National Seminar on
Climate Change Adaptation Strategies in Agriculture and Allied Sectors

03-04 December 2009
Abstracts of Papers

Editors
AVR Kesava Rao
GSLHV Prasada Rao

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Kerala Agricultural University, Vellanikkara
Thrissur 680656, Kerala

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Climate Change Adaptation Strategies
in Agriculture and Allied Sectors - Abstracts

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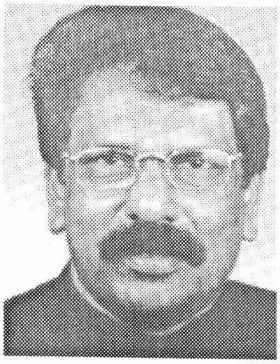

FOREWORD

The monsoon behaviour in 2007 over Kerala was totally different to that of previous years and heavy rains were noticed from June to September, leading to floods in low lying areas. The Paddy area was damaged in the Alappuzha belt of Kuttanad in Kharif 2007 due to floods. The length of rainy season was also extended, leading to delay in "puncha" sowing (second crop). No rains were noticed after "puncha" sowing since 24th November onwards. It revealed that prolonged flooded rains during the monsoon, followed by no rains during the "puncha crop" and unusual rains in March 2008 led to low paddy yield during 2007-08 in Kuttanad, which is one of the rice bowls of Kerala. Estimated loss was more than Rs.100 Crores and price rise in rice was felt for the first time due to weather aberrations. In 2009, the monsoon behaviour in Kerala was erratic both in time and space as some districts received deficit rainfall, while some excess leading to floods. Due to prolonged dry spell in Thiruvananthapuram and Kollam, area under paddy sown was relatively less. In addition, large-scale infestation of armyworm in November 2009 in paddy fields in Thrissur district is likely to affect the already dwindling paddy production. In contrast, severe summer droughts were noticed in 1983 and 2004 during which the surface water resources became scarce due to hydrological drought and the State's economy was hit very badly. Such abnormal weather phenomena could be attributed to global warming or as a part of natural climate variability/change. The Western Ghats region is one of the 25 hot spots of biodiversity in the World. Most of the biomes seem to be highly vulnerable to the projected change in climate in a relatively short span of 50 years. Such extreme weather events are not uncommon in other States too across the Country. Temperature rise and uncertainties in rainfall in recent years might be one of

the potent factors for stagnation in agricultural production in various states. The Indian foodgrains production may also revolve around 210-215 million tonnes in 2009 due to deficit monsoon.

There is a need to formulate climate change risk management strategies to minimise the ill effects of climate change on war-footing. To review and identify gaps in our knowledge in climate change adaptation strategies, the Kerala Agricultural University has organized a National Seminar on "Climate Change Adaptation Strategies in Agriculture and Allied Sectors" during 3-4 December 2009 at the Kerala Agricultural University. I am happy to note that several distinguished scientists from various research institutes in India and Australia have participated in the seminar and presented research papers.

I congratulate Dr. GSLHV Prasada Rao and his team, Centre for Climate Change Research for bringing out the proceedings in form of abstracts and full-text of papers. I hope the material will be read immensely and used by the researchers, teachers, students and planners. I take this opportunity to congratulate all the scientists who contributed material for bringing out this valuable publication.

I wish the deliberations of the National Seminar a grand success

Vellanikkara
01 Dec 2009

KR Viswambharan
Vice Chancellor

PREFACE

Agriculture can be defined as the process of using natural resources (sunlight, air, water and soil) to produce a consumable product (e.g. food, fuel and fiber), while maintaining sufficient resources for the next generation. Future agricultural production systems will need to be sufficiently flexible to respond to rapid changes in climate, to uncertainties in global markets, declining natural resources and to changing political, and population demands.

There is now mounting evidence and wide spread acknowledgement that climate change has already occurred, that future change is inevitable and that we will have to develop strategies to adapt to these changes. Human activities on the planet are affecting the global climate. Global mean temperatures have risen approximately 0.76° C since the mid 1800s and change in rainfall patterns. Sea levels, and rates of glacial retreat have also been detected which are consistent with expectations of 'greenhouse' climate change.

The classical examples of climate related incidents are the heat wave in 2003 in the European Union, drought of 2004 in southern African countries, drought in Australia and other wheat growing counties in 2006 and recent droughts in 2002 and 2009 in India during which the food grain production was adversely affected. For the first time, food price escalation was noticed in 2007 and being continued even now globally due to declining rate of major grain (rice, wheat and maize) production. Rise in current food prices, as a result of increase in global prices, inadequate monsoon and severe droughts in addition to increase in support prices, are major issues facing India. Crop simulation models indicate that area under rice and wheat globally is likely to decline in coming decades and food grain production is under threat as a result of increase in temperature and rainfall uncertainties associated with global warming. Therefore, it is high time to develop climate change adaptation strategies to mitigate ill effects of weather aberrations and sustain food production under projected climate

change scenario.

I suggest that strategic approaches for agricultural research and development should target:

(i) improved technologies for increased and profitable production and sustainable conservation of natural resources;
(ii) diversified novel farming systems that reduce risk, improved resource-use efficiency leading to improved returns to growers;
(iii) enhanced vertical integration from grower to consumer;
(iv) Training of new generation agricultural graduates and post-graduates with modern scientific, analytical communication and business skills
(v) Organisational and policy reforms

I am pleased to know that the Kerala Agricultural University (KAU) is taking initiatives in climate change adaptation strategies through capacity building and research in agriculture, animal sciences, forestry, fisheries and water resources management. I am delighted that organisers has lined up some eminent scientists from India and overseas at this national seminar.

I wish deliberations of the seminar a great success and look forward further collaborative initiatives between KAU and The University of Western Australia to address climate change related issues, capacity building in teaching and research and develop viable technologies for dynamic - integrated agricultural production systems.

Professor Dr Kadambot Siddique, FTSE
Chair in Agriculture and Director
Institute of Agriculture
The University of Western Australia
Perth, Western Australia

Editors' Preface

Climate change is real. Technologies in tune with climate change are yet to be developed for sustenance of agriculture production. National Action Plan on Climate Change (NAPCC) has been formulated by the Government of India in 2008. One of the eight identified Missions is 'Establishing a Strategic Knowledge Platform for Climate Change'. Taking the lead, the Kerala Agricultural University has established the Centre for Climate Change Research (CCCR) in December 2007 to address the climate related issues. The CCCR has already taken up detailed agroclimatic characterization and climate change analysis along with bringing awareness among various stakeholders on climate change adaptation and mitigation strategies.

To review and identify gaps in our knowledge in climate change adaptation strategies, the Kerala Agricultural University took initiatives to organize a National Seminar on "Climate Change Adaptation Strategies in Agriculture and Allied Sectors" during 3-4 December 2009 at its main campus, Vellanikkara, Thrissur, India.

Several distinguished scientists from various research institutes in India have participated in the seminar and presented research papers. Participation of eminent international scientists Prof. Peter Davis, University of Western Australia, Perth and Dr. Senthold Asseng, CSIRO has also made the national seminar as international.

There are fourteen invited presentations by distinguished scientists and 42 contributed research papers by eminent scientists and policy makers. These were scheduled in six technical sessions viz., Climate change adaptation in relation to natural resources management, Agriculture, Horticulture, Forestry, Fisheries and Animal Sciences.

The seminar could provide a common platform for teachers, scientists and policy makers to interact in relation to climate change adaptation strategies. It is hoped that the outcomes of the seminar lead for formulating multi-disciplinary and multi-institutional research projects and bring out enhanced awareness on climate change adaptation.

Dr. AVR Kesava Rao Professor of Agricultural Meteorology

Dr. GSLHV Prasada Rao Associate Director of Research (M & DM)

Dr. D. Alexander Director of Research

National Seminar on Climate Change Adaptation Strategies in Agriculture and Allied Sectors
Date: 03 Dec 2009

0900 to 1115 h — Registration and Inaugural Session
1115 h — High Tea

Technical Session I – Invited Papers (1130 to 1700 h)

Chairman: ***KR Viswambharan, Vice Chancellor, KAU***
Co-Chairman: ***D Alexander, Director of Research, KAU***
Rapporteur: ***AVR Kesava Rao, Professor, CCCR, KAU***

Time	Title of paper	Name
1130 h	National Mission on Strategic Knowledge for Climate Change – Initiatives for capacity building and knowledge sharing	Akhilesh Gupta Climate Change Programme Dept of Science & Technology, Govt. of India, New Delhi
1155	Climate Change - Impacts and mitigation strategies	GGSN Rao, Project Coordinator, AICRP on Agrometeorology, CRIDA, Hyderabad
1220	Climate Change Implications for River Restoration in Global Biodiversity Hotspots	Professor Peter M Davies, Centre of Excellence in Natural Resource Management, The University of Western Australia
1245	Climate change projections and impacts on plantations in Kerala	GSLHV Prasada Rao, Kerala Agricultural University
	13-14 h Lunch break	
1400 h	Climate change adaptation strategies for rice in Kerala	Leena Kumary S, Kerala Agricultural University
1425	Has the impact of temperature variability on wheat production been underestimated?	Senthold Asseng CSIROAustralia
1450	Climate change, fodder production and livestock	DVK Nageswara Rao, IGFRI, Jhansi
1515	Integrated Agromet Advisory Services for the Coastal Region of Kerala – Future Projection under Climate Change	RP Samui, DDG (Agrl. Met), IMD, Pune
	15:40 to 16:00 h Tea Break	
1600 h	Possible impacts of climate change on water resources of Kerala	Kamalakshan Kokkal, K S C for Science Technology and Environment, Thiruvananthapuram
1620 h	Weather risk insurance for Agriculture under projected climate change scenario	KN Rao, Deputy General Manager, Agricultural Insurance Company of India Limited, New Delhi
1640	Climate change adaptation and mitigation in Indian Agriculture	B Venkateswarlu, Director, CRIDA, Hyderabad
	1700-1830 h	**Technical Session II**
	1900	Cultural Programme
	2000	Dinner

National Seminar on Climate Change Adaptation Strategies in Agriculture and Allied Sectors
Date: 03 Dec 2009

Technical Session II Weather variability (1700 to 1830 h)

Chairman: GGSN Rao
Rapporteurs: Ajithkumar B and Sunil KM

Chemical characteristics of aerosols and snow at an elevated site over the Central Himalayas
Hegde P, Kulshrestha UC, Naja M, Pant P

Influence of EQUINOO on the Indian summer monsoon
Charlotte BV

Climate change impact on the inter-relation between tropical cyclones over north western Pacific Ocean and Indian summer monsoon
Lekshmi Revi, Sandeep VM and Rajan CK

Variability of rainfall over Peninsular India, before and after 1976
Ram Mohan HS, Lorna R. Nayagam and Rajesh J.

Spatial and temporal variation of rainfall pattern over Kerala
Babu CA and Hamza V

Seasonal variability in rainfall and temperature at Vellayani
Shalini Pillai P, Ajithkumar CE, Liji LG and Preetha PS

Studies on the seasonal changes in rainfall pattern of Kovilpatti, Tamil Nadu
Babu R, Ragavan T and Uma Maheswari C

Astrometeorology Search for planetary influence on weather
Unnikrishnan T and Prasada Rao GSLHV

National Seminar on Climate Change Adaptation Strategies in Agriculture and Allied Sectors
Date: 04 Dec 2009

Technical Session III Climate change adaptation in natural resources management
(0900 to 1000 h)

Chairman: Peter M Davies
Rapporteur: DVK Nageswara Rao

Effect of a low cost sub surface dyke using plastic film in conserving soil moisture along the timeline in a sloppy terrain

Abdul Kareem, Thulasi V, Moosa PP and Mini PK

Strategies for sustainable development of Groundwater Resources

Anandha Kumar KJ and Mall RK

Rainwater harvesting to combat the vagaries of monsoon – a case study

Visalakshi KP, Reena Mathew, Bridgit TK and Raneesh KY

Climate change and adaptation for better drinking water resource management perspectives: A case study in Thiruvananthapuram district, Kerala

Shravan Kumar V, Murallidharan V, Reshmi P and Dhanya K

Forestry options for Climate Change Adaptation – Strategies and Action Plan

Jose Kallarackal

Effect of soil and water management practices on temperature and moisture flux in humid tropical latosols

Joseph E J, Shamla Rasheed, Shameer Mohamed E and Sundararajan V

Climate change projections and possible adaptive measures – A case study over Indo-Gangetic Plains in India

Subash N and Ram Mohan HS

National Seminar on Climate Change Adaptation Strategies in Agriculture and Allied Sectors

Date: 04 Dec 2009

Technical Session IV Climate change adaptation in Agriculture (1000 to 1100 h)

Chairman: Senthold Asseng
Rapporteur: Leenakumary S

The wanted change against climate change: assessing the role of organic farming as an adaptation strategy
Sherief AK and Sreejith A

Integrated Agro Advisory System: An adaptation strategy to minimise the negative impact of climate change
Ragavan T, Babu R and Uma Maheswari C

Biomass yield, carbon partitioning and dynamics of soil carbon under elevated atmospheric co_2 in rice and wheat in a typic haplustept
Thulasi V, Deo pal and Rajesh P

Simulation modeling of growth parameters for rice genotypes at different nitrogen level and different dates of transplanting using CERES 3.5 v for eastern Uttar Pradesh
Neeraj Kumar and Tripathi P

Impact of climate change on soil degradation and rice productivity at Pattambi
Ilangovan R, Pathummal Beevi, Prasad Rao GSLHV and Moosa PP

Diversified cropping pattern in response to change in climate in southern agro-climatic zone of Tamil Nadu
Ragavan T, Babu R and Uma Maheswari C

Effect of CO_2 enrichment and seed scarification on nitrogen composition of four avenue tree species
Sudarsana Rao GV and Murthy SRK

1100 to 1130 h Tea Break

National Seminar on Climate Change Adaptation Strategies in Agriculture and Allied Sectors
Date: 04 Dec 2009

Technical Session V Climate change adaptation in Horticulture (1130 to 1330 h)

Chairman: KV Peter
Rapporteurs: Pradeep Kumar T and Latha A

Climate change and Horticulture
Peter KV and Pradeep Kumar T

Climate change adaptation strategies in agriculture: Influence of ecological variables on productivity in tea
Raj Kumar R and Mohan Kumar P

Screening Tomatoes for Rainshelter Cultivation
Indira P and George TE

Implications of climatic change and adaptations in medicinal plants
Latha A and Radhakrishnan VV

Identification of morpho-physiological traits contributing towards water stress tolerance in Nendran clones
Manju RV and Sony KB

Effect of weather on the productivity of black pepper and coffee under Wayanad conditions
Sunil KM and Devadas VS

Yield of promising somaclones in ginger as influenced by weather parameters
Shylaja MR, Vijini KV, Nybe EV, Krishnan S and Prasada Rao GSLHV

Influence of micro meteorological factors on flowering and quality of cured beans in vanilla
Shylaja MR, Vijini KV, Ramya R, Nybe EV, Prasada Rao GSLHV, Krishnan S, Asha Sankar M and Augustine A

Climate variability and cocoa in Kerala
Prasada Rao GSLHV and Manikandan N

Climate variability and cardamom across the Western Ghats of India
Prasada Rao GSLHV and Manikandan N

Shifting pattern of rainfall – an ecological indicator affecting plant regeneration – case study of a medicinal orchid
Mini Raj N, Krishnan S and Nybe EV

Response of sowing date and spacing on yield of cabbage
Zagade MV and Chaudhari JN

Effect of weather parameters on coconut yield
Ajithkumar B and Jayaprakash Naik B

1330 to 1430 : Lunch

Climate Change Adaptation Strategies in Agriculture and Allied Sectors
Date: 04 Dec 2009

Technical Session VI Climate change adaptation in Fisheries and Animal Sciences (1430 to 1530 h)

Chairman: E Nanu
Rapporteur: Joseph Mathew

Impact and adaptation options for Indian marine fisheries to climate change
Vivekanandan E and Jeyabaskaran R

Impact of climate change on fishery at Cuddalore coast
Srinivasan M and Balasubramanian T

Influence of environmental variables on production traits in exotic and Desi pigs
Joseph Mathew

Effect of climatic variations in Incidences of captive elephant violence in Kerala
Rajeev TS, Rajkamal PJ, Marshal CR, Anil KS

Heat stress induced disturbances of humoral immunity in chicken
Ramnath V and Sreekumar KP

Effect of summer and rainy seasons of Kerala on haemogram of broiler chicken
Karthiayini K, Philomina PT and Sreekumar KP

Weather based animal disease forecasts
Tresamol PV and Saseendranath MR

Effect of diurnal variation in feeding during summer season on the milk production of crossbred cows

Nisanth P, Kannan A, Saseendran PC, Joseph Mathew, Prasad V and Smitha S

Productive performance of cross bred cows in hot humid environment

Noble D

Livestock to mitigate global warming

Saseendran PC

1530 to 1545 : Tea Break

Plenary Session VII (1545 to 1645 h)

Chairman: D Alexander
Rapporteur: GSLHV Prasada Rao

1545 to 1600 h : Presentation of reports of technical sessions

1600 to 1630 h : Panel discussions

Moderator for panel discussions: Senthold Asseng

Members of panel

1. Akhilesh Gupta
2. GGSN Rao
3. Peter M Davies
4. Kamalakshan Kokkal
5. E Nanu
6. EJ James
7. Jeyabaskaran R
8. Jose Kallarackal

1630 h : Chairman's Ending Remarks

1640 h : Vote of Thanks – AVR Kesava Rao

Technical Session I
Invited Papers

Climate change - Impacts and mitigation strategies

GGSN Rao, AVMS Rao and VUM Rao
Central Research Institute for Dryland Agriculture, ICAR, Hyderabad

Increasing evidence over the past few decades indicate that significant changes in climate are taking place worldwide as a result of enhanced human activities. The inventions of last few centuries, more so in the last century, have altered the concentration of atmospheric constituents that lead to global warming. The major cause to climate change has been ascribed to the increased levels of greenhouse gases like carbon dioxide (CO_2), methane (CH_4), nitrous oxides (NO_2), chlorofluorocarbons (CFCs) beyond their natural levels due to the uncontrolled human activities such as burning of fossil fuels, increased use of refrigerants, and enhanced agricultural activities. The long-term trend of declining CO_2 emissions per unit of energy supplied reversed after 2000. Atmospheric concentrations of CO_2 (379ppm) and CH_4 (1774ppb) in 2005 exceed by far the natural range over the last 650,000 years. Annual emissions of CO_2 grew by about 80% between 1970 and 2004. The CO_2 contribution from various sources namely burning of fossil fuels and deforestation, accounts for 76.6 per cent of the total greenhouse gas emissions over the globe. 44 per cent of the entire GHG emissions over the globe are from the Industry and Energy sectors. The latest monthly mean CO_2 measured at Mouna Loa, Hawaii, USA on September 2009 is at 384.78 ppm. The highest CO_2concentration is observed in May and lowest in October. The average CO_2 concentration increased from 379 ppm in 2005 to 385 in 2009.

The Intergovernmental Panel for Climate Change (IPCC, 2007) reported that eleven of the last thirteen years (1995-2007) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). The temperature increase is widespread over the globe and is greater at higher northern latitudes. Land regions have warmed faster than the oceans. These activities accelerated the processes of climate change and increased the mean global temperatures by 0.6°C during the past 100 years, a phenomenon known as global warming. Global average sea level has risen since 1961 at an average rate of 1.8 (1.3 to 2.3) mm/yr and since 1993 at 3.1 (2.4 to 3.8) mm/yr, with contributions from thermal expansion, melting glaciers and ice caps, and polar ice

sheets. Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7 per cent (2.1 to 3.3) per decade, with larger decreases in summer 7.4 per cent (5.0 to 9.8) per decade. Mountain glaciers and snow cover on average have declined in both the hemispheres.

A marked increase in both rainfall and temperature by the end of the 21st Century compared to the current normals (1961-90) are likely in India. There are considerable differences across the model outputs, which are more conspicuous in the case of summer monsoon rainfall. The projections of the increase in rainfall from the normal period (1961-1990) to the end of the 21st Century across the models varied between 15 and 40 per cent. Similarly, in case of the mean annual temperatures, the projected increases in temperature vary between 3 to 6^{0}C. The model projections at spatial level indicate that while the maximum changes in rainfall can occur over the arid and semi-arid regions of northwestern parts of India, there would be very little or no change noted in the monsoon rainfall over major part of peninsular India. Similarly, warming is projected to increase over all the parts of the country. It may increase by 2-4^{0}C over the southern regions while it would be more pronounced (> 4^{0}C) over the northern states and in the eastern peninsula of India. The warming is expected to be higher during winter and post-monsoon months, compared to the rest of the year. At regional level, trends and projections in rainfall and temperature were also discussed and mitigation strategies suggested as a part of climate change adaptation strategies.

Climate change implications for river restoration in global biodiversity hotspots

Professor Peter M Davies
Centre of Excellence in Natural Resource Management, The University of Western Australia, 1 Foreshore House, Albany, 6330, Australia

Global biodiversity hotspots contain exceptional concentrations of endemic species. The Western Ghats/Sri Lanka (including Kerala) and southwestern Australia are two hotspots undergoing human induced and climate change. However these hotspots are geographically restricted and therefore vulnerable to climate change as there is limited ability for species to migrate to less hostile conditions. Southwestern Australia as one of the first regions to experience significant climate change is an example of the issues associated with river restoration in hotspots. In this region, since the mid-twentieth century, rainfall and runoff have declined by 20 and 50% respectively and temperatures have increased by almost 1 ^{o}C. Present climate predictions are of increasing temperature and reduced rainfall; the intensity of these changes dependent on the level of intervening political response. The current and predicted increases in temperature may influence freshwater biodiversity by exceeding tolerances of aquatic fauna. In some hotspots in the Northern Hemisphere, where possible, species have moved northwards or to increasing altitudes. Southwestern Australia is surrounded by ocean and desert, and many important national parks are located on the extreme south coast, where the landscape is relatively flat. Therefore, mitigation responses need to be *in situ* to produce a suitable biophysical envelope to enhance species' resilience in the short-medium term. These restoration techniques are applicable to global biodiversity hotspots where geography constrains species' migration.

Climate change projections and impacts on plantations in Kerala

GSLHV Prasada Rao, AVR Kesava Rao, KN Krishna Kumar and CS Gopakumar
Centre for Climate Change Research, Kerala Agricultural University, Thrissur, Kerala

Long-series of climatological data for 140 years over Kerala in the humid tropics of India indicate cyclic trends in annual rainfall with a declining trend in annual and southwest monsoon rainfall during the past 60 years. In contrast, there was an increasing trend in northeast monsoon rainfall, though not statistically significant, indicating likely shifts in rainfall patterns. Onset of monsoon appears to be little early over Kerala and rainfall distribution is highly erratic in recent years. It is also observed that the monsoon rainfall is likely to be below normal, if the onset of monsoon is early i.e., on or before 25 May. It was tested in 2001, 2004, 2006 and 2009 and found to be correct. A clear upward trend in surface air temperature over Kerala between 1961 and 2003 by 0.6^0C in maximum and 0.2^0C in minimum temperature, with an average increase in surface temperature of 0.6^0C was noticed. These changes in thermal and moisture regime have resulted in the shifting of climate from B4-3 to B2-1 moving from wetness to dryness within the humid type of climate.

Long-term statistics of area under crops showed a clear shift from foodgrain crops to non-foodgrain crops in Kerala. Rice, cocoa and cashew area declined drastically due to various socio-economic factors in addition to monsoon aberrations. Though Kerala stood first in terms of cashew production a few years ago, at present it occupies only fourth position and likely to go down further. This is due to steady decline in cashew area and also weather aberrations during the reproductive phase of cashew. Interestingly, there is increase in area under rubber, black pepper and coconut to some extent. Whereas, area under cardamom, coffee and tea appears to be relatively stable.

Disastrous summer droughts were noticed in 1983 and 2004 for the State of Kerala as a whole. Such drought conditions are not uncommon in the northern districts of Kerala viz., Kasaragod and Kannur, where unimodel rainfall distribution is prevalent with heavy rainfall during southwest monsoon followed by prolonged dry spell when northeast monsoon rainfall and pre-monsoon showers fail. Under such conditions, annual coconut production in the following year is likely to be adversely affected. More

number of droughts occurred during the decade 1981-90. Replanting of coconut on large-scale due to cut and removal of root-wilt disease and senile palms along with the more number of droughts were the reason for the sharp fall in Kerala's coconut production during the above period. The lowest coconut production in 1983-84 was attributed only to the disastrous summer drought occurred in 1982-83. Coconut price fluctuations were also observed during the drought years. Low monsoon rainfall followed by weak northeast monsoon from 1999 to 2003 led to severe hydrological drought in summer 2004. For the first time in history, some irrigation dams partially dried up. Many black pepper vines were also wiped out in Wayanad district. Higher air temperature during Jan-Mar in 2004 at Vellanikkara, Thrissur (10.55 °N and 76.27 °E) had severely affected the pod yield in cocoa and production of other thermo-sensitive crops under severe soil moisture stress conditions.

Long-period climate analysis of highranges in Kerala indicated that warming with decline in rainfall is likely at Ambalavayal in Wayanad district, where coffee, tea and black pepper dominates, while warm days with cool nights with increase in temperature range over Pampadumpara in Idukki district, where cardamom, tea and black pepper are grown. Inactive monsoon within the monsoon season (Jun-Sep) during processing of the "Monsooned Malabar" coffee may lead to increase in acidity and decrease in sugar content in the coffee beans, leading to poor quality of black coffee. A weather scenario which is not conducive to coffee may be favourable to black pepper and vice-versa. Absence of backing showers in April / May 2009 may lead to low bean production in the case of coffee, while erratic rainfall distribution during 2009 is likely to affect adversely the flowering behaviour of cardamom and black pepper. Therefore, mixed cropping coffee plantations with black pepper may sustain in Wayanad district as a strategic approach to mitigate the ill-effects of climate change / variability.

Global Circulation Model projections indicate an increase in temperature by 2 - 3^{0}C during the ensuing decades. Extreme rainfall events are likely along with sea level rise. Coastal ecosystems, forest-agro-ecosystems along the highranges and rice-ecosystems of Kerala are in threat. Crop-specific agroclimatic demarcation as a part of climate risk management may be a good tool to sustain plantation crop production, particularly in cardamom and cashew. Integrated Agrometeorological Advisory Services based on weather forewarning at the Block / Panchayat level are the need of the hour as a pro-active measure against weather aberrations. There is a need to develop climate change adaptation strategies specific to humid tropics so as to minimize the ill-effects of climate change / variability on plantation crop production to sustain the economy of the Plantation State.

Climate change adaptation strategies for rice (*Oryza sativa.* L) in Kerala

S Leena Kumary
Rice Research Station, Kerala Agricultural University, Moncompu, Kerala

Over almost a decade a fast growing literature is adding value to the growing knowledge on climate variability and its impacts on Agriculture and allied fields. Climate change is likely to increase the frequency and intensity of severe weather events on a global level. Dry spells during the monsoon season and heavy rains in summer seasons, which are part of the climate changes taking place across the world, are becoming more frequent in Kerala. Rice is most vulnerable to these changes, which are expected to affect crop growth and development, resulting in yield reduction and even crop loss to a considerable extent. Given the significance of rice as the staple food crop of Kerala and the major contributor towards its economy, adaptation strategies and mitigation measures need be applied to improve the resilience of the rice production systems of the State to climate extremes and to ensure their stability. Innovative programmes aimed at adapting agriculture to warmed / water-deficient / flood-prone / saline situations have to be developed.

Adaptation involves adjustments to decrease the vulnerability of rice production to climate change. Production losses may be averted or at least mitigated through the concerted efforts of agricultural research and policies aiming to improve rice varieties and accompanying management strategies. Selection of appropriate rice varieties is one of the important technical options for adaptation to climate change. Also, development of rice varieties that have not only high-yielding potential, but also a good degree of tolerance to high temperature, salinity, drought and flood, would be very helpful under the projected global warming and associated climate change. Conservation and responsible use of the rich genetic resources of rice (*Oryza sativa.* L) in Kerala for development of stress tolerant rice varieties with emphasis on heat and drought resistance, submergence tolerance and resistance to biotic stresses as well as adverse soil and weather conditions are needed to meet the challenges of climate change.

Has the impact of temperature variability on wheat production been underestimated?

Senthold Asseng, Ian Foster[1] and Neil C Turner[2,3]
CSIRO Plant Industry, Private Bag No. 5, Wembley, WA 6913, Australia
[1]Department of Agriculture and Food Western Australia, Locked Bag 4, Bentley DC, WA 6983, Australia
[2]Centre for Legumes in Mediterranean Agriculture, M080, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia
[3]Institute of Agriculture, M082, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia

With current annual production at over 600 million tonnes, wheat is the third largest crop in the world behind corn and rice, and an essential source of carbohydrates for millions of people. While wheat is grown over a wide range of environments, it is common in the major wheat-producing countries for grain-filling to occur when soil moisture is declining and temperature is increasing. Average global temperatures have increased over the last few decades and are predicted to continue rising, along with a greater frequency of extremely hot days. Such events have already been reported for major wheat growing regions in the world. Attributing changes in observed yield to a single factor such as temperature is not possible due to the confounding effects of other climatic factors such as rainfall and radiation, and changes in non-climatic factors such as improved cultivars, increased nutrition and new cropping technologies. By using simulation modelling, we separated the temperature impact from other yield factors. This showed that we might have underestimated the impact of temperature variability on wheat production. Surprisingly, temperature can be a major source of wheat yield variability and small observed changes in mean temperature can cause large reductions in grain production. With average temperatures and the frequency of heat events projected to increase with global warming, yield reductions due to higher temperatures during the important grain filling stage alone could substantially undermine global food security.

Climate change, fodder production and livestock

DVK Nageswara Rao and D Thammi Raju[1]
Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh
[1]Sri Venkateswara Veterinary University, Rajendranagar, Hyderabad

Indian Grassland and Fodder Research Institute is a premier establishment with its unique mandate to handle both plant and animal research. As 'Climate Change' is a hot subject of the current times, it is necessary to update the existing knowledgebase about its impact on agriculture and livestock. This helps to extend highly focused research and to translate the results into adaptable technology to mitigate the adverse effects. Considering the low adaptive capacities of 700 million people who depend on the climate sensitive sector, India's National Action Plan for Climate Change (NAPCC) identified the development and poverty eradication as the best forms of adaptation to the climate change.

It is clear that variability in climatic parameters differentially influence the physiological responses of plants and animals. It is expected that species niches, plant and crop substitution, take place when climate changes and becomes more uncertain. Research showed the direct and indirect effects of aberrant climate alter animal behaviour and resultant productivity. Agriculture contributes largely to the methane emission (78%) in India while livestock dominates the scene with a share of 9000 Gg. Cattle (43%) > goat (25%) > buffaloes (18%) > sheep (11%) > pigs (3%) is the order of the contribution and much of it comes from the enteric fermentation.

Mapping of biophysical, social, technological vulnerability and adaptive capacity profile at district level, using GIS tools forms the basis for planning and implementation of schemes to enhance adaptation capacities. A technique of visualization of inundation of area with increased water level using freely accessible ASTER Digital Elevation Model at 30 m resolution suggested use of such resources and tools for mapping risk prone areas.

Suggested mitigation strategies include intervention for physical modification of the environment and improvement in nutritional management practices, reduction of methane emission by improving rumen fermentation efficiency, establishment of fodder banks at strategic locations based on the risk prone area maps made by using remote sensing and GIS tools, silvipasture development and prioritization of livestock production. Finally, some case studies are required to understand the vulnerability at local scale that helps in refining policies to enhance the adaptation capacity of farmers.

Integrated agromet advisory services for the coastal region of Kerala - Future projection under climate change

RP Samui, MV Kamble and JP Sabale
Agricultural Meteorology Division, India Meteorological Department, Shivajinagar, Pune

Temporal and spatial variability in weather conditions make significant impact on Indian agriculture. Climate variability is the major production risk and uncertainty factor that challenge farmers in their management of agricultural systems. Decrease in food production, increase in prices of agricultural and other commodities, low employment and pessimistic economic environment, directly impact the economy and rural poor. Therefore, timely forecast on weather would have tremendous benefits in terms of *ex ante* management of the negative impacts of vagaries of weather. Modern agricultural practices such as sowing of weather-sensitive high yielding varieties, need-based application of fertilizer, pesticides, insecticides, efficient irrigation and planning for harvest require weather forecast with higher lead time which enable the farmers to take ameliorative measures. One of the prime mandates of Integrated Agromet Advisory Services (IAAS) is to render timely advice to the end users based on past, actual and expected weather so as to minimize the damages caused by hazardous weather.

An attempt has been made to describe the need based system of agrometeorological services in the State of Kerala with special reference to coastal region and high land in order to list the needs for agrometeorological services from different groups of end-users. Mid land farming is likely to be adjusted in either side putting into use alternate cropping systems. Attention has also been given to find out the gap between "what exists" and "what should be" under climate change scenario. Deforestation, loss of wetlands, rise in sea level, shift in cultivable area from foodgrains to non-foodgrains, drying of ponds and wells, indiscriminate sand mining and depletion of groundwater are the major changes expected over Kerala due to impact of climate change. Climate change or variability may also lead to disasters like floods, droughts, landslides and sea level rise. It is indicated that the Southwest monsoon rainfall is likely to decline, surface air temperature and its range are likely to increase along the high-ranges of the Western Ghats. Under such circumstances, there is threat to thermo-sensitive crops like black pepper, cardamom, tea, coffee and cashew. Therefore, climate change risk management strategies to minimize the ill effects of climate change on war-footing are highlighted. Emphasis is given on integrated agromet advisory services, its future need and the different strategies to be opted in Kerala under the climate change scenario.

Possible impacts of climate change on water resources of Kerala

Kamalakshan Kokkal, P Harinarayanan and MV Aswathy
Coastal and Environment Division, KSCSTE, Govt. of Kerala, Thiruvananthapuram

Climate change is having overwhelming influence on the global water resources scenario. Water resources of Kerala are solely depending on rainfall. The amount of rainfall received over Kerala may vary spatially and temporally and the impact of climate change may have pronounced impact on agriculture and availability of water for human requirements. Being a coastal state having a coastline of about 600 km, the impact of sea level rise due to climate change will affect the coastal ecosystems including dynamic groundwater regime of the coastal area. The Kuttanad area with a spatial extend of 500 sq.km lies below the sea level and the sea level rise due to climate change will adversely affect the salinity of the back water system which will adversely affect the biotic community and more and more land area will be submerged under water. The rainfall of Kerala is about 2.78 times of national average. The per capita water availability of Kerala is decreased to five fold during the last 100 years while at the national level it is decreased to four fold only. It has been reported that the available groundwater and surface water resources of Kerala is under great stress and the onset of climate change would aggravate the situation. Integrated Water Resources Development and Management (IWRDM) is the only option and necessary master plan has to be prepared for meeting the above challenges with due input of scientific expertise. This has to be done on war footing following the line of Winning Augmentation and Renovation of water (WAR) programmes of Department of Science and Technology (DST).

Climate change impact on Indian Agriculture: Crop insurance as adaptation strategy

KN Rao
Agriculture Insurance Company of India Limited, New Delhi

Agriculture is subject to a great many uncertainties. Yet, more people in India earn their livelihood from this sector than from all other economic sectors combined. About 60 per cent of rural households are engaged in farming activities. During 2006-07, it provided 52 per cent of employment and sustained 69 per cent of total Indian population (Economic Survey 2007-08). Another feature of the agriculture sector is the large number of small sized landholdings. Nearly 63 per cent of holdings were less than one ha, with holding size of 0.4 ha. As a consequence of small farm-holding size with associated problems like low productivity and uneconomic agricultural prices, the incidence of indebtedness has been on the rise.

Climate change is a long term issue, and is expected to be a major factor to contribute to extreme temperature, floods, droughts, intensity of tropical cyclones, and higher sea levels. While the magnitude of impact varies greatly by region, climate change is expected to impact on agricultural productivity and shifting crop patterns. The policy implications are wide-reaching, as changes in agriculture could affect food security, trade policy, livelihood activities and water conservation issues, impacting large portions of the population. Climate cannot be blamed for poverty. But, where people are poor, it presents an additional risk that can critically restrict options, and limit development. Climate change has thus become an urgent issue on the development agenda. The ability of agriculture to adapt to and cope with climate change depends on many factors, and one such factor is agriculture insurance.

Agricultural insurance has been used as a risk-mitigating tool in India since 1972. Index-based insurance was tested as a pilot in 1979 and in 1985 introduced on a countrywide basis, which was further improved in scope and content in 1999, when the Government devised the National Agricultural Insurance Scheme (NAIS). NAIS, administered by Agricultural Insurance Company of India Limited (AIC), is a yield index-based insurance that provides coverage to an approximately 35 different types of crops during the Kharif season (June – October) and 30 during the Rabi

season (December – March), annually insuring over 20 million farmers, growing crops on over 28 million ha. Though NAIS provides a formal risk management tool, it also faces many challenges that limit its market penetration, including inadequate coverage, large basis risk and delayed indemnification. In order to address these, AIC developed a pilot weather index-based insurance product in 2004, which grew into a government supported large pilot since Kharif 2007 season. Risks covered by these products include excess or lack of rainfall, dry-spell, rise in temperature, frost, humidity and wind speed.

One key advantage of the weather based crop insurance is that the payouts could be made faster, besides the fact that the insurance contract is more transparent and the transaction costs are lower. Because index insurance uses objective, publicly available data it is less susceptible to moral hazard. When used as a disaster management tool, rapid payouts are the crucial advantage of weather index insurance. This offers an alternative to the notoriously slow response to disasters in the form of relief aid, and the ad-hoc nature of this. It allows governments and relief agencies to plan ahead of crises, knowing that funds will be available when they need them. At the same time, several critical components need careful attention if weather index insurance is to be workable. A good density of weather station network is critical for this purpose. Most importantly, for weather index insurance, climate change poses several questions. First, can index insurance contribute to adaptation strategies in a country like India? For decision-makers, climate change represents a dramatic increase in uncertainty. A second question is whether index insurance can play a role in managing this uncertainty itself. Finally, does climate change challenge the viability of weather index insurance products?

It appears there are at least three ways through which index insurance might help build adaptive capacity: (i) as a risk transfer mechanism within a comprehensive strategy to manage climate risk in the face of climate change; (ii) as a mechanism to help people access the resources needed to escape climate-related poverty traps and reduce their vulnerability to climate change, and (iii) as a mechanism to incentivize risk reduction. A key challenge in designing insurance given climate change is to transfer risk and incentivize risk reduction through price incentives and risk management stipulations. Without this complementary risk reduction, more risks could become uninsurable in the future.

Climate change adaptation and mitigation in Indian Agriculture

B Venkateswarlu, Arun Kumar Shankar and AK Gogoi[1]
Central Research Institute for Dryland Agriculture, Hyderabad
[1]Indian Council of Agricultural Research, New Delhi

Climate change impacts on agriculture are being witnessed all over the world, but countries like India are more vulnerable in view of the high population depending on agriculture, excessive pressure on natural resources and poor coping mechanisms. The projected impacts are likely to further aggravate yield fluctuations of many crops with impact on food security and prices. There are already evidences of negative impacts on yield of wheat and paddy in parts of India due to increased temperature, increasing water stress and reduction in number of rainy days. Modelling studies project a significant decrease in cereal production by the end of this century. Climate change impacts are likely to vary in different parts of the country.

Even though climate change in India is now a reality, a more certain assessment of the impacts and vulnerabilities in agriculture sector and a comprehensive understanding of adaptation options across the full range of warming scenarios and regions would go a long way in preparing the nation for climate change. A multi-pronged strategy of using indigenous coping mechanisms, wider adoption of the existing technologies and or concerted research and development effort for evolving new technologies are needed for adaptation and mitigation. Policy incentives will play crucial role in adoption of climate needy technologies in agriculture too as in many other sectors. The State Agricultural Universities and Regional Research Centres will have to play major role in adaptation research which is more region and location specific while national level efforts are required to come up with cost effective mitigation options, new policy initiatives and global cooperation.

Technical Session II
Weather variability

Chemical characteristics of aerosols and snow at an elevated site over the Central Himalayas

P Hegde, UC Kulshrestha[1], M Naja[2] and P Pant[2]

Space Physics Laboratory, Vikram Sarabhai Space Centre, Thiruvananthapuram, Kerala
[1]School of Environmental Sciences, Jawaharlal Nehru University, New Delhi
[2]Aryabhatta Research Institute of Observational Sciences, Manora Peak, Nainital

Atmospheric aerosols play significant role in the climate of the earth on local and regional scale through scattering or absorption of incoming solar radiation/outgoing terrestrial radiation. The radiative effects depend on the physico-chemical properties of aerosols. Chemical composition of aerosols is a deciding factor in producing cooling or heating in the atmosphere. While majority of species like SO_4, NO_3 and Cl produce cooling, black carbon / soot aerosols cause warming. To understand the high spatial heterogeneity of aerosols, it is essential to characterise them on regional basis to quantify their radiative impacts. This paper presents the results of the study on chemical composition of aerosols and snow samples collected in and around a high altitude location Manora Peak, Nainital (1950 masl, 29.4°N; 79.5°E) during August 2006 to January 2007. This high altitude mountain site in the Himalayas can provide the conditions of background aerosols without significant contamination from human activities.

Ambient aerosols were collected using an air sampler (Thermo Anderson – GHV2000) at Manora Peak, Nainital and snow samples were collected during winter 2006 from two well-identified snowfall events at various altitudes ranging from 1800 to 2800 m amsl (in and around Nainital). The prevailing meteorology at Manora Peak during the observation period encompasses synoptic northwesterly circulation. Chemical composition of aerosols and snow (cations and anions) were measured using standard analytical techniques. Both aerosols as well as snow samples showed the presence of natural as well as anthropogenic components. Independent measurement of Black Carbon (BC) showed that BC constituted 6.2 (4)% of total aerosols mass. In general, snow chemistry mimics aerosol chemistry with similar relative abundances and interspecies relationships. The water-soluble components account about 12% of total mass of the aerosols. Sulphate, a tracer for anthropogenic sources was found to be the major anion. Back Trajectory analysis showed that there is a dominant transport mechanism (long range transport) controlling aerosol and snow concentrations of most of the chemical species. Proper quantification of the chemical data from two contemporaneous atmospheric processes (aerosol dry deposition and snow) may be helpful in making and validating regional climate forcing models.

Influence of EQUINOO on the Indian summer monsoon

BV Charlotte
Department of Atmospheric Sciences, Cochin University of Science and Technology
Cochin, Kerala

Large scale air sea interaction plays vital role in regulating the Indian Summer Monsoon Rainfall (ISMR). A study was carried out to understand the influence of Sea Surface Temperature (SST), zonal wind and convective activity over the Indian Ocean region during EQUINOO (Equatorial Indian Ocean Oscillation), IOD (Indian Ocean Dipole), El Nino, La Nino and Southern Oscillation on the ISMR. Data used for this study were monthly anomalies of SST, cloud, OLR and zonal wind from NOAA and NCEP.

SST, wind and convection had opposite patterns in both positive and negative phases of EQUINOO. During El Nino years, convection and low level westerlies extended up to international dateline whereas during La Nina years, they extended up to 130°E only. Strong EQUINOO years showed enhanced convection over the western equatorial Indian Ocean and weak convection in the eastern side. A dipole like structure was observed in the equatorial convection.

Strong EQUINOO years were always associated with positive phase of monsoon (surplus ISMR) and vice versa. Monsoon rainfall and EQINOO were positively correlated with good significance level. The monsoon rainfall was solely controlled by EQUINOO in the absence of El Nino. In 1951, 1956, 1957, 1969, 1986, 1992, 1999 and 2002, when ENSO and EQUINOO co-occurred, the combined effect was reflected on the monsoon rainfall. But in the years 1963 and 1997, the effect of ENSO and EQUINOO was opposite (when El Nino in the Pacific co-occurred with strong EQUNOO in the Indian Ocean), convection and wind pattern appeared similar to a strong EQUINOO year and monsoon was wet. It is found that EQUINOO had an edge over ENSO in influencing ISMR. When IOD and EQUINOO occurred simultaneously, monsoon appears to be more active. Although IOD had weak negative correlation with monsoon rainfall, EQUINOO can regulate IOD effect on ISMR.

Climate change impact on the inter-relation between tropical cyclones over north western Pacific Ocean and Indian summer monsoon

Lekshmi Revi, VM Sandeep[1] and CK Rajan
Centre for Climate Change Research, Kerala Agricultural University, Thrissur, Kerala
[1]Department of Atmospheric Sciences, Cochin University of Science and Technology, Cochin, Kerala

The present study has designed to examine the relationship between Tropical Cyclone (TC) activity over NW Pacific and monsoon rainfall over India. In this study relation between the tropical cyclone track data from Joint Typhoon Warning Centre over NW Pacific and significant features of monsoon circulations over Indian region have been looked into. It has been observed that the TC activity over NW Pacific is inversely and significantly correlated with monsoon rainfall over India. The characteristic of SST over Northern Indian Ocean and NW Pacific Ocean is analyzed during the occurrence of TC over NW Pacific. As a result of the warm SSTs gives result a large number of TCs over the West Pacific during summer. Spatial dependence of the relationship revealed that TCs forming over NW Pacific and moving northwards have an adverse effect on Indian monsoon rainfall. The extended TC activity can cause anomalous circulation anomalies like large-scale subsidence over the Indian region, which may weaken the Indian monsoon circulation and rainfall activity. It was observed that TCs forming over the South China Sea and moving westwards may have a positive impact on monsoon rainfall over India. The westward propagating TCs of the West Pacific can act as precursors of low pressure disturbances in Bay of Bengal and cause good rainfall over different parts of India. It also revealed that in most of the occasions during the onset and stabilization period of the south west monsoon, generally no typhoon formation takes place in the Pacific region. There were cases when typhoon is developed and move to Bay of Bengal and intensify the monsoon depression. It happened only in the last week of June or fist week of July. In the recent years it noticed that, soon after the monsoon onset or very close to the monsoon onset period, typhoon used to develop in the Pacific and intensify. It was noticed that the monsoon activity has been subdueded in such cases. This can be taken as one of the effects of the global warming and related climate change.

Variability of rainfall over Peninsular India, before and after 1976

HS Ram Mohan, Lorna R Nayagam and J Rajesh
Department of Atmospheric Sciences, Cochin University of Science and Technology
Cochin, Kerala

To understand the variability in rainfall over the different subdivisions over peninsular India with a focus over Kerala, subdivisional rainfall from IITM for the period 1951-2005 formed the material for the study. Southwest monsoon (SWM) and Northeast monsoon (NEM) rainfall over peninsular India experienced more number of WET / DRY years. Coastal Andhra Pradesh, coastal Karnataka and Rayalaseema had more WET years after 1976 during SWM. Rayalaseema had 8 Wet years after 1976 in comparison to 2 Wet years during 1951-1975. All other subdivisions experienced more DRY years after 1976. An increase in the mean rainfall and Standard Deviation (SD) is observed over these subdivisions except Coastal Karnataka, where the mean and SD decreased by about 211 mm.

The number of WET years decreased over coastal Andhra Pradesh and coastal Karnataka while in all other subdivisions the number of WET years increased. It is noticeable that Tamil Nadu experienced 6 WET years after 1976, compared to 1 WET year during the period 1951-75. The number of DRY years also increased from 2 to 4. Over Kerala, the WET years increased from 3 to 8 after 1976. Over Rayalaseema also the number of WET years increased. Except Tamil Nadu, south and north Interior Karnataka, all subdivisions have experienced lesser number of DRY years after 1976 compared to the period 1951-75. The mean and Std. dev. increased after 1976 except over south and north interior Karnataka, where they decreased. Over Coastal Andhra Pradesh, the mean rainfall increased but the SD decreased.

Over Kerala subdivision, the number of WET years during the NEM season increased from 3 in the pre 1976 phase to 8 in the post 1976 phase, whereas the number of DRY years decreased from

4 to 2 during the same periods. Above normal years have also increased during 1977-2001. Wet years during the SWM season have decreased from 4 (1951-1975) to 2 (1977-2005). Meanwhile the number of DRY years has increased to 6 (1977-2005). Also the below normal years have increased drastically after 1976.The mean rainfall of SWM over the subdivision has decreased from 1928.6 mm to 1870.4 with a decrease of 97 mm in Std. dev., whereas the NEM mean increased by 37mm with an increase of 19 mm in Std. dev. The trend of rainfall for the SWM and NEM rainfall shows that the SWM has a decreasing and NEM rainfall has an increasing trend with an increase in mean rainfall. These statistics point that during the SWM season, an increase in dry years has occurred after 1976, whereas an increase in the number of WET years is observed in the NEM rainfall.

Spatial and temporal variation of rainfall pattern over Kerala

CA Babu and V Hamza
Department of Atmospheric Sciences, Cochin University of Science and Technology, Cochin, Kerala

Topography of Kerala comprises coastal, midland and high land regions. Total annual rainfall in the state varies from 380 cm over the extreme northern part to about 180 cm to the south. In the southern region, the contribution of rainfall during the southwest monsoon is around 40-50 % and in the northern area, it is around 80%. In this paper, the temporal and spatial variations of rainfall events over coastal, midland and high land stations are presented. Hourly rainfall data from different locations were procured from the hydrology department. Analysis was carried out for representative stations in the regions.

At the north Kerala coastal station, more rainy days are found in the monsoon season. More than twelve rain events were found to occur between 10 and 12 hours (IST) in June. At this station, more events are seen during southwest monsoon season. At mid Kerala station, bimodal rainfall pattern is found, one is in the monsoon season and the rain events are almost uniformly distributed all over the monsoon months. The second mode is found in the October. Here, maximum rain occurrence is seen in the wee and late evening hours. The midland station showed similar pattern of the coastal station, but the diurnal pattern differed.

In high land, the bimodal distribution is found; both occurring in the southwest monsoon. Diurnal variation of the rain events is seen in the day hours (maximum occurrence between 12 and 16 hours during June and 7 to 12 hours during August). For the high land, the frequency of rain occurrence is less than that of the coastal and midland stations since the station is situated in the rain shadow region. It is interesting to note that this station exhibits three modes in the seasonal pattern during March, July and November. The frequency of the rain events is high during November. In all the three modes the diurnal feature is almost same.

Seasonal variability and trend in rainfall and temperature at Vellayani

P Shalini Pillai, CE Ajithkumar, LG Liji and PS Preetha
Regional Agricultural Research Station (Southern Zone), KAU,
Thiruvananthapuram, Kerala

Attempts were made to analyze the temporal variation in rainfall recorded over twenty-five years (1984-2008) at the Regional Agricultural Research Station (Southern Zone), Vellayani, Thiruvananthapuram, Kerala. A declining in trend is observed in rainfall and the number of rainy days during the month of June and an increasing trend in October. In recent years the monsoon exhibits a shy trend during the initial phase. The diurnal temperature variation has narrowed significantly during April and May. The study indicated the possibility of advent of slight changes in commencement of cropping season and varietal choice. The trend of rainfall and rainy days over the years (N=25) was estimated using linear regression models and the significance of their coefficients tested.

Studies on the seasonal changes in rainfall pattern of Kovilpatti, Tamil Nadu

R Babu, T Ragavan and C Uma Maheswari
AICRPAM, ARS (TNAU), Kovilpatti, Tamil Nadu

Data on rainfall and rainy days at the at Agricultural Research Station, Kovilpatti, Tamil Nadu was analyzed for a period of 30 years from 1975 to 2004 and then compared with the rainfall distribution for the four years 2005-08. The analysis reveals that the total rainfall increased from the normal rainfall of 731 mm from 2005 onwards with an increase in rainfall from 17 per cent to 48 per cent. The increase in rainfall had also increased the number of rainy days from 43 days to 46 and 51 days during 2005 and 2008 respectively. Rainfall during the summer season (March-May) has increased. Normal rainfall during summer season at Kovilpatti was 147 mm in nine rainy days. This had increased to 263 mm (79%) in 2005 and 381 mm (159%) in 2008. There was not much variation in the southwest monsoon (June to September) rainfall. But there exists significant variation in the pattern of rainfall. September rainfall had decreased considerably from the normal rainfall of 81 mm to 28 mm (-65%) in 2005, 37 mm (-54%) in 2006, 11 mm (-87%) in 2007 and 9 mm (-89%) in 2008.

Changes in the September rainfall had a significant impact on the ensuing cropping period of northeast monsoon period. Further, the pre-monsoon sowing of cotton fails considerably as there is practically no rainfall during the end of September. Hence, there is a need to change the sowing time at Kovilpatti for pre-monsoon sown crops especially cotton. Increase in rainfall was observed during the summer months particularly during March. There is a need to implement proper land management technologies for better utilization of the rainwater received without loss of soil by water erosion. This can be achieved by going in for deep ploughing of soil immediately after harvest of the crops. Roto slasher can be used to chop the residue and leaving it *in situ* in the field. This would facilitate increased moisture storage by increasing infiltration (due to deep ploughing). Sowing of green manure crops may be thought off during the summer months to utilize the rainfall as well as to increase the organic matter content of the soil for sustaining the productivity of crops in drylands.

Astrometeorology – Search for planetary influence on weather

T Unnikrishnan and GSLHV Prasada Rao
College of Horticulture, Kerala Agricultural University, Thrissur, Kerala

Growth of every living organism has some correlating factor with weather and heavenly bodies. Sun being the major source of energy and moon having high influence on earth, these things are unavoidable. Astrology is considered as the eyes of Vedas since most of the treasure of knowledge lies in it was came through the analysis of heavenly bodies. While the study of the celestial bodies and their compositions, motions and origins is called astronomy, astrology is the applied astronomy. Many people made different attempts to predict weather using astrometeorology and most were highly accurate.

Research going on and the planetary influence on weather were very well studied by the ancient astronomers. The new branch of astronomy called Muhurtha was developed using this concept. According to this in a good muhurtha time, there will not be rain or other vagaries of weather like lightning, earthquake etc. The muhurta will vary for different purposes according to the star of the persons related and age, place etc. This will lead to the prediction of weather using astrology. For example we cannot predict rain in a desert using the concept of astrometeorology alone. In such situations we should use our common sense.

It is believed that the rotation and revolution of the earth are the main factors towards the changes in weather. Studies revealed that when a planet seemed to rest in cancer it will influence well in the northern hemisphere while the entry of a planet in Capricorn will highly influence the southern hemisphere regions. This was tested and found highly effective as in 2007 as Venus which is considered as watery sign planet in astrology was in Cancer during that period and high rain was in Kerala. But in 2008 and 2009 monsoon period, Mars and Ketu were in Cancer which caused less rainfall. As a forecast for 2010, since Mars is in Cancer, there is high possibility of increasing warm condition and drought in Kerala and India as a whole up to June 1.

Technical Session III
Climate change adaptation in natural resources management

Effect of a low cost sub surface dyke using plastic film in conserving soil moisture along the timeline in a sloppy terrain

Abdul Kareem, V Thulasi, PP Moosa and PK Mini
Krishi Vigyan Kendra Kannur, Kerala Agricultural University

Compared to the national average, unit land of Kerala is receiving 2.5 times more rainfall. Despite the heavy rainfall received the state experiences severe drought in summer which can be attributed to the inefficient utilization of rain water. In Kerala, where pressure on land is very high, surface storage of water in large reservoirs with adverse ecological impact is not an economical proposition. In this context, the construction of sub surface dyke can offer a solution. Subsurface dyke is the structure that is built in an aquifer with the intention of obstructing the natural flow of groundwater, thereby increasing the amount of water stored in the aquifer. Ground water availability in small valleys can be effectively increased by improving the storage potential, by construction of sub surface Dykes with impervious material like clay, bitumen, or polythene sheets besides bricks and concrete. The structure need not be thick or project above the surface. The ideal location for the dyke is a well defined, wide, greatly sloping valley with a narrow outlet having limited thickness of loose soil or porous rock on the top with massive or impervious rock below.

In areas of a well defined watershed with a narrow outlet and undulating topography, which is typical of Kerala, subsurface dyke is an efficient system to prevent water losses so as to conserve and utilize the rainfall that is received in a watershed. The water conserved in the upstream side of the dyke can be utilized for irrigation and other purposes. It also allows for recycling of irrigation water and nutrients in the catchment area. Plastic films can serve as a cheaper alternative to masonry wall as an efficient barrier against the subsurface flow of water.

Strategies for sustainable development of groundwater resources

KJ Anandha Kumar and RK Mall
National Institute of Disaster Management, Ministry of Home Affairs, New Delhi

Groundwater has played a vital role in fulfilling the demands of domestic, agricultural and industrial sectors. Indiscriminate development and unscientific management of groundwater resource have led to problems of groundwater depletion and pollution. Present status of knowledge of aquifer systems, their geometry and potential is based on the data generated by hydrogeological surveys, groundwater exploration, geophysical studies carried out by CGWB and other such state agencies. To meet India's future agricultural production and the growing water requirement of the domestic and industrial sector, the use of groundwater was initiated in 1950's. Coupled with this initiation, subsidy on the power for irrigation use has promoted the unplanned and extensive use of groundwater. This has ultimately resulted in long term damage in some places where groundwater levels have gone down. Natural phenomena like recurrent drought-flood-scenario, tidal intrusions in the vicinity of the sea have restricted the availability of surface water round the year, putting stress on the groundwater resources. This has also led to salinity problems in the coastal areas. Extensive use of surface water available at the subsidized rate in the irrigation command on the other hand has also deteriorated the soil and has created waterlogging in the command areas, especially in the upper reaches.

The hydrological cycle is being modified quantitatively and / or qualitatively in most agro climatic regions and river basins of India by human activities such as land use change, water use, inter-basin transfers, cropping pattern, irrigation and drainage. Many of the areas are getting transformed from safe areas to over-exploited areas with fall in groundwater table. Change in precipitation pattern (intensity and duration) being discussed recently, raises the question on the present pattern of groundwater recharge potential. Further, the projection of IPCC and such studies in India that heavy rainfall events will increase with no change in amount of rainfall, will impact the groundwater recharge directly. Therefore, future projects on rainwater harvesting and groundwater recharge may have to include the idea of climate change / change in rainfall pattern. Sustainable management of surface and groundwater and the supporting natural environment have gained considerable importance in recent years, especially in view of climate change. This paper tries to address these problems and strategies to deal with them.

Rainwater harvesting to combat the vagaries of monsoon – A case study

KP Visalakshi, Reena Mathew, TK Bridgit and KY Raneesh
College of Horticulture, Kerala Agricultural University, Thrissur, Kerala

Studies were conducted to assess the efficiency, durability and acceptability of different types of roof catchments, storing capacity of different types of storage structures with respect to quality of water, under the ICAR adhoc Project on "Technological and Institutional Interventions in Rainwater Harvesting in Kerala", during 2005-07 at the Kerala Agricultural University. Motivating models of rainwater harvesting from rooftops and land rain harvesting were established at the Campus which can enlighten on the scope and importance of conservation of rainwater in Kerala. The runoff coefficient of sloping aluminium sheet roof was observed as 0.91 and that of flat RCC roof slab as 0.73. Water quality analysis showed that the physico-chemical parameters of rainwater stored in all types of storage structures were within permissible limits as per the BIS even after six months of storage, whereas the microbial analysis showed that the water stored only in ferro cement tank and lined (750 micron HDPE) underground tank were free from e-coli, colliform bacteria and streptococcus. The evaporation loss from lined pond could be reduced up to 50% by providing 75% shade net on top, compared to the pan evaporation. An additional area of 0.8 ha could be brought under cultivation using rainwater collected in a renovated pond at the seed farm.

Climate change and adaptation for better drinking water resource management perspectives: A case study in Thiruvananthapuram district, Kerala

V Shravan Kumar, V Murallidharan, P Reshmi and K Dhanya
Centre for Earth Science Studies, Thiruvananthapuram, Kerala

Climate change and global warming are the two widely accepted and experiencing phenomena in many parts of the globe and almost all the countries are very much concerned to face them with possible adaptation of strategies for a better future with all limitations and constrain to cope with nature's fury.

The resultant effects of climate change are, deviations in weather observations leading to uncomfortable living conditions and loss in overall economic growth and prosperity especially in agriculture and human health. Kerala state with rich rainfall pattern compared to other parts of Indian states, with lush green environment and extensive wetlands, also record fewer natural calamities as devastating cyclones and intense droughts and floods in comparison to other parts of India and outside. The present study is mainly focused on the impact of climate change on drinking water resources in Thiruvananthapuram District with an emphasis on feasible adaptations for the future. The study area falls in southern part of Kerala with an average annual rainfall of 150 cm of rainfall with two distinct SW and NW monsoon peaks. It has three major rivers and four taluks and twelve developmental blocks with seventy eight Panchayats. The region has drinking water scarcity in many parts during summer months. The paper discusses various issues on water harvesting and water conservation practices for adaptation and assesses water resource potentials and present status.

Forestry options for climate change adaptation – Strategies and Action Plan

Jose Kallarackal
Emeritus Scientist (CSIR), Kerala Forest Research Institute, Peechi, Thrissur, Kerala

Because global vegetation and soils contain about three times as much carbon as the planet's atmosphere, terrestrial ecosystems offer an opportunity to absorb and store (sequester) a significant amount of carbon dioxide (CO_2) from the atmosphere. By planting trees, preserving forests, and changing cultivation practices to increase soil carbon, for example, it is possible to increase the size of carbon sinks. According to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report released in 2007, forests and their biodiversity are at great risk during this century. This means that we have to resort to adaptation and mitigation measures in the forestry sector to offset the climate change impacts. Three important measures are suggested to adapt the forestry sector to climate change consequences

1. Management for Carbon Conservation
2. Management for Carbon Storage
3. Management for Carbon Substitution

Not only will actions that promote carbon conservation and sequestration reduce net emissions, but they also make good social, economic, and ecological sense. Sustainable development, industrial wood and fuel production, traditional forest uses, protection of natural resources, water quality improvement and recreation, are all important objectives for managing forests properly. If all forests were managed for these purposes, then reductions in carbon emissions could occur as well.

Effect of soil and water management practices on temperature and moisture flux in humid tropical latosols

EJ Joseph, Shamla Rasheed, E Shameer Mohamed and V Sundararajan
Water Management (Agriculture) Division, CWRDM, Kozhikode, Kerala

Crop water deficit during summer season and low soil fertility are among the major limiting factors for higher crop productivity in Kerala. Climate change and global warming phenomenon is gradually increasing the atmospheric evaporative demand, which will lead to higher crop water deficits and lower productivity. A study was conducted in a coconut plantation in Kozhikode district to evaluate the effect of sustainable soil and water management practices like cover cropping and post-monsoon tillage on temperature and moisture flux in soil. Cover cropping, post-monsoon tillage, and unploughed area as control were compared. Soil temperature at different soil depths (2.5, 5, 10, 20, 30 and 50 cm) was recorded daily at 8.30 am and 2.30 pm using soil thermometers installed in each treatment plot. Soil moisture content at each depth was measured. Rainfall and ambient temperature were recorded.

Cover cropping is found to have significant effect on controlling the soil temperature. The daytime soil temperature in cover-cropped plot is lower than that of ploughed and unploughed plots. The morning soil temperature of cover-cropped plot is also lower than that of other plots, but the difference is narrower in surface soil. Soil temperature in surface layers is found to fluctuate significantly between day and night. Diurnal fluctuation of subsoil temperature is minimal. Cover-cropped plot is found to have the lowest soil moisture content, which can be attributed to the transpiration from cover crop.

Post-monsoon tillage significantly influences the soil moisture content, and the ploughed plot is found to have the highest moisture content, followed by the control and cover-cropped plots. Post-monsoon tillage creates soil mulch over the surface, thereby helping in the conservation of soil moisture. High soil moisture content in ploughed treatment may be due to the disruption of the soil-atmosphere-continuum, and thereby minimizing the capillary rise of water from the sub-soil and its loss. Higher soil temperature in the ploughed plot may be due to higher thermal conductivity of the moist soil.

Though cover cropping controls soil temperature, it hastens soil moisture loss. Therefore, it is advisable to practice cover cropping during monsoon season for controlling soil erosion, and use the cut dry shoots for mulching during summer season. Post-monsoon tillage is effective in conserving soil moisture.

Climate change projections and possible adaptive measures – A case study over Indo-Gangetic Plains in India

N Subash and HS Ram Mohan[1]

Division of Crop Research, ICAR Research Complex for Eastern Region
ICAR Parisar, Bihar Veterinary College P.O. Patna, Bihar
[1]Department of Atmospheric Sciences, School of Marine Sciences,
Cochin University of Science and Technology, Cochin, Kerala

The IPCC in its fourth assessment reported that under climate change the chances of occurrence of extreme climatic events would increase in the Indian Subcontinent. The Indo-Gangetic Plain extends over four countries – India, Pakistan, Nepal and Bangladesh. The IGP in India occupies nearly 20% of the total geographical area of the country and encompasses five States: West Bengal, Bihar, Uttar Pradesh, Haryana and Punjab. Rice-wheat is the major cropping system in the IGP. The influence of climate change on rice-wheat cropping system for five locations of IGP has studied using the modelling approach.

Minimum temperature in rice showed a negative trend at two sites, with one (Kanpur) statistically significant whereas three sites showed a positive trend, with two sites, Samastipur and Ludhiana showing significantly positive trend of 0.03 ^{0}C/year and 0.06 ^{0}C/ year, respectively. In wheat season, three sites showed a negative trend, while Ludhiana and Samastipur showed statistically significant positive trend ($P < 0.01$). The maximum temperature in rice remained stable over the years at Faizabad and Ludhiana showing a negative trend and three positive (Kanpur, Hisar and Samastipur). But during August and September, most of the sites showed increasing trend of maximum temperature. These significant changes in weather parameters during different stages of the crop result in declining trend of potential simulated yield of rice. The simulated rice yield for Faizabad, Kanpur, Ludhiana and Hisar showed a decreasing tendency of 7.2, 8.5 3.8 and 5.8 per cent, respectively by 2025 when compared to the base year 2007. Samastipur showed an increasing simulated rice yield of 11.4 per cent from 2007 to 2025. The simulated wheat yield for Faizabad, Kanpur, Hisar and Samastipur showed an increasing tendency of 13.9, 14.4, 8.9 and 9.6 per cent, respectively during 2025 when compared to 2007. The expected yield decline during the ensuing decades is a matter of serious concern and improved variety with more adjustability in the changed climate should be developed. The projected decrease in rice yield at four sites and decrease in wheat yield at one site provided an insight into the possible food insecurity threat of the region and measures should be taken to improve the yield based on integrating biotechnological advancement, precision farming and use of advanced and scientific crop cultural and management practices.

Technical Session IV
Climate change adaptation in Agriculture

The wanted change against climate change: Assessing the role of organic farming as an adaptation strategy

AK Sherief and A Sreejith[1]
Training Service Scheme, Department of Agricultural Extension, KAU
[1]IRCA, United Kingdom Certified Environmental Management System Lead Auditor

Conventional input intensive agriculture practiced over the last century has been a major contributor to climate change, second only to energy sector. The communities engaged in pesticide and synthetic input rich agriculture is most vulnerable to the impacts of climate change. Many emerging economies including India have had the opportunity to develop National Adaptation Plans of Action in the context of the United Nations Framework Convention on Climate Change but implementation of those programmes and strategic links to resourcing actions are often lacking. Adaptation in the agricultural sector can be seen in terms of both short-term and long-term actions. Changing to organic farming systems is the most efficient and long term adaptation strategy. Organic agriculture is believed to be the most sustainable approach against climate change ensuring food security; it employs low external input and high output strategies.

This paper attempts to review the potent role of organic agriculture as an adaptation strategy to deliver a tangible and hopeful alternative towards sustainable livelihood in the backdrop of climate change. The methodology involves thorough review of scientific literature. The study discusses the carbon sequestration achieved as well as reduction in emission with respect to low pesticide use and fossil fuel based farm machinery use in organic farming. The analysis of results concludes that the organic system of farming is the most resilient adaptation strategy against climate change and offer greater potential as a sustainable livelihood mechanism in times of climate transition.

Integrated Agro Advisory System: An adaptation strategy to minimise the negative impact of climate change

T Ragavan, R Babu and C Uma Maheswari
AICRPAM, ARS (TNAU), Kovilpatti, Tamil Nadu

Vulnerability to weather related disasters is an age-old phenomenon for human sustenance. Monsoon plays an important role for the agricultural output as large area sown in the region dependent on rainfall. Hence, agricultural growth is highly correlated with the behaviour of monsoon rainfall. In southern agro climatic zone of Tamil Nadu, it was observed that even in normal monsoon years in recent years the normal occurrence of soaking rainfall before onset of monsoon was delayed and forcing the farmers to go up late sowing. Even when monsoon is normal, long dry spells during the cropping period and heavy downpour at initial phases leading to waterlogging adversely affect the crop production in these regions. Integrated agromet advisory services play a special role to save the crops as well as to minimize losses with prior intimation to the farmers regarding weather aberrations and the strategies to be adopted.

An impact study on agro advisory services rainfall occurrences revealed that, during NEM, the farmers usually go for dry sowing of coarse millets and cotton at 39th and 40th standard week with pre monsoon showers, but during 2008 the shower was not occurred till 42nd standard week. The farmers of the Kovilpatti region were advocated to undertake sowing with onset of monsoon with short duration cultivars (Sorghum-K8, Cotton-KC3, SVPR 2, Pearl Millet-ICMV221) with expectation of subsequent rain after on-set of monsoon. By this advisory, the farmers were able to save the seed material by avoiding pre-monsoon dry sowing and that was used for monsoon sowing. Otherwise the crop could be resulted with lesser productivity due to improper and lesser germination and very less plant population due to 15-20 days prior dry sowing, which might have caused dehydration of seed materials. However, this kind of advisories based on the weather forecasts would help the farmers to save the precious seed material and its cost under rainfed situation. By this way, the medium range weather forecasts help the rainfed farming community to decide the appropriate time of sowing to get good crop stand and higher productivity through rainfed crops.

Biomass yield, carbon partitioning and dynamics of soil carbon under elevated atmospheric CO_2 in rice and wheat in a typic haplustept

V Thulasi, Deo pal[1] and P Rajesh
Krishi Vigyan Kendra, Kannur, Kerala
[1]Division of Soil Science and Agricultural Chemistry,
Indian Agricultural Research Institute, New Delhi

To study the impacts of elevation of CO_2, a pot culture and field experiments were conducted in open top chambers (OTC) and Free Air Carbon dioxide enrichment facility of the South Asian Network, New Delhi at Indian Agricultural Research Institute, New Delhi raising rice and wheat in two seasons. A decomposition study was also conducted in phytotron chambers (at the National Phytotron facility, New Delhi) wherein ambient and elevated CO_2 grown rice and wheat residues were allowed to decompose in litterbags. The data obtained were used for evaluating the ability of CERES-N model to simulate carbon and nitrogen mineralization from those residues.

Average biomass yield of all the plant parts increased due to exposure to elevated CO_2 in both the crops. Carbon content in different plant parts (except grain in both the crops and root in rice) either remained unaffected or increased marginally due to increase in atmospheric CO_2, which suggests absence of dilution effect in spite of increase in biomass yield. All the active carbon fractions were positively influenced by increase in atmospheric CO_2. The gains in soil carbon pools under elevated (both under OTCs and FACE) over ambient CO2 were MBC > DOC > CHC > LBC in rice and DOC > MBC > CHC > LBC in wheat rhizospheres. However, there were no significant changes in total C in soil under both the crops. In case of decomposition study inside phytotron, the amount of residues remained inside the litter bags showed comparatively higher values for the elevated CO_2 grown residues indicating their slow rate of decomposition. The decreased rate of decomposition of elevated CO_2 grown residues were clearly visible from the values of TOC and MBC contents in soil. However the difference between the values associated with ambient and elevated residues was higher for rice as the effect of elevation of CO_2 was more prominent during its decay. Ambient CO_2 grown residues had lower C/N ratios during decomposition as a result of which an increase was observed in the rate of mineralization.

Hence, lower C/N ratios of RA and WA in comparison to RE and WE at all stages of decomposition had enormous consequences in nitrogen cycling in soil. The process of decomposition and N mineralization from ambient and elevated grown rice residues were found to fit well to the modified CERES model with an exception in case of N mineralization from WE.

Thus, elevation of atmospheric CO_2 concentration brought an increase in the biomass and belowground partitioning and all active carbon pools in crop rhizosphere; the extent of gains were related to the relative liability of the active pools.

❖ Though marginal, significant increase in total soil carbon in upper layers of FACE indicates a definite possibility of carbon sequestration.

Decreased rate of decomposition might increase the residence times of the elevated CO_2-grown residue decomposition systems, thus supplementing sequestration of carbon in soil.

Simulation modelling of growth parameters for rice genotypes at different nitrogen level and different dates of transplanting using CERES 3.5 v for eastern Uttar Pradesh

Neeraj Kumar and P Tripathi
Department of Agriculture meteorology, College of Agriculture, Narendra Deva University of Agriculture & Technology, Narendra Nagar Kumarganj, Faizabad

The present investigation was carried out at Agrometeorological Instructional Farm of Narendra Deva University of Agriculture & Technology Kumargang, Faizabad during Kharif season of 2005-06 to investigate the CERES 3.5 v model validations for rice at different dates of transplanting and different genotypes. Treatment consisted of three genotypes *viz.* Sarjoo-52, NDR-359 and Pant Dhan-4, two date of transplanting viz. July 5th, 2005 and July 25th, 2005 & three nitrogen levels viz. 80 kg/ha, 120 kg/ha and 160 kg/ha. The experiment was laid out in Randomized Block Design. Among the genotypes prediction accuracy of Pant Dhan-4 was found better in respect of No. of tillers/m^2, 50 % Flowering Date After Transplanting (DAT), Panicle initiation (DAT) and Physiological maturity (DAT) on 5th July transplanting at 120 kg/ha nitrogen as comparison to 25th July transplanting. The simulation modelling was subsequently validated against observed data from field experiment. From the response of simulation model it was observed that accuracy of simulated value decreases with late transplanting in all the genotypes.

Impact of climate change on soil degradation and rice productivity at Pattambi

R Ilangovan, Pathummal Beevi, GSLHV Prasad Rao[1] and PP Moosa

Regional Agricultural Research Station, KAU, Pattambi, Kerala
[1]College of Horticulture, Kerala Agricultural University, Thrissur, Kerala

No doubt the climatic aberrations will severely set back agricultural development in most of the tropical countries particularly India, where an increasing share of the poorest and most vulnerable population resides. We analyzed weather data at the Regional Agricultural Research Station, Pattambi for the period of 81 years (1927 to 2008) of rainfall data and 58 years (1950 to 2008) of temperatures. We found that the decreased trends of rainfall and temperatures were changed abnormally and influenced the soil fertility and rice yield in Pattambi. Here we report that last five years (2003 to 08) the annual mean minimum temperatures have increased by 0.5°C and 0.42°C, respectively during the month of July and June months when compared to 58 years of data. Decreased values were observed annual mean maximum temperature were decreased almost all the months to the maximum of 1.3°C when compared to 58 years of observed values. Grain yield was declined to the maximum of 280 and 360 kilos per acre respectively in kharif and rabi seasons. Changed climate also degraded the soil over the period of years and reflected in decreased yield were also observed. This report provides a direct evidence of decreased rice yields from increased nighttime temperature associated with global warming. It is evident that improved knowledge is needed to effects of changes in climate on crop yields and physical process such as soil erosion and nutrients degradation.

Diversified cropping pattern in response to change in climate in southern agro-climatic zone of Tamil Nadu

T Ragavan, R Babu and C Uma Maheswari
AICRPAM, ARS (TNAU), Kovilpatti, Tamil Nadu

Rainfall variability rather than the climate change is evident form high intensity, uneven, erratic distribution and shifts in rainfall pattern. There is a change in cropping systems across the southern agro-climatic zone as the index, the long duration commercial fiber crop cotton area is declining while the short duration commercial millet, maize and pulses area is getting increased. Occurrence of late onset and early withdrawal of NE monsoon rains and intermittent dry spells for more than 3 weeks at critical stages of the crop growth adversely affected the productivity of crops and pave the way for outbreak of pest and diseases and thus increased the cost of production. Diversified cropping by comparatively lesser duration crops like maize (100-110 days) and pulse crops (75 days) were found to escape weather abnormalities due to its hardiness and they can tolerate or accommodate to the available soil moisture period in Vertisols for its survival and productivity.

The area under cotton crop was 46,000 ha during 1995 in Tuticorin district of southern agro climatic zone. Due to, rainfall variability the area declaimed to 6,900 ha in 2006-07. At the same time the area under pulses increased from 15,000 ha to 40,000 ha. Area under maize drastically increased due to its industrial value through demand by poultry forms, from 900 to 4000 ha from 2005 to 2008. Diversified alternate pulse crops registered the yield of 600-750 kg/ha. Whereas, maize productivity went up to 4500 - 5000 kg/ha with the B:C ratio of 1:2.5 - 2.8.

The declining of cotton area has mainly encountered with variability of rainfall. Since it is being 140-160 days duration crop the soil moisture was not enough to meet the water requirements at critical phenological stages leading to lesser productivity. Comparative analysis revealed that there was 250-300 percent potential yield in cotton without any reduction in the cost of production. Diversified cropping with maize and pulses has more advantages like, short duration, needs lesser intercultural operations, possibility of mechanical harvest / threshing, and minimum support price. It resulted in more economic return than the conventional cropping of cotton under rainfed Vertisols of southern agro-climatic zone.

Effect of CO_2 enrichment and seed scarification on nitrogen composition of four avenue tree species

GV Sudarsana Rao and SRK Murthy[1]
Regional Agricultural Research Station, KAU, Pattambi, Kerala
[1]Agricultural College, ANGR Agricultural University, Bapatla, AP

The growth rate of many avenue tree species is very slow during seedling phase and is not adequate before transplanting, which creates a constraint for field establishment. Presently, there is an increasing concern over the raising levels of major green house gas CO_2 in the atmosphere. Indiscriminate and extensive deforestation and the burning of fossil fuels are the two major sources of increasing CO_2 levels. Since CO_2 level is the primary substrate for photosynthesis in green plants, it would offer a great potential for increasing the growth of many annual and perennial species. The ambient CO_2 level available to the tree seedlings was enhanced by trapping the CO_2 released during dark respiration of seedlings and soil respiration. For many of the avenue tree species belonging to the family leguminosae that exhibit seed dormancy due to impermeability of their hard seed coats, seed scarification was carried out by acid / hot water treatment. In the present investigation four tree species namely gulmohar (*Delonix regia*), tamarind (*Tamarindus indica*), Yellow gulmohar (*Peltophorum ferrugineum*) and Subabul (*Leucaena leucocephala*) were taken up for study to understand dry matter accumulation and nitrogen composition during their seedling growth period. CO_2 enriched seedlings recorded significantly increased dry matter accumulation than the seed scarification. CO_2 enrichment combined with seed scarification resulted in a marginal increase in dry matter accumulation compared to CO_2 enrichment alone.

Maximum seedling dry matter accumulation of these four avenue tree species was observed with the combination of CO_2 enrichment and seed scarification. The increasing dry matter results in reduction in nitrogen concentration due to dilute effect but the total nitrogen uptake and NUE were increased due efficient utilization of nitrogen. Among the four avenue tree species, gulmohar responded well and had higher seedling dry matter. Tamarind, yellow gulmohar and subabul responded less. Thus, gulmohar could be preferred for avenue plantations and for social forestry purposes.

Technical Session V
Climate change adaptation in Horticulture

Climate change and Horticulture

KV Peter[1] and T Pradeep Kumar

[1]Former Vice Chancellor, Kerala Agricultural University, Vellanikkara, Thrissur, Kerala
College of Horticulture, Kerala Agricultural University, Vellanikkara, Thrissur, Kerala

Climate change is now gaining increased attention worldwide due its impact on food security and the very survival of mankind. Impact of climate change is more pronounced in third world countries where entire farming is seen under rainfed conditions. Rise in temperature drives thousands of species to extinction, trigger more frequent floods and droughts and sink low lying islands and coastal areas by rising sea levels. Climate is probably the most important determinant of vegetation patterns globally and has significant influence on the distribution, adaptation and cultivation of crops. Several climate–vegetation studies have shown that certain climatic regimes are associated with particular plant communities or functional types. While several studies are available on the impact of climate change in cereal crops, such simulation model studies are limited in horticultural crops. Perennial tropical horticultural crops are facing the biggest threat from climate change as the scope of genetic adaptation is severely limited.

Horticultural crops are essentially high value crops ensuring maximum returns to the growers with multiple scopes for value addition. Industry prefers these crops due to their consumer appeal. This sector provides the diversification of agriculture owing to better land use, creation of employment opportunities and overall nutritional security. In India, horticulture accounts for about 29.5 % of the country's agricultural GDP from 8.5 % area and 10 % of the total agricultural export earnings. India is the second largest producer of fruits after China, with a production of 47.68 million tonnes of fruits from an area of 4.18 million ha. Five fruits viz., mango, banana, citrus, apple and guava together covered about 75% of total fruits produced in the country. Impact of climate change is more on perennial fruit crops and plantation crops as the ill effects on yield will be reflected only after a period and simulation models are difficult to adopt. Keeping the above in view, the impact of climate change on horticulture crops is reviewed in this paper and presented so as to have initiatives in climate change adaptation strategies.

Climate change adaptation strategies in agriculture: Influence of ecological variables on productivity in tea

R Raj Kumar and P Mohan Kumar
UPASI Tea Research Foundation, Nirar Dam BPO, Valparai, Tamil Nadu

Tea, a rain fed plantation crop cultivated over 0.56 million hectares provides food security to millions and offer employment opportunities to more than eight million people in the country besides earning a considerable amount of foreign exchequer. Undue anthropogenic activities and burning of fossil fuels resulted in global warming in turn affecting the environmental conditions. Climatic variables are interrelated and hence their compounded effect imposed deleterious impact on living organism. Even though adjacent to forest ecosystem, tea plantations experienced an unprecedented ecological imbalance. Comparative analysis of the change in climatic variables between the 2008 and the decennial mean of immediate earlier years exhibited a lot of variation. Overall mean minimum temperature increased by 0.2°C while mean maximum temperature rose by 0.8°C. Naturally, overall mean sun shine hours increased by 0.53 hours per day which reflected on ambient temperature. Relative humidity declined from the decennial average and varied from 0.6 to 1.3%. Number of wet days during the year 2008 was 150 which had declined to 140 leading to total rainfall lesser by 75.2 cm.

Earlier, tea plantations of south India experienced two high cropping periods intervened by low cropping seasons which coincides with the favorable and unfavorable environmental variables. In the recent past, the cropping pattern had changed due to unpredictable climatic factors. Comprehensive analysis of crop data of the Anamallais revealed that there was a paradigm shift in yield from as high as 3403 kg made tea/ha in 1997-98 recorded to 2522 kg during 2007-08 with a huge variation of 804 kg made tea. Obviously, cultural operations carried out in plantations will also account for the variation in the productivity to an extent. Impact of climate change on tea plantations, strategies to be launched for adaptation with respect to sustenance of tea plantations are presented and discussed.

Screening tomatoes for rainshelter cultivation

P Indira and TE George
College of Horticulture, Kerala Agricultural University, Thrissur, Kerala

Tomato is one of the most important vegetable crops suited for protected cultivation. Indeterminate tomatoes are usually grown in polyhouses, so as to utilize its vertical space also. But most of the indeterminate tomatoes bred for polyhouses are susceptible to bacterial wilt. Moreover being F_1 hybrids their seed cost is very high and the farmers have to depend on the private/public sector organisations every time. These factors ultimately affect the cost benefit ratio and interest of tomato polyhouse growers.

Investigation on screening indeterminate tomatoes for rainshelter was started in the Department of Olericulture, College of Horticulture, Vellanikkara during 2004-2005. Tomato varieties released so far from KAU are determinate and semi determinate types. Most of the indeterminate tomatoes available in the market are F_1 hybrids and most of them are susceptible to bacterial wilt also. Hence this study was undertaken to select an indeterminate, bacterial wilt resistant and open pollinated tomato variety suited for rainshelter cultivation.

Many exotic and indigenous indeterminate tomatoes were collected and after two preliminary evaluations and seven accessions were selected. They were grown in pots under three growing conditions viz. open field (T_1), rainshelter cladded with UV stabilised sheet and shade net(T_2), rainshelter cladded with UV stabilised sheet alone(T_3), along with semideterminate varieties'Anagha' and 'Sakthi'. Among these varieties LE643-1 was identified as high yielding one with an average yield of 3.54kg/plant in the rainshelter and 2.48 kg/plant in open field.

Implications of climatic change and adaptations in medicinal plants

A Latha and VV Radhakrishnan
College of Horticulture, Kerala Agricultural University, Thrissur, Kerala

Global climate change has considerable implication on Indian agriculture and biodiversity hence on our food security and farmers livelihood, we need to take steps to increase our adaptive capacity. Small changes in temperature and rainfall could have significant effect on quality of fruits, vegetables, tea, coffee, aromatic and medicinal plants with resultant implications on their prices and trade. In medicinal plants, quality and quantity are equally important and quality is at the expense of quantity and vice versa. The abiotic factors have profound influence on the secondary metabolite production and quality development of medicinal plants and so the climate change also influence. Abiotic stresses affect the quality positively with respect to some medicinal plants. The increased CO_2 concentration enhances the photosynthetic production of medicinal plants which have C_3 pathway and correspondingly the quality. Climate change also affects the flowering of many plants. *Cassia angustifolia,* which used to regularly flower in the month of April coinciding with the festival of Vishu in Kerala, is now flowering in all the seasons, which is considered to be due to climate change.

Greater attention is needed on adaptations to climate change. Adaptation measures in agriculture include introduction of more resistant crops, integrated crop management, crop diversification and increasing efficiency in irrigation. These measures may not be sufficient to meet the challenges of climate change. Income alternatives are another opportunity to adapt the climate change. Livelihood diversification and additional employment need to be created in the rural areas. Cultivation and value-addition of medicinal plants is an emerging area for rural employment generation and livelihood improvement. Homestead herbal farming is to be encouraged. Simple adaptations such as change in planting time and crops with herbal species could help in reducing the impacts of climate change to some extent. Development of resource conserving technologies can be another adaptation. Medicinal plants require low resources as inputs for their proper growth and quality development. Greenhouse gas emission from agriculture can be mitigated by changing land use by increasing area under biofuels crops, tree medicinal plants, agroforestry and others.

Identification of morpho-physiological traits contributing towards water stress tolerance in Nendran clones

RV Manju and KB Sony
College of Agriculture, Vellayani, Thiruvananthapuram, Kerala

One-third of the total land area is considered potentially suitable for agriculture. Yield reductions due to drought stress are already serious, and agricultural production scenario may become worse as the most significant impacts of climate change are decline in rainfall and increase in temperature. An understanding of the physiological control of tolerance to the key stresses is of paramount importance for undertaking any crop improvement programme. In general, water extraction, conservation, water use efficiency and difference in intrinsic cellular tolerance characters like membrane stability, protein synthesis, proline accumulation etc. determine drought tolerance. Identification of existing crop varieties with such tolerance characters will be the most suitable strategy for getting prepared for the future water limiting, high temperature climatic conditions. In this angle, evaluation of germplasm in banana gains importance. Cultivation of banana is gaining importance because of its export potential and food value. In Kerala, Nendran occupies top position among cultivated varieties. Nendran banana exhibits intraclonal variation with respect to growth and yield and in Asia, South India is the only area where this variability is exhibited. The highest yield is reported in Quintal Banana, among the Nendran clones. A screening was undertaken for physiological traits contributing towards stress tolerance in Nendran clones at the Instructional farm, College of Agriculture, Vellayani, and the results are presented in this paper.

Effect of weather on the productivity of black pepper and coffee under Wayanad conditions

KM Sunil and VS Devadas
Regional Agricultural Research Station, Ambalavayal, Wayanad, Kerala

The effect of temperature and rainfall on yield of pepper and coffee were studied under Wayanad conditions. The amount of rainfall and maximum temperature during the entire growth period were correlated with pepper and coffee yields during the period 2000 to 2008. It was observed that the temperature and amount of rainfall during the second fortnight of March determined the productivity of the pepper considerably. Increase in maximum temperature (18 March to 31 March) had a significant positive correlation and resulted in good yields whereas the amount of rainfall adversely affected the yield. The yields were further reduced considerably if it is followed by a dry spell. On the other hand a total monthly rainfall more than 15 mm during February had a significant positive correlation and resulted in high yield of coffee. Multiple linear regression models were developed based on maximum temperature and rainfall and can be used for predicting the productivity of the above crops.

Yield of promising somaclones in ginger as influenced by weather parameters

MR Shylaja, KV Vijini, EV Nybe, S Krishnan and GSLHV Prasada Rao
College of Horticulture, Kerala Agricultural University, Thrissur, Kerala

Investigations on the influence of weather parameters on yield of selected somaclones in ginger were attempted at College of Horticulture, Kerala Agricultural University. Yield data of selected somaclones recorded for four seasons (2005 -08) were correlated with weather parameters of respective seasons. Strong correlations existed between yield of somaclones and weather parameters. Performance of clones was found to vary in the varied weather situations of the four seasons, suggesting situation specific recommendation of clones for large scale cultivation.

Influence of micro meteorological factors on flowering and quality of cured beans in vanilla

MR Shylaja, KV Vijini, R Ramya, EV Nybe, GSLHV Prasada Rao, S Krishnan, M Asha Sankar and A Augustine
Kerala Agricultural University, Thrissur, Kerala

Investigations on the influence of micro meteorological factors on flowering and quality of cured beans in vanilla were under taken at College of Horticulture, Kerala Agricultural University, Vellanikkara and in selected farmers' fields at Thrissur, Palakkad and Malappuram districts during 2004 to 2007. The micro meteorological parameters were found to vary in the experimental fields of three districts selected for the study. Flower initiation, flower opening and quality of cured beans in vanilla were influenced by micro meteorological parameters. The ideal micro meteorological parameters identified in the present study could be extended to other areas to improve production and productivity of vanilla. The information gathered on micro meteorological situations of vanilla gardens of different districts could be utilized for manipulation of micro climate.

Climate variability and cocoa in Kerala

GSLHV Prasada Rao and N Manikandan
Centre for Climate Change Research, Kerala Agricultural University, Thrissur, Kerala

The State of Kerala is one of the cocoa plantation states in India and ranked first in cocoa production. In 1980s the area under cocoa was very high and revolved around 18,000 ha. Thereafter, a sharp decline was noticed and reached to its low in 1994-95. The cocoa had experienced the market crisis in early 1970s, 1980s and 1990s during which most of the cocoa plantations were cut and removed. The percentage decline in area was 62 per cent. A gradual regain in cocoa area was noticed since 1995-96 onwards and stabilized at 10,500 ha in 2007-08. Overall there was sharp decline (42%) in area during the study period. The production and productivity was the lowest in 1982 - 83 (82kg/ha), followed by 1983 - 84 (215kg/ha). The maximum (6000 t) cocoa production was recorded in 2007-08 with lesser area. The trend was similar in the case of productivity, recording the maximum in recent years (570kg/ha). As a whole, the study revealed that there was a sharp decline in cocoa area while increase in production and productivity.

Increase in maximum and minimum temperatures while decrease in monsoon rainfall and increase in post monsoon rainfall were the trends observed in Kerala. Interestingly, cyclic trends of 40-60 years were observed in annual rainfall of Kerala. Such trends differed widely from location to location and season to season within the State of Kerala. It was more so when short periods' data were analyzed due to high variability in annual rainfall in recent years.

It is a complex phenomenon to workout relationship between rainfall and the cocoa production at the State level as the crop had undergone a market crisis in 1980s and 1990s and cocoa plantations were cut and replaced with other profitable crops. It was a neglected crop for long because of the low price in the market. Recently, farmers started to take care of cocoa plantations on commercial angle. However, high rainfall appeared to be adversely affected the annual cocoa production of the State. Difference in cocoa yield during rainy months was very significant, followed

by post monsoon between good and poor yield years and thus the adverse influence of heavy rains on cocoa yield during the monsoon period. Also, the maximum temperature during summer plays a major role in deciding the annual yield of cocoa. The maximum temperature during summer was high (34.7 °C) in poor yield years while less (34.2 °C) in good yield years. A mean maximum difference of 1.1 °C was noticed in April between good and bad yield years. The study revealed that high maximum temperature during summer, followed by heavy rains during the monsoon period is the major climatic constraint limiting the cocoa production and productivity in the humid tropics. Under the projected climate change scenario, uncertainties in monsoon rainfall and increase in maximum temperature during the summer are likely to influence cocoa in terms of area and production to a considerable extent in the humid tropics.

Climate variability and cardamom across the Western Ghats of India

GSLHV Prasada Rao and N Manikandan
Centre for Climate Change Research, Kerala Agricultural University, Thrissur, Kerala

The natural habitat of cardamom is characterised by cool-humid-microclimate and the Western Ghats provide an ideal conditions for cardamom cultivation. It is mainly grown in the States of Kerala, Karnataka and Tamil Nadu, accounting for an area of 41,362 ha, 26,661 ha and 5,255 ha, respectively (Spices Board, 2008). Among these States, Kerala accounts for the major portion of production (76 %), followed by Karnataka (16 %) and Tamil Nadu (8 %). The forests of Western Ghats exert a domineering influence on soil, water resources and microclimate of cardamom. The fast-dwindling forest cover and its consequence over climate (associated environment problems) are the concern across the cardamom tract of the Western Ghats since last two decades. On the other hand, the projected global warming and rainfall changes may adversely affect forest ecosystems. The studies in India predict that there are shifts in boundary of forest and climate types during the transient periods. Though there are uncertainties with respect to projections of climate change on forest ecosystems, evidence is growing to show that climate change couples with socio-economic and land use pressures is likely to affect the area and the production of cardamom in forest ecosystems adversely. Keeping the above in view an attempt has been made to understand the effects of climate variability on cardamom production across the Western Ghats.

A marginal decline in rainfall was noticed at all locations during the southwest monsoon except at Madikeri. In contrast, a marginal increasing trend in rainfall from October to March (Post monsoon and Winter) at Pampadumpara, Ambalavayal (October and November), Madikeri, Saklespur (December – March) and Mudigere across the cardamom tract was noticed. If such trend continues at the above locations, it may be beneficial to cardamom producers. The decline, though insignificant, in summer showers (March-May) at all the locations across the cardamom tract except at Saklespur was the concern of the cardamom growers for sustenance of cardamom plantations. The marginal decrease in annual rainfall was more evident since last one-and- a-half decade across the cardamom tract at many locations. Increase in surface maximum and minimum temperatures was phenomenal at Pampadumpara since 1990 onwards irrespective of seasons. The difference between the maximum and minimum temperature was widening at several locations across the Western Ghats. Rainfall uncertainties and widening temperature change are the concern, which may adversely affect the area and cardamom and its production.

Shifting pattern of rainfall – an ecological indicator affecting plant regeneration – case study of a medicinal orchid

N Mini Raj, S Krishnan S and EV Nybe
College of Horticulture, Kerala Agricultural University, Thrissur, Kerala

Performance of Jeevakom (*Seidenfia rheedii* Sw.), a medicinal orchid, under the changed rainfall regimes in central Kerala is presented in this paper. Domestication trials on this valuable medicinal plant were taken up at Kerala Agricultural University during 2004-2009. Growth and yield were correlated with the daily showers received during growing season which was divided into four quarters in accordance with the growth phases of Jeevakom. Number of dry spells and total rainfall received in each of these quarters were worked out. Quarterly pattern of dry spells followed a trough pattern imitating a tick mark. In contrast, the quantum of rainfall had peaked and positively skewed distribution, the peakedness typical of the trough, a more or less mirror image. From the pattern observed over a five-year period, it could be inferred that an evenly distributed summer showers, followed by timely and good southwest monsoon with lesser dry spells, again followed by a timely and good northeast monsoon seem to be ideal for jeevakom. The spatial and temporal distribution of rainfall and not the total rainfall is critical for highly rainfall dependant species like jeevakom.

Response of sowing date and spacing on yield of cabbage

MV Zagade and JN Chaudhari
Dr. BS Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra

Cabbage crop sown on 15th October produced significantly higher yield than delayed sowing on 30th October and 15th November. Planting of cabbage with spacing of 45 x 45 cm^2 recorded significantly higher yield than 60 x 30 cm^2 and 60 x 45 cm^2. The interaction between the sowing of cabbage crop on 15th October with spacing of 45 x 45 cm^2 produced significantly higher cabbage yield than the remaining treatment combinations.

Effect of weather parameters on coconut yield

B Ajithkumar and B Jayaprakash Naik
RARS Pilicode, Kerala Agricultural University, Kasaragode, Kerala

Weather data for six years (2003-2008) from the RARS Plicode agromet observatory were taken for the study. Coconut yield data from the RARS farm for six years (2003-2008) were collected for studying the crop weather relation. Correlations were worked out between the coconut yield and weather parameters and regression equations were developed for predicting coconut yield.

The rainfall data during the study period (2003-2008) was analyzed. It was found that the annual average rainfall during the period was 3370 mm. The season-wise average rainfall was also worked out for the above period. It was 2675 mm for Southwest monsoon, 274 mm for northeast monsoon, 420 mm for summer season and 2 mm for winter. Under rainfed condition, rainfall is the most important factor which determines the coconut yield. Results of the study revealed that the rainfall during the southwest monsoon season was positively correlated with the coconut yield whereas the rainfall during the northeast monsoon season showed a negative correlation with the yield. By monitoring the weather parameters during the southwest and northeast monsoon seasons, coconut growers can predict the future yields in advance with good skill.

Technical Session VI
Climate change adaptation in Fisheries and Animal Sciences

Impact and adaptation options for Indian marine fisheries to climate change

E Vivekanandan and R Jeyabaskaran
Central Marine Fisheries Research Institute, Cochin, Kerala

It was realized about ten years ago that the scope for increasing fish catch from the coastal waters is limited. Climate change is projected to exacerbate this situation and act as a depensatory factor on fish populations. Warming of water has potential impact on fish diversity, distribution, abundance and phenology, which will have, in turn, effects on the ecosystem structure and function. Global warming and the consequent changes in climatic patterns will have strong impact on fisheries with far-reaching consequences for food and livelihood security of a sizeable section of the population. Acidification of water will have effects on calciferous animals. Increased incidence of extreme events such as storms, floods and drought will affect the safety and efficiency of fishing operations, flow of rivers, area covered by wetlands and water availability and will have severe impacts on fisheries. Sea level rise will have effects on the coastal profile and livelihoods of communities. The potential outcome for fisheries may be decrease in production and value of fisheries, and decline in the economic returns from fishing operations.

Impact of climate change on fishery at Cuddalore coast

M Srinivasan and T Balasubramanian
CAS in Marine Biology, Annamalai University, Tamil Nadu 608 502

Fisheries and aquaculture play an important role in economics around the world, in both developed and developing countries. Our country is marching towards blue revolution, by exporting 6, 02,835 tonnes with values of 8607.94 crores of rupees during 2008. The export of marine products has steadily grown over the year - from a mere Rs.3.92 crores in 1961-62 to Rs. 8, 607.94 crores in 2008-09. Indian fish production increased from 0.75 million tonnes in 1950-51 to 6.90 million tonnes in 2006-09. Fisheries sector occupies a very important place in the socio economic development of India. India is the 16th largest exporter of marine products in the world and 9th largest exporter of marine products in Asia (MPEDA, 2009).

Physical and ecological impacts of climate change on marine ecosystem and fishery resources are to be studied in detail. The oceans are warming, but with geographical differences and some decadal variability. Warming is more intense in surface waters but is not exclusive to these, with the Atlantic showing particularly clear signs of deep warming. Although there are no clearly discernable net changes in ocean upwelling patterns, there are indications that their seasonality may be affected. There will be negative impacts on the physiology of fish in localities where temperatures increase, through limiting oxygen transport. This would have significant impacts on aquaculture and result in changes in distribution, and probably abundance, of both freshwater and marine species. Temperature-regulated physiological stresses and changes in the timing of life cycles will impact the recruitment success. Keeping the above in view, an attempt has been made in this paper to understand the impact of climate change on fishery at Cuddalore coast, Tamil Nadu.

Influence of environmental variables on production traits in exotic and Desi pigs

Joseph Mathew
College of Veterinary and Animal Sciences, KAU, Mannuthy, Kerala

The study was conducted to assess the influence of environmental variables on production traits in exotic and desi pigs, their adaptation status and the 'cost' they have paid in terms of production in the adaptation process. Samples of Large White Yorkshare (LWY) and Desi Pigs belonging to Centre for Pig Production and Research, (CPPR) Mannuthy and AICRP on Pigs were used for the study. Available production and reproduction data of animals were collected. Important traits such as litter size and weight at birth and weaning, birth weight, average weaning weight, pre-weaning and post-weaning mortality, daily weight gain, feed conversion ratio, age and weight at slaughter were collected and analysed. These traits were compared between breeds and correlated to relevant environmental variables such as average temperature, humidity, rainfall, sunshine, and wind speed on monthly and seasonal basis. The classification of season was done as per Somanathan (1980) i.e., rainy season from May to November and dry season from December to April. The depression in performance of exotic LWY pigs was arbitrarily estimated based on to important pedigree traits available (i.e., No. of piglets born and reared) on the basic stock imported during 1977).

The yearly variation and trends in various production and reproduction traits in LWY and Desi pigs are in accordance with the previous findings of Kaplon and Rozyckki (1988) and Gutiev (1991) on this account, especially with respect to daily weight gain. The LWY pigs were found to have a relatively better performance in almost all the favourable traits. An yearly zig- zag trends observed in the traits may be attributed to herd inbreeding, periodic exchange of boars with resultant heterosis, level of adaptation, season and varying degrees and forms of interaction between these elements. Apparently clear trends for variations in all environmental variables existed between the dry and rainy seasons. The alterations in temperature combined with humidity and other variables seems to exert reasonable stress on animals there by affecting the production and reproduction traits. The environmental variables showed significant influence on traits such as litter size and weight at birth and weaning, pre-weaning and post weaning mortality in LWY and Desi pigs. Deterioration in two important traits i.e., number of piglets born and reared in LWY pigs may be attributed to the cost of adaptation paid by them on introduction to tropical environment. At present exotic pigs like LWY and Landrace are reared in tropical and humid tropical climates assuming that they are well adapted to this climate. But the deterioration in the production traits noticed above calls for a reconsideration with respect their genetic make up and adaptability.

Effect of climatic variations in incidences of captive elephant violence in Kerala

TS Rajeev, PJ Rajkamal, CR Marshal, KS Anil
College of Veterinary and Animal Sciences, KAU, Mannuthy, Kerala

Captive elephants in Kerala play an integral role in enriching its cultural fraternity and have become indispensable item in all festivals irrespective of religion. Available data on festivals show existence of 25,000 such performances in Kerala, entertaining 1 Crore people every year in approximate. Unfortunately there were many saddening instances of elephant running amok and turning violent in our state, the mishaps in which many a lives of mahouts and that of even public were lost brutally. In view of the above facts, an exploratory study was conducted to find out the possible causes / influential factors leading to elephant violence. The forecasts and apprehensions by environmentalists in regard of elevation in ambient temperature than previous years and reports of more incidents of violence were the motivating factor to the study. The existence of physiological causes like musth and psychological causes were ruled and the role of environmental factors like boosted atmospheric temperature and relative humidity, geographical peculiarities of the venue of incidents etc were probed.

There were a significantly higher number of incidents of elephant violence, death and damages in 2007 even though the elephants involved were not in musth (until this report) as compared to 2006. Elephants involved in majority of violent incidents in 2007, had no external/physical provocation of any sort as against in 2006. Therefore, the probable causative factor for a higher incidence of violence in 2007 can only be attributed to the higher mean day temperature in the festival months of February, March and April 2007. Nevertheless, the reason for a higher incidence of violence in coastal regions could be that, high temperature coupled with high humidity in these geographical areas would be disturbing the thermoregulatory mechanism and this matter is yet to be fully discerned. The time of incidence occurrence reveals that the hotter hours of the day leads to more stress to the animals. The vulnerability and low susceptibility to temperature and humidity variations by older animals also might have catalyzed. There are studies indicating that, a higher temperature will disturb the normal physiological functions of wild elephants Vis-à-vis their communication. These results also agree with the suggestions and findings on relationship of animal behavior with change in physical atmosphere. The findings of this study shall be useful for the public, mahouts and elephant owners to come out with fruitful suggestions and deliberations for measures to be adopted for reducing thermal stress to elephants in future during these months to avoid causalities and brutal killings of man by this pachyderms.

Heat stress induced disturbances of humoral immunity in chicken

V Ramnath and KP Sreekumar
College of Veterinary and Animal Sciences, KAU, Mannuthy, Kerala

The stress of high ambient temperature may negatively influence the performance of chickens. The objective of this study was to find out variations in antibody mediated humoral immune response to hot humid environmental stress in chickens. Local strain of egg type domestic chicken (*Gallus domesticus)* was utilized for the present investigation. Heat stress (HST) was provided by exposing the birds for 4 consecutive hours/day to a temperature of 40 ± 1^0C and relative humidity 80 ± 5% for 10 days. Antibody titers developed against sheep RBC (SRBC) were evaluated in all birds. The HST birds showed significantly ($P<0.05$) lower peak $\log_2$ HA titre of 4.67 ± 0.23, as well as log2 IgG titre of 3.17 ± 0.20 and $\log_2$IgM titre of 1.67 ± 0.12 against SRBC when compared to Non-stressed birds (NHST).Similarly HST brought about lower percentage of plaque and rosette forming spleenocytes when compared to their NHST counterparts. Noticeable changes were also found in Heterophil-Lymphocyte ratio and plasma corticosterone levels between HST and NHST groups.

Effect of summer and rainy seasons of Kerala on haemogram of broiler chicken

K Karthiayini, PT Philomina and KP Sreekumar
College of Veterinary and Animal Sciences, KAU, Mannuthy, Kerala

The study was conducted to evaluate the influence of summer and rainy seasons of Kerala State on certain blood parameters of four to eight weeks old Vencob strain of broiler chicken. Twelve broiler chicken each were subjected to the study in summer (March to May) and rainy (June to August) months of the state. The birds were all of the same age, body weight and were maintained under ideal conditions on standard broiler rations. The study was conducted from fourth to eighth week of age. Blood samples were collected at fourth, sixth and eighth week of age to evaluate various parameters viz. total erythrocyte count (TEC), total leukocyte count (TLC), volume of packed red blood cells (VPRC), haemoglobin (Hb), erythrocyte indices and H/L ratio. The ambient temperature and relative humidity were recorded daily during the entire study period.

The weekly (Mean± SE) ambient temperature during the summer season was 33.68 ± 0.75 °C (Maximum) and 24.70± 0.30°C (Minimum). The relative humidity during the summer season was 86.64± 1.05 %(Forenoon) and 58.95± 3.79% (Afternoon). During the rainy season the ambient temperature was 29.43± 0.26 °C (Maximum) and 23.04±0.10 °C (Minimum). The relative humidity during the rainy season was 93.30±0.29% (Forenoon) and 75.83± 1.74% (Afternoon).

The Hb, VPRC and MCV values of four week old birds were significantly (P£ 0.05) lower in summer than rainy season. This reduction was due to the effect of heat stress on birds. However, on continued exposure to high ambient temperature the birds showed an adaptive response, which was evidenced through the non significant difference (between seasons) in these parameters at sixth and eighth week of age. The birds housed in summer expressed a numerically lower TLC and higher H/L ratio than those reared in rainy season. H/L ratio of 0.2, 0.5, and 0.8 indicated low, optimum and high level of stress in chicken. The H/L ratio of 0.72± 0.02 in summer showed that the birds were under high stress during the hot humid summer season, which adversely affected the haematopoietic activity leading to a fall in certain blood parameters. The results also revealed that continued exposure of the birds to the same temperature and humidity resulted in an adaptive response as far as haemogram of the birds are concerned.

Weather based animal disease forecasts

PV Tresamol and MR Saseendranath
College of Veterinary and Animal Sciences, KAU, Mannuthy, Kerala

Many endemic diseases prevalent in India cause enormous loss to the livestock owners. Diseases have cascading effects on the life and productivity of the affected animals which will have serious repercussions not only on the productivity of animal husbandry sector but also on agricultural sector. To derive maximum economic benefits through disease control programmes development of animal health information databank, a livestock disease information system is necessary. With this objective the project on Weather based animal disease forecasts has been envisaged to develop a weather related national disease forecasting system for enhanced livestock production through sustained reduction of animal diseases in different agro-eco zones.

Weather related disease forecasting deals with predicting the future based on past livestock disease data associated with meteorological and other related phenomenon. Retrospective data regarding animal diseases and meteorological factors were collected from 1995 onwards and the correlation of disease outbreaks with the weather parameters was assessed .This helped in forming disease forecasts for all the districts of Kerala. This forecast has been validated with the real-time disease diagnosis in selected districts. These findings of the study will be useful for the farmers for adopting various control measures based on the forecast made, thereby reducing disease outbreak and subsequent economic loss. Once National Animal Disease Referral Expert System (NADRES) is well established, daily animal disease forecast can be made available to the public through print as well as electronic media, thereby the farmers can adopt suitable control measures such as vaccinations well in advance. This will certainly revolutionize the animal husbandry sector for boosting up the production, in turn the economy of our country.

Effect of diurnal variation in feeding during summer season on the milk production of crossbred cows

P Nisanth, A Kannan, PC Saseendran, Joseph Mathew, V Prasad and S Smitha
College of Veterinary and Animal Sciences, KAU, Mannuthy, Kerala

The present study was aimed to investigate the effect of feeding during cooler hours of summer season on milk yield and composition of crossbred cows in mid lactation. The experiment was conducted at the University Livestock farm and Fodder Research and Development scheme (ULF and FRDS), Kerala Agricultural University Mannuthy, Thrissur in the summer season from February to May 2008. Twelve healthy crossbred cows in mid lactation were divided into two groups of six and were randomly allotted to two dietary treatments. The T1 animals were maintained on routine management protocol followed in the ULF and FRDS based on the recommendations of package of practices. The T2 animals were maintained on concentrate mixture and green grass as roughage with 1/3rd of the concentrate and roughage fed during the day time (10 am) and rest in evening (6.00 pm) and early morning (5.00 am) hours. Water was made available throughout the day. The parameters measured included daily maximum temperature, minimum temperature, relative humidity, daily roughage intake, dry matter percent of roughage, daily concentrate feed intake, dry matter percent of concentrate, daily milk yield, milk fat, total solids and solids not fat. The average dry matter intake and milk yield was significantly higher ($P<0.05$) in T2 than T1 while no significant difference was noted for average milk fat and solids not fat among the two treatment groups. From the overall results obtained it was concluded that the night time feeding of the animals during summer season improved the dry matter intake with comparatively higher milk yield and better persistency and that there was some long-term effect on performance of evening fed cows.

Productive performance of cross bred cows in hot humid environment

D Noble
College of Veterinary and Animal Sciences, KAU, Mannuthy, Kerala

The physiological and productive adaptability, effect of dietary supplementation of buffer salt and feeding of high proportion of undegradable protein to ameliorate the effect of stress of Brown Swiss, Holstein Friesian and Jersey crossbreds in hot humid environmental conditions of Kerala was evaluated. The experimental trial consisted of three trial periods. For trial I, eight cross bred cows from three genetic groups were exposed to direct solar radiation from 9AM to 3PM while equal number of animals was kept within the shed throughout the day. Except for exposure, feeding and management practices remained the same for both groups. Milk and blood samples were collected from sheltered and exposed animals immediately after exposure period once in four days for analysis of all compositional parameters, physiological responses and climatic variables. During trial II, half the numbers of animals of each genetic group were fed supplementary buffer salt and undegradable protein and same parameters were studied.

In trail III, a fresh set of animals were used and LDH, GOT, GPT, $T_3$and T_4 were analyzed. From the results obtained, it was concluded that the adaptive indices based on physiological responses failed in ranking the genotypes in terms of their relative adaptability to hot humid conditions. Dietary supplementation of buffer salt at the rate of 0.5% and feeding of undegradable protein had helped in ameliorating the effects of heat stress in cattle. The exposed animals showed relatively low levels of T3 values and the possibility of incorporating blood levels of T3 in adaptive indices with productive parameters need to be explored. There is also scope for improving the efficiency of adaptive indices by providing due weightage for low basal physiological response levels combined with the rate of decline in milk production, under high heat stress conditions.

Livestock to mitigate global warming

PC Saseendran
College of Veterinary and Animal Sciences, KAU, Mannuthy, Kerala

The livestock sector contributed over 5.26 per cent to the total GDP during 2006-07 and 31.7 per cent GDP from total agriculture and allied activities. Livestock were blamed for 18 percent greenhouse gas emissions and found to be less than five percent. The annual FYM availability 284 million adult cow units of India are 1376 million tones. NPK percentage in FYM is 1.5: 0.8: 1.9 and total NPK from livestock is equal to 205.85 lakh tonnes, 109.79 lakh tonnes and 260.75 lakh tones respectively. The annual requirement of NPK in India was estimated as70.38LMT nitrogen, 40.31 LMT phosphorous and 38.61 LMT potash. Daily biogas yield in the Country from 284 million cattle and buffaloes is 1457 m^3. With biogas entire 300 million families of India can be provided with cooking gas and 120 million liters of petrol could be saved. The reduction in fossil fuels use, nitrous oxide release from fertilizer and energy saved would mitigate global warming.