involved group discussions on key aspects of the research proposal i.e. the science, collaborators, milestones and funding needs.

Main areas for future development include geo-referenced data management; cropping system model development; scientific capacity building for model use and interpretation; and developing client-oriented applications. This will be closely coupled with field experimentation specifically designed to improve modelling capacity in relation to new RCTs (e.g. developing permanent systems of zero tillage and raised bed planting for RW, direct seeded rice in unpuddled flats, and crop residue and nutrient management etc) and their role in promoting yield stability and gains in the face of climate change and variability.

Past multi-location experiments need to be subjected to more complete ecosystem modelling analyses to evaluate yield gaps and hypothesize causes for yield gaps to allow better selection of cultivars and management strategies to accommodate climate change and variability. Models should be improved with respect to simulating responses of RCTs and increases in CO_2 and the effects of stressfully high or low temperature on fertility, grain filling, and yield. More emphasis should also be placed in acquiring emissions data from agronomic experiments, particularly conservation management technologies, which would allow the potential impact of newer management practices on climate change mitigation to be provided at the same time as developing adaptation strategies. The linkage between adaptation and mitigation would provide win-win solutions for the sustainable development of the RW cropping systems. The value of the proposed research program for underpinning and contributing to the developing CGIAR Challenge Programs on “Food and Water” and “Climate Change”, to the Global

Environmental Change and Food Systems (GECAFS) initiative and to the Indian Agriculture Research Centre "Climate Change Network" was well recognised.

A full proposal for developing systems analysis capability for the RW rotational systems and targeted field research will be formulated to aim at a number of agencies representing both global change science donors (e.g. APN, national research councils) and other development agencies.

Outcomes and Products

The workshop identified several areas of research that needs to be strengthened in future. The key elements that should form the basis of a future project to be submitted to APN and other donors as discussed in the workshop are listed below:

There is a need to develop systems-level experiments to study mechanisms of puddling, infiltration, and cyclic drying related to the newer systems of direct seeding in non-puddled fields along with more limited time as wet paddy. Direct seeding is being pushed by the need to reduce labour and speed the timing of sowing and rice crop establishment, to prevent delayed sowing of both rice and wheat. There is a general need to better understand all the processes of soil water movement, soil water chemistry, and soil nutrient dynamics. This would be facilitated by experiments conducted with focus on measurements and modelling in this subject area. This type of experiment would need to be at only a few locations that emphasised good scientists to take quality time-series measurements of soil and crop processes.

1. Past multi-location experiments need to be subjected to more complete ecosystem modelling analyses to evaluate yield gaps and hypothesize causes for yield gaps to allow better selection of cultivars and management strategies to accommodate climate change and variability. Models should be improved with respect to simulating responses of resource conserving technologies and increases in CO_2 and the effects of stressfully high or low temperature on fertility, grain-filling, and yield.
2. More emphasis should also be placed in acquiring emissions data from agronomic experiments, particularly conservation management technologies, which would allow the potential impact of newer management practices on climate change mitigation to be provided at the same time as developing adaptation strategies. The linkage between adaptation and mitigation would provide win-win solutions for the sustainable development of the rice-wheat cropping systems.
3. Main areas for future development include geo-referenced data management; cropping system model development; scientific capacity building for model use and interpretation; and developing client-oriented applications. This should be closely coupled with field experimentation specifically designed to improve modelling capacity in relation to new resource conserving technologies (e.g. developing permanent systems of zero-tillage and raised bed planting for rice-wheat, direct seeded rice in unpuddled flats, and crop residue and nutrient management etc..) and their role in promoting yield stability and gains in the face of climate change and variability.
4. The value of the proposed research programme for underpinning and contributing to the developing CGIAR Challenge Programs on "Food and Water" and "Climate Change", to the Global Environmental Change and Food Systems (GECAFS) initiative and to the Indian Council of Agriculture Research's "Climate Change Network" was well recognised.
5. A full proposal for developing systems analysis capability for the rice-wheat rotational systems and targeted field research will be formulated to aim at a number of agencies representing both global change science donors (e.g. APN, national research councils) and other development agencies. This project should aim to bring together modelers and experimentalists, and maintain rigor in their approaches. For the IGP-RW

effort, there needs to be a formalized interaction (meetings, work sessions, also to be funded) between modelers and experimentalists that gives more credit and participation of those research scientists with the modelers. To accomplish this, research steps are:

Conduct new systems-level experiments to study in-depth processes to discover mechanisms of tillage, puddling, beds, infiltration, and cyclic drying related to the newer systems of direct seeding in non-puddled fields.

Understand the dynamics of residue incorporation and decomposition as an alternative to current burning of residue.

Quantify the extent of early need of full paddy (or even to regulate weeds, stimulate yield, provide reducing environment to make micronutrients available, but minimize methane emissions Use this information for modelling and to predict scenario consequences of management change to decrease water use, improve water use efficiency, and reduce methane emission.

Benchmark existing models as to their ability to handle rice-wheat rotational systems (crop yield, quality, soil changes)

Identify and correct deficiencies in the crop models. Examples include: incorporating effects of salinity into the crop models, which they do not address now. Response to carbon dioxide and temperature should be tested and improved for rice and wheat models. There is good data and literature available to improve mechanism of response to carbon dioxide and effects of stressfully high or low temperature on fertility, grain-filling, and yield.

7. Identified key constraints in the rice-wheat systems that need immediate attention (Table 1).

Table 1. Identified major issues and possible multi-disciplinary solutions for sustaining rice-wheat systems.

Problem Area	Causal Factors for the Problem	Possible Multi-Disciplinary Solutions
A. Crop Establishment		
l.Late seeding of wheat after rice	Delayed rice harvest, untimely rains, short turn around time for seeding of wheat. Excessive soil moisture interfere tillage operations in eastern parts of the IGP, avoidance of yield reducing factors	Reduce tillage operations, seeding wheat crop with zero-till seed-cum-fertilizer drill. Grow short-duration rice cultivars, reduce basmati duration, (However, aroma development is adversely affected due to high temperature at panicle formation stage) screen wheat cultivars suited to zero-till drill, reduced tillage conditions, surface seeding of wheat, *utera* cultivation, wheat cultivars suited to surface seeding, reduced tillage practices, use of two wheel tractors for timely sowing
2. Late planting of rice	Generally, farmers wait for rain to prepare land and to puddle field	Early transplanted rice and wheat have higher yields, direct seeding of rice can be done earlier
3. Loss of seed viability	High humidity and poor seed storage	Improved seed storage, and seed priming

4. Low plant density in puddled transplanted rice and high plant density in direct dry seeded rice	Drudgery of transplanting operations, hired labor. High seed rate in DSR	Introduce rice transplanter, direct seeding of rice in unpuddled conditions, use of seedling broadcasters, seeding of sprouted seeds with drum seeder, cultivars with better ability to compete with weeds and tolerance to early soil drying under direct seeded conditions. Reduce seed rate in DSR
B. Crop Diversification		
1. Bottlenecks in green manuring in RWCS	Shortage of water in peak summers, non-availability of good quality seed of *Sesbania* and sunhemp. Shortage of time for inclusion of green manure crop between rice and wheat	Grow grain legumes e.g. mungbean/urdbean/ sunhemp/cowpea and incorporate crop residues, develop fast growing *Sesbania* cultivars, avoid early transplanting of rice. It gives enough time for a 50-day green manure crop. Grow alternative crop such as cowpea during pre-kharif (summer) season
2. Low groundnut yields in RWCS	Poor seed germination at low temperature in winter season in north west	Change land configuration (ridge planting) to raise soil temperature, mulching, develop bunch type photo-insensitive groundnut for toria-wheat-groundnut system with terminal heat tolerance at pegging
3. Low productivity of sugarcane	Summer planting of cane; poor germination and crop stand	Inter-crop wheat , mustard, chickpea, peas, *methi*, with sugarcane, less weed. Higher land equivalent ratio
4. Unstable and low production potential of pigeonpea in kharif season	Climatic variability, low yield, long crop duration, low stability, flower drops and diseases, more risks	Identify inter-crop that can go well with pigeonpea. Develop/ introduce spray equipment and agronomic practices, develop hybrids, insulate yield instability and stress tolerance, genetically
5. Low cotton yields	Flowering synchronizes with onset of the monsoons and problem of American ball worm	Early sowing, develop cultivars with synchronous flowering so that crop is amenable to mechanical picking. Develop hybrids and varieties having tolerance to *H. armigera*
6. Reduced biodiversity due to large area coverage with single cultivar	High risks spread HYV of rice and wheat tolerant to biotic and abiotic stresses	Develop alternative crop establishment techniques such as bed planting, substitution with legumes and accelerate crop improvement programs on oilseeds and pulses
C. Nutrient Management		

1. Nutrient mining	Intensive cropping with no soil fallowing , unbalanced use of chemical fertilizers, reduced use of organics and green manure, luxury consumption of K, removal of crop residues	Integrate conjunctive use of organic and chemical fertilizers, use green manure etc. Develop cultivars with efficient system for use and nutrient translocation into sinks. Develop appropriate technologies for return of crop residues to soil, advise K application. Reduce P fixation and liming needs in eastern acidic soils through use of siliceous organics
2. Declining soil fertility and increased incidence of multiple nutrient deficiencies 3. Decline in soil organic carbon (SOC) content	Negative nutrient balances, mismatch between nutrient demand and supply, use of concentrated fertilizers, HYV/ hybrids needs more nutrients Coarser textured soils with alkaline pH, faster microbial decomposition rates, excessive tillage, low moisture and high summer temperature. In fine textured acidic soils, excessive tillage	Rationale use of fertilizers, use slow release fertilizers, deep placement and use of USG, reduce nutrient losses and improve fertilizer use efficiency, develop cultivars with better root system and ability to extract soil nutrients from relatively unavailable forms. Seed priming, seed enrichment Reduce tillage, use surface mulches, enhanced use of FYM and crop residues, incorporate legumes in cropping systems. Screen, cultivars with better rooting systems. Promote practices that protect SOC
4. Nutritionally poor quality grains increased medicare costs	Poor rain and irrigation water management, poorly leveled lands, night irrigation, low power tariffs, supply driven irrigation systems. Field to field irrigation practices	Improve irrigation and canal operation schedules, shift transplanting to June, intermittent irrigation. Change irrigation methods, breed cultivars for improved WUE for target environments. Avoid growing rice in very coarse textured soils, which need frequent irrigation. Peripheral bunding for rainwater storage, grow rice on raised beds
D. Water Management		
1. Nutritionally poor quality grains increased medicare costs	Food grains with inherently low levels of mineral nutrients and vitamins, processing further enhances losses	Fortification of feeds, fodder and grains, improve nutrient absorption/uptake , change dietary habits. Develop cultivars with efficient nutrient translocation systems such as to increase the fraction of absorbed nutrients in edible portions, improve quality of produce for greater bioavailability to human beings. Adjust N application and irrigation practices
2. Receding water-table in fresh-water aquifer zones in the northwest	Poor rainwater management, transplanting of rice advanced to April-May, low canal supply, pan formation due to puddling reduces percolation of water. Continuous ponding	Improve percolation rates and rainwater conservation with peripheral bunding, reduce surface crusting. Replace rice with maize/ soybean/pigeon pea. Bed planting for *in situ* rain-water conservation. Direct seeding of rice and O-tilled wheat. Shift transplanting to June

3. Drainage congestion	Low lying areas, clogging of drainage systems, excessive rainwater, *in situ* water conservation measures lacking	Clear drainage congestion points, promote use of external inputs. Introduce surface seeding avoids rice fallows/ target technologies
4. Poor nutrient-water interactions	Mismatch in nutrient and water supplies, low soil fertility	Develop integrated nutrient supply systems. Grow appropriate cultivars. Screen cultivars for graded levels of soil fertility. Develop lodging resistance cultivars which are efficient nutrient users as well
E. Abiotic Stresses		
1. Waterlogging and salinity problems	Poor water management practices, use of low quality water. Salinity effects manifest on yield, salt sprays. Poor infiltration leads to temporary waterlogging, crop yellowing at CRI growth stage of wheat	Better the water management practices, and provide drainage. Develop salt tolerant cultivars. Leaching/drainage fraction with each irrigation not needed under monsoonal climate. Leach when salinity builds up excessively Improve soil water permeability with gypsum, use additional P and spray urea 1 % for control of chlorosis. Develop wheat cultivars suited to temporary waterlogging. Practice zero tillage and bed planting
2. Terminal rise in temperature and un-seasonal rains	Green house gas emissions and climate change	Adjust cropping system and crop choices. Develop cultivars with terminal heat tolerance, introduce dormancy in rice and wheat varieties
3. Lodging of rice and wheat crops	High plant populations, high fertility, poor root system, untimely watering	Irrigate at appropriate time. Breed for lodging resistance. Practice bed planting
4. Low yield of intercrops	Shading of upper story crops	Adjust spacing , change land configuration / crop geometry, breed appropriate varieties with specific plant type
F. Integrated Pest Management		
1. Weed Management in direct seeded and unpuddled rice	Non-ponding/ unpuddled soil conditions	Introduce stale beds, submerge in initial 2 weeks; identify chemical molecules for wetlands/ aquatic systems
2. Blasts, leaf folder, sheath blight and stem borers in rice, false smut in scented rices, root knot nematodes	Early planting, excessive N / late N applications, wet regimes	Better water and N management and adjusting planting time. Effective molecules. Resistant varieties, use neem cakes

3. Yellow rusts/blights in wheat	Susceptible genotypes, new rust races	Varietal improvement with continued gene development and insulation through integrated gene management
4. Weed management in wheat	Development of resistance in *Phalaris minor*	Replace wheat with mustard/ sugarcane. Plant wheat without/ minimum tillage, competitive crop cultivars
5. New pest emergence	Availability of niches for pest carry over	Solarization, biological control , change substrate for growth of favourable biota
G. Engineering Problems		
1. Lack of appropriate prototypes for seeding into loose residues on the surface	Implements for seeding in standing crop residues not available locally	Develop practices for surface decomposition of residues, residue incorporation. Develop prototypes for seeding into loose residues surface retention
H. Animal Nutrition		
1. Shortage of fodder and low quality fodders	Crop residues are burnt, high harvest index (HI), lignin rich feeds	Introduce fodder crops in RWCS, develop techniques for improvement of feeds/ fodder, breed cultivars for high biomass and HI.
2. Nutritional problems	High silica content in rice residues, toxins in rain soaked fodders, toxicity due to arsenic, fluorides ions in fodder	Immobilize toxic ions in soil solutions through use of gypsum, develop techniques for conservation of fodder. Develop cultivars capable of selective ion absorption, reduced uptake of F, As, Si etc
3. Enhanced green house gas (GHG) emissions	Rice culture and methane production, low carbon sequestration rates	Improve soil, agronomic and water management practices for improving the carbon sequestration rates, develop cultivars with better root system, screen rice cultivars for reduced methane transport
K. Environmental Issues		
1. Enhanced green house gas (GHG) emissions	Rice culture and methane production, low carbon sequestration rates	Improve soil, agronomic and water management practices for improving the carbon sequestration rates, develop cultivars with better root system, screen rice cultivars for reduced methane transport
2. Burning of crop residue	Absence of spreaders in combines leaves a swath in rows. Non availability of prototypes for seeding into loose residues	Crop cutting close to ground, removal/ incorporation of crop residues, develop new seeding equipment, develop controlled traffic seeding with zero-till and mulching with shrub master/stubble shavers

3. Declining solar radiation	Increased particulate material into the atmosphere, unreliable solar radiation data, equipments not calibrated/ replaced	Study the expected decay in quality of (un-calibrated) devices to achieve a correction factor, estimate trend of increase in particle input, model rising levels of aerosols over the region

A CD containing all presentations was also prepared and distributed and is included with this report.

Conclusions

The workshop helped bringing the field researchers and crop modellers together and was able to pinpoint the lacunas in complete understanding of the rice-wheat production systems. The key areas of research both in field research and modelling that need improvement have been identified. There was consensus that adaptation and mitigation strategies need to be identified without compromising on production to ensure win-win solutions for the sustainable development of the rice-wheat cropping systems.

Future Directions

These discussions need to expanded into a full research proposal to be submitted to APN. The Project Leader of GCTE will explore funding options for this. The proposal will also contribute to the CGIAR Challenge Programs on “Food and Water” and “Climate Change”, to the Global Environmental Change and Food Systems (GECAFS) initiative and to the Indian Council of Agriculture Research’s “Climate Change Network”.

Appendix I

RWC-GCTE Research Planning Workshop on

“Climate Variability and Rice-Wheat Productivity in the Indo-Gangetic Plains” October 8-10, 2002, New Delhi

Workshop programme

Tuesday 8 October		
1st Session	Introduction	
9:00-9:15	Overview of RWC and rice-wheat system – tillage options & Initial research questions	Raj K Gupta
9:15-9:45	Overview of rice-wheat system – agronomy, yield trends and nutrient management issues	JK Ladha
9:45-10:00	Meeting Objectives	John Ingram
10:00-10:15	GCTE Agroecology and production systems overview	John Porter/ John Ingram
10:15-10:45	Discussions	
10:45-11:15	Coffee	
2nd Session	Key Yield reducing issues	
11:15-11:30	Water logging/ receding water tables, timely planting	Raj K Gupta
11:30-11:40	Pests & disease	Amerika Singh
11:40-13:00	Discussions	
13:00-14:00	Lunch	
3rd Session	Agronomic Constraints	
14:00-14:20	Climate variability and change: agronomic constraints in Bangladesh.*	Ahsan Uddin Ahmed
14:20-14:40	Agronomic constraints in Nepal	DS Pathic/ Kishore K Sherchan
14:40-15:00	Agronomic constraints in IGP	RL Yadav
15:00-15:45	Agronomic constraints in IGP- Open discussion	JK Ladha
15:45-16:15	Coffee	
4th Session		
16:15-17:00	Initial discussion of main objectives in systems analysis for Rice-Wheat	Raj K Gupta/ John Porter
Wednesday 9 October		
5th Session	Current modelling capability: presentations on different aspects of rice-wheat systems modelling stressing problems and limitations (general discussion, not concentrating on any particular approach):	
9:00-9:10	Wheat	Peter Jamieson
9:10-9:20	"Systems analyses with the CROPGRO-legume model to discover yield gaps associated with pests, disease, soils, and management."	Ken Boote
9:20-9:40	Process-based rice growth models of the GCTE Rice Network and some more recent developments.	Kazuhiko Kobayashi
9:40-9:50	“Modeling C and N biogeochemistry in agro-ecosystems"	Changsheng Li
9:50-10:00	Pests & Disease	N Kalra/ Sehgal
10:00-10:10	Potato	Walter Bowen

10:10-10:30	Discussions	
10:30-11:00	Coffee	
6th Session		
11:00-11:40	Description of key rice-wheat experimental datasets	Bijay singh, SS Hundal, RL Yadav
11:40-12:00	Discussions on data structures/ formal data structure- “quality data sets”	Peter Grace/ Walter Bowen
12:00-13:00	Discussions on further data needs of model development	
13:00-14:00	Lunch	
7th Session	Current modelling capability: presentations on different systems modelling approaches for rice-wheat rotation and data needs.	
14:00-14:15	"Modelling crop rotations using APSIM - prospects for simulating rice-wheat systems"	Peter Carberry
14:15-14:30	CROPSIM	Tony Hunt
14:30-14:45	Sirius/ SOCRATES	Peter Jamieson
14:45-15:00	DSSAT	Walter Bowen
15:00-15:15	WTGROWS/ SURCROS	PK Agarwal
15:15-15:45	"Monitoring and modelling rice-wheat cropping systems"	J Timsina
15:45-16:15	Coffee	
8th Session		
16:15-17:00	Discussions on initial model runs	Tony Hunt to lead / PK Agarwal
Thursday 10 October		
9th Session		
9:00-10:00	Initial discussions on nature of a 3-5 year research project & Main aspects of research plan, and key milestones.	John Porter to lead
10:00-11:00	Discussions in breakout Groups on key aspects of research proposal: (science, collaborators, funding needs). Breakout groups will be identified at the workshop	
11:00-11:30	Coffee	
10th Session		
11:30-13:00	Discussions in Breakout groups (continue)	
13:00-14:00	Lunch	
11th Session		
14:00-14:30	Report back from breakout groups	John Porter to lead
14:30-15:00	Collaboration with proposed CGIAR Challenge Program on Climate Change and with GECAFS	Peter Grace/ John Ingram
15:00-16:00	Actions for proposal writing and plans for follow up	John Porter/ Raj K Gupta/ John Ingram
16:00-16:30	Coffee	

Table 2. List of Participating countries were funded by APN.

S.No	Participants	Address	Country	Funding
1.	Dr Peter Grace	C/o Sinclair Knight Merz PO Box 246, Spring Hill Queensland 4004 AUSTRALIA	Australia	APN
2.	Dr. Jagdish Timsina	CSIRO ,Australia jagadish.timsina@csiro.au	Australia	APN
3.	Dr Rob Williams	Yanco Agricultural Institute Yanco New South Wales 2703 AUSTRALIA	Australia	APN
4.	Dr. Peter Carberry	APSRU&QCCA, Department of Primary Industries (DPI), PO Box 102 Toowoomba QLD 4350, Australia	Australia	APN
5.	Dr. Ahsan		Bangladesh	APN
6.	Dr Kazuhiko Kobayashi	National Institute for Agro-Environmental Sciences Atmospheric Impacts Unit 3-1-3 Kannondai, Tsukuba, Ibaraki 305-8604, JAPAN	Japan	APN
7.	Dr DS Pathic	Director (Crops), RWC RTCC Nepal Nepal Agricultural Resarch Council , NEPAL	Nepal	APN
8.	Dr Kishore K Sherchan	Chief, Agriculture and Environment Unit Nepal Agriculture Research Centre NEPAL	Nepal	APN
9.	Dr Peter Jamieson	New Zealand Institute for Crop & Food Research Private Bag 4704 Christchurch NEW ZEALAND	New Zealand	APN
10.	Professor John Porter	C/o Dr Peter Jamieson New Zealand Institute for Crop & Food Research Private Bag 4704 Christchurch New Zeland	New Zealand	APN
11.	Dr JK Ladha	IRRI DAPO Box 7777, Metro Manila, Phillipines	Philippines	APN
12.	Dr Ken Boote	Agronomy Department University of Florida PO Box 110500 Gainesville, FL 32611-0500 USA	USA	APN
13.	Dr Changsheng Li	USA Complex Systems Research Center Inst for Study of Earth, Oceans & Space University of New Hampshire Durham NH 03824 3525	USA	APN
14.	Dr. Walter Bowen	Leader, soil and Nutrient Dyanmics Program Resources Development Division, IFDC, PO Box 2040, Muscle Shoals, AL 35662 USA	USA	APN
15.	Professor. S S Hundal	Department of Agricultural Meteorology PAU Ludhiana Punjab 141 004 INDIA	India	APN

S.No	Participants	Address	Country	Funding
16.	Dr. Bijay Singh	Department of Soils Punjab Agricultural University Ludhiana, 141 004 INDIA	India	APN
17.	Dr. I. P. Abrol	Center for Advancement of Sustainable Agriculture. C-9/9564 Vasant Kunj, New Delhi-110070	India	APN
18.	Dr. P.K. Agarwal	Head, Division of Environmental Sciences NRL Building, IARI Pusa Campus, New Delhi-110012	India	APN
19.	Dr. C. Sharma	APN Liaison Officer for South Asia Center for Global Change NPL, New Delhi	India	APN
20.	Dr. R.L. Yadav	National Coordinator ,Rice Wheat	India	APN
21.	Dr. Amerika Singh	Director, NCIPM, IARI	India	APN
22.	Dr. Naveen Kalra	Principal Scienist, NRL	India	APN
23.	Dr. Mukesh Sehgal		India	APN
24.	Mrs Prabhjyot Kaur	Dept. of Agricluture Metreology, PAU, Ludhiana	India	APN
25.	Dr.R.R kelker	Director General, Dept of Meterological Department, Mausam Bhawan, Lodhi Road , New Delhi -110003	India	APN
26.	Dr. MK Tiwari	Principal Scientist , National Phiysical Laborartry, IARI, ND -12	India	APN
27.	Dr. JS Samra	DDG (NRM) Krishi Bhawan, ND - 1	India	APN
28.	Prof Inubushi	TERI		
	Dr. LS Rathore	Adviser, National Centre for Medium-Range Weather Forecasting Supercomputer Centre, Mausam Bhavan Complex,Lodhi Road NewDelhi-3	India	APN

Table 3. List of Participanting countries funded from sources other than APN.

S.No	Participants	Address	Country	Funding
	Professor. Tony Hunt	Plant Agriculture Department University of Guelph ,Guelph Ontario N1G 2W1 , CANADA	Canada	Self
	Dr. Sommer Rolf	Rolf Sommer Natural Resources Program CIMMYT (International Maize and Wheat Improvement Center) Tel. +52 (55) 5804 2128 Fax +52 (55) 5804 7558/59	Germany	Self
	Mr. John Ingram	GECAFS International Project Office NERC Centre for Ecology & Hydrology Maclean Building, Crowmarsh Gifford Wallingford, OX10 8BB, UK	UK	Self

Appendix II

A CD ROM that was distributed during the workshop is attached with this document. The CD ROM contains presentations made during the workshop and other workshop details.