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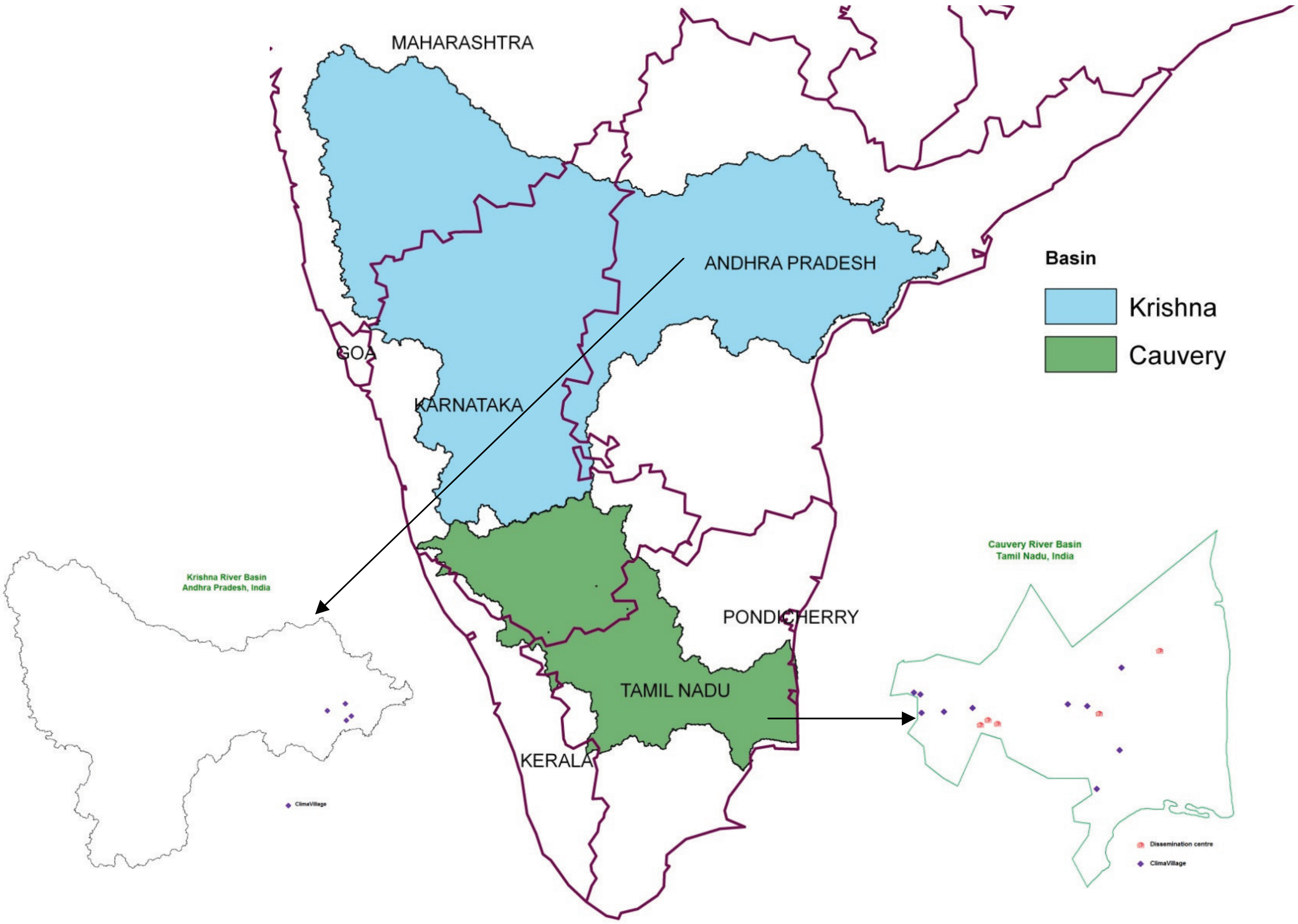
NEWS LETTER

ClimaRice : Testing climate uncertainties and validating selected technologies on farmers fields (2010-2012)

Contents

ClimaRice Operational Area



Partnering Institute	Short Name	Project Scientists
Norwegian Institute for Agricultural and Environmental Research, AS, Norway	Bioforsk	Udaya Sekhar Nagothu International Co-ordinator
Tamil Nadu Agricultural University, Coimbatore, India	TNAU	V. Geethalakshmi & A.Lakshmanan
International Pacific Research Centre, Hawaii,	IPRC	H.Annamalai
International Water Management Institute, Hyderabad, India	IWMI	K. Palanisami, Krishna Reddy & Kiran Jella

Note from Dr. P. Murugesa Boopathi
Vice Chancellor, Tamil Nadu Agricultural University Coimbatore

Climate change is one of the greatest challenges, the global community has ever faced. The impact of climate change on agriculture is an issue of great significance to the lives and livelihoods of millions of poor people who depend on agriculture for survival. Research on the impact of climate change on agriculture is a high priority in India as the impact is expected to be widespread and severe. Research findings indicate that a 2ºC increase in temperature would cancel out the positive effect of elevated CO_2 on rice yields.

I am pleased to note that Agro Climate Research Centre of Tamil Nadu Agricultural University is carrying out a collaborative research project “ClimaRice” with a goal of sustaining rice productivity amidst changing climate. The scientists of TNAU in collaboration with IPRC, Hawaii, USA and BIOFORSK, Norway have modeled the Cauvery river basin for its future changes in climate, hydrology and rice productivity. In addition various adaptation and mitigation measures including water and nutrient management, microbial technologies to minimize methane emission from rice fields have also been developed for dissemination and ultimately enabling the policy makers to frame suitable climate change policies and legislations. Various Socio economic scenarios developed as a result of interaction with various stakeholders of the Cauvery basin will help the research team to develop location specific adaptation strategies. I am extremely satisfied with the ClimaRice project activities and this newsletter certainly serves as a window for various stakeholders and fellow research groups to understand the progress of the project and its deliverables. I wish the ClimaRice scientists the very Best in all their endeavors.

(P. MURUGESA BOOPATHI)

Note from Ms. Signe Guro Gilen, Counselor, Section for Cooperation & Communication, Royal Norwegian Embassy, New Delhi.

International Food Policy Research Institute (IFPRI) has estimated that food production in South Asia will decrease by 44 per cent by 2050, if climate change adaptation measures are not put in place. A one degree rise in global temperature will curtail the growing season by a week in Punjab. By losing one week of growing period, nearly 400 kg of wheat per hectare could be lost. In this context it is heartening to note that the second phase of the ClimaRice project has an interesting combination of climate change prediction and climate change adaptation. Adaptation measures are being tested in farmers’ field, climate and hydrological modeling tasks have begun, capacity building for department staff and farmers are in progress. I am glad to note that Bioforsk is steering the project very well with close cooperation with the Indian partners. The project is also closely aligned with the state governments of Tamil Nadu and Andhra Pradesh and I am glad to note that government staff at different levels is participating in training and dissemination activities, as well.

Signe Gilen

(Signe Guro Gilen)

A brief overview of project activities in 2011

During the second year (2011) Climarice project concentrated on the following components,

- Testing uncertainty in regional monsoon projections
- Development, demonstration and implementation of adaptation measures on farmers' fields.

Ensemble (multiple) integrations with IPRC_RegCM were performed and the period of integrations covers the decades 1980-2010 (current climate) and 2020-2050 (near-term future climate), and focus areas are: Cauvery and Krishna river basins. The impacts of IPRC_RegCM model outputs on the hydrology and rice productivity was assessed and range of adaptation options using Crop Weather Models for the changing hydrology and future climate (predicted by IPRC) have been developed for the Cauvery and Krishna river basins. Field-testing on the influence of SRI and Alternate Wetting and Drying (AWD) on ground water hydrology was carried out for restructuring the irrigation schedule for maximizing water use efficiency. The rice cultivation systems such as SRI, Alternate Wetting and Drying (AWD) and Direct seeding of rice were field validated in farmers' field for increasing nutrient use efficiencies and minimizing green house gas emission. Suitable bio inoculants (Blue green algae and methylotrophs) were formulated and validated for better nutrient dynamics in rice field.

A series of capacity building workshops, technical assistance to managers, knowledge sharing and awareness activities were a major focus in 2011. Importance was given to dissemination and capacity building of farmers and stakeholders in cooperation with Department of Agriculture, Krishi Vigyan Kendras, Self Help Groups and Climafarmers through focus group meetings, stakeholders' workshop and panel discussions.

Project highlights: 2011

1. Modeling of Ponnanaiyar basin in Trichy District using SWAT model was completed, and recommendations for water allocation under different hydrological scenarios were developed.
2. Temperature tolerant rice cultivars were screened in Climate Control Chamber facility at TNAU, Coimbatore. Results will be published in 2012.
3. Algal carbon sequestration and GHG emissions under rice ecosystem was measured. Results will be published in a scientific journal.
4. SRI trials were conducted in Nachalur and Neithalur villages of Trichy district in coordination with Department of Agriculture, Government of Tamil Nadu. A manual on SRI will be developed in 2012.
5. A number of capacity building programs were organized in 2011, including the training on Aqua Crop model (conducted by the FAO team) and SWAT models (organized by IITM).
6. A book summarizing the results from phase 1 of ClimaRice project was published. During 2011, five research articles were published in referred journals. The article entitled "Climate Change Adaptation in Bhavani Basin using SWAT model" has been published in the Journal of ***Applied Engineering in Agriculture***, which is a top ranked journal in Agricultural Engineering with high impact factor.
7. A number of teams from Norway, Government of India, state governments, NORAD and the embassy interacted with the project team on various occasions and also visited the project sites in Andhra Pradesh and Tamil Nadu.

2. ClimaRice events in Cauvery River Basin

2.1. ClimaRice review team visit

Figure 1. Drip irrigation field trial at Abhisekapuram, Trichy, India

Odd Arnesen from Norway and Dr. Monowar Alam Khalid, Earthwatch, New Delhi, India visited Cauvery Basin during January, 2011 to evaluate the various ongoing activities within ClimaRice project. The team visited ADAC&RI, Trichy, Water resource Organization, Trichy, Saraswathi KVK, Karur and SWMRI, Tanjore.

Figure 2. Dr. Odd Arnesen addressing ClimaFarmers at Nachalur, Trichy, India

They also visited rice drip Irrigation trials maintained by Mr. Narayanan (a farmer in L. Abhisekapuram, Lalgudi, Trichy) and discussed the advantages of micro irrigation in rice. They participated in a farmer's feedback meeting at Nachalur village, Tanjore district in the Cauvery River Basin.

Dr. Odd Arnesen and Dr. Khalid also addressed the stakeholders meeting organized by SWMRI. Project scientists Dr. V. Geethalakshmi, Professor and Head, Agro Climate Research Centre and Dr. A. Lakshmanan from Tamil Nadu Agricultural University, Coimbatore and Mr. Suresh Mathevan from the Royal Norwegian Embassy, New Delhi accompanied the review team.

2.2. ClimaRice Book launch

A joint workshop on "Water and Climate" was organized by The Norwegian Institute for Agricultural and Environmental Research (Bioforsk, Norway) and TERI, India, on the 02 Feb, 2011, at the Taj Palace Hotel, New Delhi.

Figure 3. ClimaRice book

During this workshop, the book titled "Sustainable Rice Production on a Warmer Planet" was launched by the Norwegian Minister of Research and Higher Education, Mrs. Tora Aasland at the Delhi Sustainable

Development Summit 2011, special event "Water and Climate".

During the inaugural session, Mrs. Tora Aasland, handed over the first copy of the book to Indian Minister of Water Resources, Mr. Salman Khurshid, as a symbolic gesture of Indo-Norwegian co-operation. She appreciated the work done by the ClimaRice partners, Bioforsk, TNAU and IPRC, Hawaii, and the efforts made to bring out the book. The Minister said that the book gives a good and important insight into a research area, with an untraditional approach. Dr. Nagothu Udaya Sekhar, International Coordinator of ClimaRice projects briefed about the book and Dr. Rajendra K Pachauri shared his views during the workshop.

Figure 4. Climarice Book release by Hon'ble Ministers Tora Aasland and Shri Salman Khurshid in the presence of Dr. R. Pachauri

2.3. Stakeholders work shop at TNAU, Coimbatore

The Stakeholder's Conference of ClimaRice I and II was conducted on 21st February, 2011 at TNAU, Coimbatore. Dr.V.Geethalakshmi, Professor and Head, ACRC and principal Investigator of ClimaRice welcomed the gatherings and explained the genesis of the project since inception and project achievements. Dr. Nagothu Udaya Sekhar, International Coordinator, Bioforsk briefed the importance of integration of stakeholders into climate research and developing adaptation strategies and policy guidelines together with farmers and stakeholders.

The Climate change adaptation research being carried out in Andra Pradesh was explained to the stakeholders by Dr.Kota Thirupathaiah, IFS, Director General, Water and Management Training and Research Institute (WALAMTARI,) Hyderabad. Mr. Ole Riedar Bergum, First Secretary, The Royal Norwegian Embassy, New Delhi highlighted the India-Norway cooperation in Climate, energy and adaptation. Dr. Subodh Sharma, Advisor, Ministry of Environment and Forests, Government of India delivered key note address on the Current research in India to address climate change impacts.

The book entitled "Sustaining Rice production in a warmer planet " and the ClimaRice project third News Letter were released during the conference. Dr.P.Subbian, Registrar, Tamil Nadu Agricultural University delivered the inaugural address on Climate change and food security.

The seeds of short duration rice cultivar, IET 5764 (*Prasanna)* which comes to harvest in 75 - 80 days and found to be suitable to extreme weather events were handed over to ClimaRice dissemination centres for mass multiplication and subsequent distribution to the Clima farmers for validation.

The ClimaFarmers representing the six dissemination centres of the ClimaRice project were provided with the IET 5764 short duration rice cultivar to test verify the potential of the variety in their own field conditions. Further this rice cultivar is given to the dissemination centre for aerobic system of rice cultivation.

In the technical session, Dr.H.Annamalai presented the Climate modeling results to stakeholders. Dr.V.Geethalakshmi briefed the integration of Climate, hydrological and crop weather models and Dr.A.Lakshmanan summarized various adaptation and mitigation strategies developed in ClimaRice project. Dr.Trond Rafos explained the initiatives being taken up on pest and disease modeling and the mobile based pest and disease forewarning system.

Figure 5. Stakeholders workshop, 2011- Inaugural session

Dr.Hakon Borch presented the developments on creation of web based data base. Dr.K.Palanisami briefed the ClimaRice activities being taken up in Krishna Basin, Andra pradesh. Ms. Rebekka highlighted the importance of addressing gender issues in ClimaRice and informed the stakeholders about the activities to be carried out on gender issues. Mr. Narayanan, Climafarmer, Trichy shared his experiences in Drip irrigation to rice and integrated farming system.

Mr. Ranganathan, Chairman of Cauvery Delta Development Studies (CCDDS) discussed the importance of promoting indigenous technologies for facing climate change issues in agriculture.

The officials from Department of Agriculture, Agricultural Engineering, Water Resource Organization, Voluntary Organizations besides water managers and farmers participated and discussed the various adaptation measures. Dr.V. Geethalaksmi summarized the outcome of the conference and extended vote of thanks.

Figure 6. Mr. Ranganathan handing over IET5764 seeds to the Registrar, TNAU, Coimbatore

2.4. First Annual Review meeting at TNAU, Coimbatore

The first annual review meeting of ClimaRice 2 for the year 2010 was conducted at TNAU campus, Coimbatore, on 22.02.11. At the meeting Officials from the Royal Norwegian Embassy, New Delhi and ClimaRice Project Scientists participated**.**

2.5. ClimaRice Scientist (Dr. V. Geethalakshmi) in State level panel on developing climate change adaptation strategies

Dr. V Geethalakshmi, Professor and Head, Agro Climate Research Centre, Tamil Nadu Agricultural University, Coimbatore has been chosen to be part of the action group involved in development of Climate change adaptation strategies for the state of Tamil Nadu. She attended the preliminary meeting during March, 2011. The follow up meeting was held in 6th January, 2011.

Figure 7. Dr .V .Geethalakshmi with Ms. Shantha Sheela Nair, vice-Chairman, Planning commission, Govt. of Tamil Nadu & Dr. Subbiah, RIMES, Bangkok

2.6. Introductory ArcGIS workshop at TNAU, Coimbatore

Introductory GIS Workshop was held from 4th May, 2011 to 6th May, 2011 at TNAU, Coimbatore. Dr. Balaji Narasimhan, Assistant Professor, Department of Civil Engineering, Indian Institute of Technology Madras, Chennai was the resource person for the workshop. Engineers and research associates from six different institutes and Government departments participated in this workshop. The participants were from Tamil Nadu Agricultural University, Coimbatore, Water Resources Organization, Public Works Department (PWD) of Trichy and Thanjavur, International Water Management Institute (IWMI), Hyderabad, Water and Land Management Training and Research Institute (WALAMTARI), Hyderabad, Irrigation and Command Area Development Authority (CADA), Rajamundry, Hyderabad and National Institute for Rural Development, Hyderabad. The basic of Geograhic Information System and SWAT model were explained to the trainees by Dr. N. Balaji.

2.7. Project planning meeting at BIOFORSK, Norway- 5-15 June, 2011

The ClimaRice project review and planning meeting was held at Bioforsk (Norwegian Institute for Agricultural and Environmental Research), AS, Oslo, Norway between 5th and 15th June, 2011. The project scientists from Tamil Nadu Agricultural University, Coimbatore,

Figure 8. ClimaRice and Climawater team at Ullensvang, Norway, June 2011

Figure 9. Discussion at the Bioforsk Research Centre, at Hardanger, Norway, June 2011

IWMI, Hyderabad, IIT, Delhi, IPRC Hawaii and Bioforsk, Norway participated in the meeting. Discussion and review were carried out besides field visits to Horticultural research Station, Hardanger (Western Norway) and Farmers fields.

2.8. Advanced training on SWAT at TNAU, Coimbatore

As part of the ClimaRice II project, the third capacity building workshop on Advanced SWAT modelling was held from Sep.16 to18, 2011 at Tamil Nadu Agricultural University (TNAU), Coimbatore. Fourteen engineers and research associates from various institutes and Government departments participated in this workshop. The participants came from the following four organizations:

1. Tamil Nadu Agricultural University, Coimbatore
2. International Water Management Institute (IWMI), Hyderabad
3. Water and Land Management Training and Research Institute (WALAMTARI), Hyderabad
4. Indian Institute of Science, Bangalore

In this workshop, the primary focus was on setting-up the SWAT model for individual river basins for which the participants have collected some data. The sessions were mostly hands-on for all the three days.

The workshop was mostly hands-on and was conducted at the Computing Facility of the GIS and Remote sensing department of the Directorate of Natural Resource Management, TNAU, Coimbatore.

During the first SWAT workshop in December, 2010, and second workshop in May 2011, the participants were introduced to the hydrologic model SWAT and Geographical Information System (GIS). During the second workshop the participants were requested to organize the datasets for their respective watersheds. The participants were clearly told that during the current workshop they have to be ready with their own datasets. Accordingly many of the participants made good progress towards setting-up the model for their watershed. On Day 1, most of time was spent with individual participants on one-on-one basis to check the integrity of individual SWAT model set-up. Irrigation is one of the important agricultural management practice, hence a detailed procedure and discussion on using SWAT to simulate different irrigation practices was discussed and demonstrated.

On Day 2, an introduction was given to the sensitivity analysis of SWAT model parameters. The importance of conducting the sensitivity analysis to choose the model parameters for calibration and validation was discussed and demonstrated. Hands-on training was given to participants on doing one-at-a-time sensitivity analysis using SWAT CUP. The participants were also introduced to the concept of Uncertainty in model inputs and its implication while analysing the model results.

On Day 3, the discussion on uncertainty analysis was continued. Individual participants were encourage to do sensitivity and uncertainty analysis on their individual watersheds. An overview of Calibration and validation which was already covered in the first workshop was briefly revisited to reiterate the important concepts. A hand's on demonstration was given on using the SWAT-check utility to verify model inputs and summary of model outputs to check for any potential error in the data. A good discussion ensued after that on various aspects of modelling.

Prof. R. Srinivasan, Director, Spatial Sciences Laboratory, Texas A&M University was present during all 3-days and presented the sessions on Sensitivity and Uncertainty analysis. The certificates of completion of this workshop were distributed to the participants.

Follow-up action:

The focus of the next workshop will be on simulating different climate change scenarios in SWAT, analysis of model results and development of best management scenarios to offset the climate change impact. Prior to this workshop, one scientist each from TNAU and IWMI will spend three weekends at IIT Madras with Dr. Balaji Narasimhan over the next three months to:

- Finalize SWAT model set-up, verify, calibrate and validate the model
- Run climate change scenarios and analyze the impact on supply and demand sides of water and the effect on crop yield

Develop alternative management practice to offset the impact due to climate change.

2.9. Capacity building to farmers of Cauvery basin on adaptation technologies

Figure 10. Farmers observing Azolla germplasm at ADAC&RI, Trichy, India

In Cauvery Basin of Tamil Nadu, to sensitize the farmers on the multiplication and usage of Azolla and Blue green algae, one-day training programme was organized at ADAC&RI, TNAU, TN, India on 11-05-2011.

ADAC&RI, Trichy is one among the dissemination centers under ClimaRice II Project. Azolla germplasm and mother inoculum centre has been established at ADAC&RI, Trichy recently under ClimaRice programme. 50 Farmers from three Climavillages including volunteers from WSHGs participated in this programme and were trained on cultivation and usage of these biofertilizers. The trainees were given a manual on azolla cultivation and 5 kg azolla mother inoculum (seed) to initiate the cultivation on their farms. Two trainees, Mrs. Leelavathy from Nallur and Mr. Sampath from Nachaloor shared their experience on behalf of the trainees and mentioned that the training had provided hands on experience on ecofriendly biofertilizers and thanked the organizers for providing the seed inoculum at free of cost to the trainees.

2.10. Training on Bio intensive Agriculture at ADAC&RI, Trichy

Figure 11. Training inaugural session at ADAC&RI, Trichy, India

A training programme to ClimaFarmers was organized at ADAC&RI, Trichy on 29.08.2011 to educate them on the usage of various Biofertilizers and Biocontrol agents in Rice farming. Scientists from ADAC&RI, Trichy trained the farmers on the usage of Azospirillum, Cyanobacteria, *Trichoderma* and *Pseudomonas.*

Figure 12. Dr. Nagothu Udaya Sekhar distributing Barnyard millet seeds to Mrs. Saraswathi, a ClimaFarmer

Figure 13. Azolla germplasm at ADAC&RI, Trichy, India

Dr. Nagothu Udaya Sekhar, Project Coordinator, ClimaRice and Dr. Nambi, MSSRF, Chennai also participated in this programme and distributed Biological inputs and seeds to farmers. He also interacted with them to understand the impact of ClimaRice programme in their area. Farmers were visited the Azolla nursery and Barn yard millet field.

2.11. Discussion with SRI farmers for developing Action plan for second season rice cultivation, 2011.

An interactive meeting was organized at Saraswathi KVK, Karur with ClimaFarmers of Nachaloor and Neithaloor villages. Nachaloor and Neithalur villages of Trichy district are being concentrated for SRI cultivation under ClimaRice as these villages adopted SRI successfully during last season. Dr. Nagothu Udaya sekhar (Bioforsk), Dr. Nambi (MSSRF), Dr. V. Geethalakshmi and Dr. A. Lakshmanan (TNAU) and Dr. Diravium (SKVK) interacted with farmers to understand the issues in SRI cultivation.

Figure 14. Discussion with ClimaFarmers at SKVK, Karur

2.12. Field visit to short duration rice cultivar, IET 5764 trial plot

The short duration rice cultivar, IET 5764 which comes to harvest in 75 - 80 days and found to be suitable to extreme weather events was cultivated by Mr. Renganathan at his field in Mannargudi. Dr. Nagothu Udaya sekhar (Bioforsk), Dr. A. Nambi (MSSRF), Dr. Chandrasekaran and Dr. Vallalkannan (Assitant Professor, SWMRI, TNAU), Dr. V. Geethalakshmi and Dr. A. Lakshmanan (TNAU), Dr. Chidambaram, Thanjavur (ClimaRice advisory board member) and officials from Department of Agriculture, Tamil Nadu visited the field and interacted with Mr. Renganathan. The action plan to promote the cultivation of this rice variety was discussed.

Figure 15. Discussion with Joint Director of Agriculture, at Tiruvarur, Tanjore, India

The Joint Director of Agriculture, Thiruvarur extended his willingness to work with ClimaRice team to promote SRI cultivation intensively in 2 selected villages in Thiruvarur and this activity is coordinated by SWMRI, Tanjore.

2.13. Visit to Climavillages supervised by the TRRI, Aduthurai Mat Nursery

Figure 16. Mat nursery trials on farmer's fields at Manalur village, Kumbakonam, India

Dr. Nagothu Udaya Sekhar and Dr. A. Nambi visited Manalur village of Tanjore district and had discussion with ClimaFarmers who were cultivating rice under SRI. The team visited one of the climafarmer's fields and observed the Mat nursery for SRI.

They also participated in the farmers meeting at Tirubhuvanam village.

Figure 17. Discussion with ClimaFarmers at Manalur, Kumbakonam, India

3. ClimaRice events in Krishna Basin, Andhra Pradesh

3.1. AquaCrop Workshop

The AquaCrop model workshop was held from February 14th to February 18th, 2011, at MCRHRD, Hyderabad, with resource persons from FAO. Engineers and Scientists from, TNAU, IWMI, WALAMTARI, I&CAD attended the workshop. Dr. Dirk Raes and Ms. Eline Vanuytrecht conducted the theoretical and practical sessions to the participants. Trainees are assigned to work with their own available data and planned to have a follow-up meeting scheduled in 2012.

3.2. Seminar on basics of climate change at irrigation & command area department

A Seminar was organized by WALAMTARI and IWMI on 02.08.2011 to the Andhra Pradesh state irrigation department on the "Basics of Climate change with special reference to monsoon modeling and future water scenarios in the Krishna River basin, Andhra Pradesh". Dr. Annamalai, IPRC, Hawaii presented about the greenhouse effects and its relation to the radiations and temperature on our planet. The climate change of HadCM3, FDI_CM_2.0 & 2.1, MRI, NCAR_PCM and

MPI_ECHAMS are briefed by showing surface mean temperature and increasing rainfall maps. IPRC regional climate model simulations with current climate (1989-2008) and future climate (2081-2100) over Krishna basin was presented. The model interprets that there would be an increase in rainfall in Krishna basin in the future climate simulation.

Figure 18. Presentation by Dr. Annamalai, IPRC, Hawaii, USA, August 2011

3.3. Training on Azolla culture– Livestock feed and Biofertilizer for Rice at Regional Agricultural Research Station, LAM

Figure 19. Associate Director of Research, LAM, Farmers, Scientist at the Azolla pit demonstration

ClimaRice II has formal cooperation with the Agricultural University of Andhra Pradesh through the Regional Agricultural Research station at Lam, Guntur. In August 2011, Dr. A. Lakshmanan and Dr. V. Geethalakshmi from Tamil Nadu Agricultural University were invited to train the farmers, scientists, NGOs on Azolla cultivation and their importance in methane emission reduction.

3.4. Azolla house inauguration and field monitoring by the ClimaRice team in Guntur, Andhra Pradesh

Figure 20. ClimaRice team with press after the inauguration of Azolla house at RARS, LAM

As a part of monitoring and review of the ongoing validation practices for *Kharif,* 2011, Dr. Udaya Sekhar Nagothu, Project Coordinator, Bioforsk; Dr. K. Palanisami, Director ITP visited the ClimaRice pilot villages in the Krishna River basin, Andhra Pradesh. The team interacted with the Associate Director of Research, Lam and scientists from agronomy, physiology, economics, plant breeding on various issues of the climate change and varietal screening for the climate changes. Azolla mother inoculums nursery was inaugurated at Regional Agricultural Research Station, Lam, Andhra Pradesh. The team visited the field to get an overview of the various trials related to Direct seed sowing, varietal testing, Machine transplantation, improving water use efficiencies taken up in *Kharif*, 2011 in the pilot villages. The team also interacted with the famers in the field and shared their experience in the adaptation of the respective practices.

3.5. Workshop for governmental officials in Guntur district, Andhra Pradesh

A district level workshop was organized for agricultural department on sustainable paddy production under climate change conditions at Regional Agricultural Research station, Lam during November, 2011. District Joint director of Agriculture and Additional Director of Agriculture, Associate Director of Research (LAM), Scientists from LAM attended the workshop and visited the paddy fields at Jonnalagadda village, Guntur. The main focus of the training and visit was to explain the impact of climate changes in agricultural specially focusing on the paddy production.

Figure 21. Visit to direct seeded paddy field by Guntur district agricultural department at Jonnalagadda villae, Guntur rural mandal

An interactive session was carried out where all the sub-divisional (10) Assistant Directors explained the present rainfall pattern and it impacts on various crops (paddy, cotton, chillies, Maize, pulses). Field visit was organized to the ClimaRice farmers' fields, practicing direct seed sowing in paddy. The importance of direct seed sown paddy under water scarce conditions was explained to the visitors. Farmers interacted with the Joint Director of Agriculture about the challenges they face in such practices, cost of cultivation and yields due to the direct seed sown paddy. RBC flumes installed for water measurements were also shown and officials were explained the methodology used to calculate the water use efficiency.

3.6. Principal Secretary, Agriculture and Vice-Chancellor ANGRAU visit to ClimaRice II fields

On December 16th 2011, Mr. Nagi Reddy, Principal Secretary, Agriculture and Vice Chancellor of the Andhra Pradesh Agricultural University, ANGRAU (in-charge) visited the ClimaRice II project fields of Jonnalagadda village and the Regional Agricultural Research Station (RARS), located at Lam, Guntur district. The scientists from RARS, Lam explained the Principal Secretary and other members of the visiting team about the project objectives and the validation practices being taken up in the farmers' fields in the village.

Figure 22. Principal Secretary, Agriculture and Vice Chancellor, ANGRAU at ClimaRice II fields

During the discussions, farmers notified that shifting to alternative rice cultivation, helped in the reduction of costs and labour needs, besides addressing climate change impacts. The Principal Secretary suggested to bring up the Drum seeded rice technique into practice in the farmers' fields. Y. Sridhar, Joint Director of Agriculture, Dr. Sankar Reddy, Associate Director or Research, RARS, Deputy and Additional Directors of Agriculture; scientists, Regional Agricultural Research Station LAM and T.V. Satyanarayana, Dean of Ag. Engineering accompanied the team.

4. List of field trials carried out during Khuruvai and Thaladi seasons, 2011 in Cauvery Basin

Field Trial during Kuruvai and Thaladi, 2011 in Cauvery Basin

Sl.No	Name of the Clima Farmer & Village/ Dissemination center	Trial Detail	Remarks
1	Narayanan, Abisekapuram, Lalgudi, Trichy	i) Drip irrigation in Rice (Area: 1 acre) ii) Barn yard millet as Alternate crop (Area: 1 acre)	These are second season trials. The farmer had good yield in barn yard millet during first season summer crop. As an up scaling strategy, We are planning to distribute 10 kg of Barn yard millet as seed to 50 farmers to try in their field as summer crop.
2	Saraswathy Thirumangalam, Lalgudi, Trichy	Biointensive pest and disease management in Rice using Biocontrol agents and Biofertilizers (1 acre)	Mrs.Saraswathy is a member of WSHG and she is producing *Trichoderma* as an activity under SHG and selling them to other farmers
3	Ranganathan	• Drip irrigation in Rice(1 acre) • Testing short duration rice cultivar IELT	The short duration rice variety can be a good contingency crop during monsoon failure/ delayed monsoon
4	Clima farmer group Nachaloor, Neithaloor	SRI Cultivation to understand merits and demerits under farmers perspective	Second year trial
5	ADAC&RI, Trichy	• Validation of Barn yard millet and generating seeds for distribution to Climafarmers • Algal carbon sequestration	Trials are carried out in the College experimental farm.
6	Saraswathy KVK, Trichy	Barn yard millet- 1 acre	Trial will be initiated shortly
7	Ramakrishnan, Thirubuvanam, Aduthurai	Quantification of water use efficiency under SRI and Conventional rice cultivation systems- 1 acre	Water quantification is carried out Using V notch and the Automatic Weather Station in TRRI, Aduthrai is used to quantify the Rain effects.
8	Velmurugan, Ramamoorthy Duraisamy Navalur Kuttapattu, Trichy	Quantification of savings in fertilizer use and yield increse under biofertilization in Rice, each one acre	The farmer is given with Azospirillum, BGA and Azolla and the trial will be supervised by ClimaScientists from ADAC&RI, Trichy

5. Student Fellowship given under ClimaRice

	Student	Thesistitle
	Completed	
1	O Ramadevi	Assessing the impact of elevated temperature and CO_2 on rice crop through controlled condition experiments and modeling techniques.
2	A Sankar	Methane emission studies from sodic soil and development of mitigation strategies.
3	M. Ramya	Influence of elevated temperature on the dynamics of pests and diseases of rice
	Ongoing	
1	K.Bhuvaneshwari	Impact of Climate Change hydrology on Ponanaiyar basin and rice productivity.
2	D. Rajalakshmi	Downscaling of climate scenarios using RegCM4 model for reducing the climate projection uncertainties.
3	A. Manikandan	Development of weather based pest forewarning model for major pests of Rice
4	J. Snehalatha	Quantification of Algal carbon sequestration in rice soil ecosystem for minimizing global warming potential

Salient Findings from Student Research

1. Assessing the impact of elevated temperature and CO_2 on rice crop through controlled condition experiments and modeling techniques.

An experiment was carried out to study the impact of elevated temperature and CO_2 on rice with four dates of planting and under two different environmental conditions viz., ambient and modified environmental conditions (Climate control chamber) with $+4^0$C than ambient temperature and CO_2 enrichment to 650 ppm. The CERES-Rice model of decision support system for agro technology transfer (DSSAT) was calibrated, validated and used to assess the impact of climate change for developing adaptation strategies to rice. Crops grown under modified environment recorded reduced growth characters, lesser dry matter partitioning towards grain and lower grain yields compared to the plants grown under open ambient condition. Crop grown under elevated temperature and enriched CO_2 attained panicle initiation, flowering and maturity earlier than the crop grown under open ambient condition. The CERES-Rice model simulated phenology and grain yield closer to the observed experimental values. Among the different sowing windows tested as adaptation strategy to climate change, normal date of sowing yielded more compared to advanced or delayed planting under both ambient and modified climatic conditions. Higher water productivity was registered under SRI in addition to higher yield and water saving 16 and 7.85 % respectively during *Kharif* and *Rabi* season. The highest grain yield (6687 kg ha^{-1}) was obtained with 100 per cent nitrogen application (152 kg N ha^{-1}) under warmer climatic conditions.

2. Effect of temperature, redox and dissolved oxygen on methane flux of rice soil ecosystem and designing mitigation strategies to minimize global warming potential

A Study was conducted to assess the methane emission from the rice cultivation under different organic manure and also to explore the relationship between methane flux and air/soil temperature. As climate change mitigation strategy, the potential of blue green algae and azolla in minimizing methane flux at source in paddy field ecosystem was investigated. Combined application of organics and blue green algae not only recorded higher yield but also found to emit less methane in paddy cultivation than the application of organic manure alone. The methane flux in farm yard manure and green leaf manure applied plot was 58.54 mg m^{-2} day^{-1}, while the flux was reduced to 20 per cent due to BGA and *Azolla* application (46.37 mg $m^{-2}day^{-1}$). The study reiterated the potential of bio-fertilization with blue green algae and *Azolla* in paddy fields as a potential climate change mitigation strategy. It minimized methane emission, besides yield enhancement by nitrogen fixation.

3. Influence of elevated temperature on the dynamics of pests and diseases of rice

Influence of increasing temperature on the dynamics of pests and diseases population of rice (Oryza sativa L.) was investigated under laboratory and pot culture experiments. Experiments were conducted on two paddy pathogens *viz*., rice blast (*Pyricularia grisea* Cooke) and sheath blight (*Rhizoctonia solani* Kuhn) and rice pests *viz*., brown plant hopper (*Nilapervata lugens*), yellow stem borer (Scirpaphoga incertulas) to measure the impact of elevated temperatures on these rice crop in climate control chamber. The results of pathological study revealed that under elevated temperature the growth of both pathogens decreased under *invitro* condition. Under pot culture experiments maximum disease incidence in paddy sheath blight and blast was observed at 30°C and at 28°C respectively with the corresponding decrease in growth with increase in temperature and high relative humidity above 90 per cent. Investigations in the insect pests of rice revealed that there was an inverse correlation between temperature and total life span, developmental time and also fecundity. However there was a positive correlation between temperature and net reproductive rate and development rate. In the same way survival of pests also had a negative correlation with temperature.

6. Project spin offs

1. ClimaRice dissemination technology (AZOLLA) draws attention of funding agencies for up scaling

Azolla is a water fern that is considered as a prime component in Integrated Farming System. Azolla harbors a blue green alga, *Anabaena* that fixes atmospheric nitrogen and farmers use azolla as biofertilizer to provide nitrogen to rice and other crops. As a result the farmers can minimize the application of

Figure 23. SHG volunteers in Azolla cultivation

chemical fertilizer. In rice cultivation, Azolla minimizes the emission of methane by enhancing the dissolved oxygen content of the water impounded in the paddy field. In recent days, *Azolla* is very much used as a sustainable feed substitute for livestock especially dairy cattle, poultry, piggery and fish.

The multiplication of *Azolla* needs small piece of land, minimum water facility and manpower. All these inputs are very much available for rural women at their door steps and no paid external inputs or building facilities are needed. Hence Azolla cultivation has been promoted as one of the dissemination technologies in **ClimaRice I and II.**

The popularity and the interest on Azolla cultivation among farmers attracted the attention of **Navajbai Ratan TATA Trust, Mumbai**, India and the trust suggested Dr. A. Lakshmanan (Project Scientist, ClimaRice) to submit a Proposal on Azolla to upscale the technology among rural women in **three districts of Tamil Nadu,** India. The proposal has been selected for funding by the Trust under their Mission on **Reviving Green Revolution**, with a financial support of Indian Rupees Two Million Seven Hundred and Eighty Three Thousand.

2. Developing community based crop insurance for climate risk management

Through ClimaRice I and II projects, climate change scenario for Tamil Nadu has been developed up to the end of the century which indicates increase in temperatures and change in rainfall pattern. Agricultural activities strongly depend on climatic conditions, and agriculture is subsequently exposed to significant economic risks. Farmers have always developed strategies to successfully manage the economic risk of agricultural production, by measures either to reduce or to adjust to climatic risks; for example, diversification of agricultural production, intercropping, agro-forestry or investment in cattle in order to save money for hard times are traditional methods of many small-scale farmers in Tamil Nadu to cope with unfavorable climatic conditions. However, the biggest challenge to agriculture production emerges from increasing extreme climate events in climate change scenarios. In the ClimaRice project, Crop Weather Insurance has been considered as one of the adaptation tool.

In this context, discussions were made with the Agriculture Insurance Corporation (AIC) of India which is a Government body that takes up insurance related activities in India. Based on the experiences gained through ClimaRice, a project was sanctioned to **Dr. V. Geethlakshmi**, by AIC for taking up a study on "**Developing community based crop insurance for climate risk management".**

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8. Newsletter articles

8.1. Climate change and adaptation in agriculture sector

Udaya Sekhar Nagothu
Bioforsk, Norway

Climate change and climate variability creates both risks and opportunities and more significantly for the poor. A majority of the rural population in India is dependent on Agriculture and associated activities for their income and livelihood. These activities are sensitive to any change in the climate as it directly impacts the productivity. Adapting to changing climate is essential for individuals and communities to sustain their livelihoods. Improving adaptive capacity at various levels is essential, and this can be done by strengthening ongoing initiatives, introducing new measures, training and capacity building.

Adaptation measures or strategies should be supported by an overall framework including

measures that should be:

- Environmentally sound (protect local ecosystems, local genetic resources, environmental services)
- Acceptable to the local communities (social and cultural issues)
- Supported by a proper institutional, legal and policy framework (tenure and ownership, regulations, laws, institutions, governance, allocation of resources, civil society networks)
- Cost effective and affordable by local communities

According to FAO (2005 and 2007) a Framework for adaptation in Agriculture should include different types of responses including targeted research, reduction of food security risk, protecting genetic resources and intellectual property rights, strengthening agricultural extension and communication systems and increasing training and education. Reilly and Schimmelpfennig (1999, p. 768ff.) define the following "major classes of adaptation for agriculture" that include: seasonal changes and sowing dates; different variety or species that suit droughts or floods, water supply and irrigation systems; and other inputs (fertilizer and pesticide application, tillage methods, grain drying). These adaptation strategies are important for counteracting the ill effects of climate change besides taking advantage of the beneficial effects of changes in climate.

Stakeholder involvement from the beginning is critical for building trust and ownership of the adaptation measures developed, and in our view, a key to project success. Bo Lim *et al.* (/2004) in their book outline the principles of Adaptive Policy Framework (APF), and also focus on the stakeholder involvement and feedback to develop the APF. To this end, we have established active co-operation with stakeholders from the planning phase of the ClimaRice project. This has enabled continuous interaction with relevant government agencies, farmer's organizations, water user associations, NGOs and research agencies. So far, the feedback from stakeholders was useful in developing adaptation measures in both Andhra Pradesh and Tamil Nadu where the project is being implemented.

In principle, short term or primary level adaptations are important, since they bring about results that are visible to the stakeholders and also help in building trust. One of the main focus areas of the ClimaRice projects is to demonstrate and validate selected adaptation measures on farmers' fields. Demonstrable benefits from the short term adaptation measures are useful to develop and implement the long-term adaptation strategy in terms of policy and institutional changes (eg., new crop and land techniques). It was observed in the ClimaRice study areas that farmers have been adapting themselves to extreme weather events including periodic floods and droughts that affect them from practising agriculture. They have started to respond by changing cropping systems, delaying sowing activities, building soil and waterconservation structures on their farms, practising mixed cropping to make best use of the limited water and using new rice varieties. Overall, experiences from the project will be used further in upscaling, policy development and capacity building in cooperation with stakeholders.

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8.2. Socio-economic Impact of Climate Change on Rice Production in Southern India and Assessing Uncertainties in Regional Climate Model Projections

S. Senthilnathan[1, 2], H.Annamalai[1], V. Prasanna[1] and Jan Hafner[1]

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Rice is the major and staple food crop in the southern state of Tamil Nadu, India, and agriculture provides employment to about 60% of the rural women. The state is the sixth largest contributor to rice production in India. The average size of land holdings is only 0.83hectre (ha) and about 91% of the farming Community comes under the category of marginal (<1 ha) and small farmers (1-2 ha). The state is the sixth largest (25% contribution) contributor to rice production in India. Tamil Nadu receives about 80 percent of its annual rainfall during northeast monsoon season (Sep-Dec). Under enhanced green house gases forcing, climate models project significant changes in the behavior of the monsoon. To understand how the projected monsoon changes impact rice production, as a first step, the present study is focused on assessing uncertainties in the current climate and its imprint on current yield. This aspect is carried out by performing high-resolution regional model climate simulations (IPRC_RegCM) with multiple lateral forcing, and the climate variables from regional model serve as input to economic model (Multiple regression model). Preliminary results indicated that uncertainties in IPRC_RegCM simulations are reflected more in monsoon rainfall than temperature. However, there is a close correspondence between years of anomalous climate conditions and rice yield departures. The uncertainties in climate variables, particularly rainfall, are reflected in large diversity in yield.

8. 3. Uncertainties in Climate Change Projections: Challenge for Adaptation

H. Annamalai

IPRC/SOEST, University of Hawaii

It is certain that the increase in greenhouse gases (GHG) in the atmosphere results in an imbalance in the net radiative forcing (incoming *versus* outgoing radiations). This is balanced by temperature warming. To compensate the warming, atmospheric water vapor content increases (i.e., moisture availability increases). The increase in moisture is expected to intensify the hydrological cycle (precipitation and evaporation). Even in the absence of any changes to the atmospheric circulation, in a warmer world, enhanced moisture transport will lead to more rainfall in regions where heavy rainfall is already occurring (climate scientists term this "rich-get-richer"). While the underlying physics that governs the global hydrological cycle is fairly understood, the magnitude of warming in the future is very uncertain – climate models' projections of global mean surface temperature, for example, vary from 1.5 to 4.5^o C. Based on the above chain of reactions, therefore, projecting the robust changes in the strength of precipitation, even at global scale, has large uncertainties.

The need of the hour is, however, to quantify the expected changes at regional scales for developing measures for adaptation. By examining a suite of models and many possible pathways of projected increase in GHG towards the end of the century, climate modelers isolate the regions where most models agree in projecting at least the "sign" of precipitation and temperature changes, and offer a physical argument for such changes. For regional changes, a clear understanding of the underlying physics provides confidence into the models' projections. Our recent experience based on ClimaRice II project suggests that rainfall associated with both the summer (southwest) and winter (northeast) monsoons will increase in a warmer world – in other words, we are confident of the changes in the "sign" but there is a large diversity in the amplitude of the changes (5 to 25% compared to the present climate). While variability associated with the monsoons (floods and droughts) may increase, there is no clear consensus among the models. Therefore, the inherent systematic errors in the climate models, particularly at regional scales, pose a big challenge for developing various measures for adaptation.

8.4 Screening temperature tolerant rice cultivars for climate change

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Introduction

Tamil Nadu has about 7% of the Nation's population, occupies 4% of the land area and has 3% of the water resources of the Nation. The annual average rainfall of Tamil Nadu is only 930 mm as against the national average of 1200 mm. Agriculture is the major livelihood supporting about 40% of the population of Tamil Nadu especially to the less endowed rural people. The total area under Rice cultivation in Tamil Nadu is 20.16 Lakh Hectare and total production is 62.53 Lakh Metric tonnes. In this the Cauvery delta basin alone occupies 3.1 m. ha area.

Increase in Green House Gases concentration in the atmosphere and the resultant global warming is expected to increase the frequency of extreme weather events.

Temperature extremes coinciding with critical stage of plant development often cause a major threat to crop productivity under field condition. For eg: High temperature at flowering can induce floret sterility by affecting anther dehiscence, pollination and pollen germination and can limit grain yield of rice crop. Increase in atmospheric CO_2 levels might reduce transpiration due to stomata closure, thereby increasing leaf/canopy temperature and may alter the physiological function of the crop. Hence there is a need for screening temperature tolerant rice cultivars to suit to changing climate. In this line, under ClimaRice project a study was conducted with the following objectives.

- To screen the rice cultivars (74 genotypes) to high temperature tolerance.
- To identify the effects of high temperature stress on spikelet sterility in different rice cultivars.
- To examine the relationship between pollen fertility status with respect to high temperature.

Methodology

Heat Tolerance Screening in Rice experiment is carried out in the Climate Control Chamber (CCC) and its impact was analyzed by comparing it with the open ambient condition. Short, medium and long duration were chosen for the experiment which includes varieties, land races and B lines (Female lines) are represented in table 1. Staggered sowing was done for different varieties in order to coincide the flowering stage of all cultivars of different duration. In the climate control chamber, temperature rise was given from 50 days before flowering. At the initial stage 1°C increase from ambient was kept. After one week 2°C increase was maintained in the Climate Control Chamber. Likewise every week 1°C was increased up to a maximum of 5° C hike from the ambient. After that constantly 5° C increase was maintained inside the chamber.

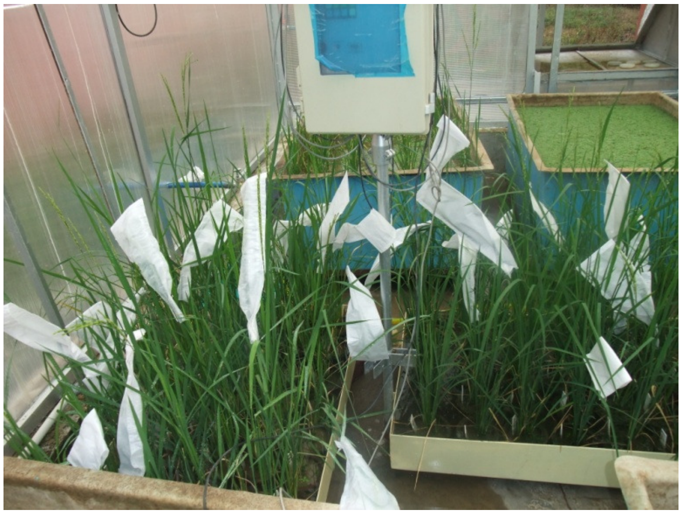

Figure 24. Spikelet sterility study at Climate Control Chamber, TNAU, Coimbatore, India

Table.1 List of rice cultivars under screening for high temperature tolerance

Short duration		Poongar*	145
Variety	**Duration**	FR 13A	142
IR 50	110	Rasacadam*	144
Anna 4	105	**Medium duration**	
ADT 45	115	**Variety**	**Duration**
ADT 36	115	Co 43	140
ADT 37	115	Co 50	135
ASD 16	120	ADT 38	135
TKM 9	115	ADT 39	130
IR 64	115-120	IW ponni	135
Co 47	120	ADT 46	140
ASD 18	120	Co 49	135
ADT 43	110	TRY 1	140
N 22	105	ASD 19	135
PMK 2	110-115	IR 20	140
PMK 3	110-115	PY 4	140
PTB 30	108	Bhavani	130
SLO 16	101	Norugan*	126
BG 301	106	Kuliyadichan*	131
PMK 1	115-120	Mattaikar*	131
Bala	114	Nootripathu*	135
Co 18	113	Somavari*	134
PTB 25	113	Mikuruvai*	126
Long duration		Kodaikulathan*	127
Variety	**Duration**	Thattan samba*	134
BPT 5204	145	Manavari*	132
Swarna	150	Malayalathan samba*	133
CR 1009	165	IR 58025 B**	135
ADT 40	160	TNAU CMS 2 B**	130
Kallurandaikar*	156	TNAU CMS 23 B**	135
Kattikar*	144	TNAU CMS 24 B**	138
Jeeraga samba*	143	IR 74	139
Tadukkan*	150	TKM 6	138
Thillainayagam*	153	Perumkaruppan	135
Shenmolagai*	151	Hinottikari	130
Vellai samba*	146	Moorebarekan	128
Earapalli samba*	146	Pavizham*	125
Godavari samba*	145	Bahadur*	125
Anaikomban*	148	Kulichichira*	130
Karthigai samba	145	Satyaranjan*	128

*Land races.**B lines.

Figure 25. Experiment at Field

The surviving plants are then screened for high temperature tolerance. These land races were included for their nutritional value and to preserve the indigenous from genetic erosion. The experiment is in progress.

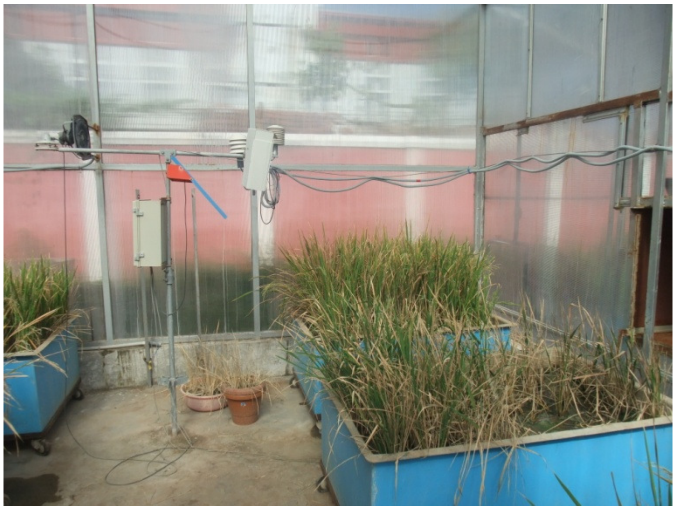

Figure 26. Screening temperature tolerant cultivars at Climate Control Chamber, TNAU, Coimbatore, India

8.5. Vulnerability Index, Krishna River basin, Andhra Pradesh

K. Palanisami, C. R. Ranganathan and K. R. Kakumanu
IWMI, Hyderabad

The word 'vulnerability' is usually associated with natural hazards like flood, droughts, and social hazards like poverty etc. Of late it is extensively used in climate change literature to denote the extent of damage a region is expected to be affected by various factors affected by climate change.

Intergovernmental Panel on Climate Change (IPCC) has defined Vulnerability as "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. Accordingly, vulnerability has three components: exposure, sensitivity and adaptive capacity.

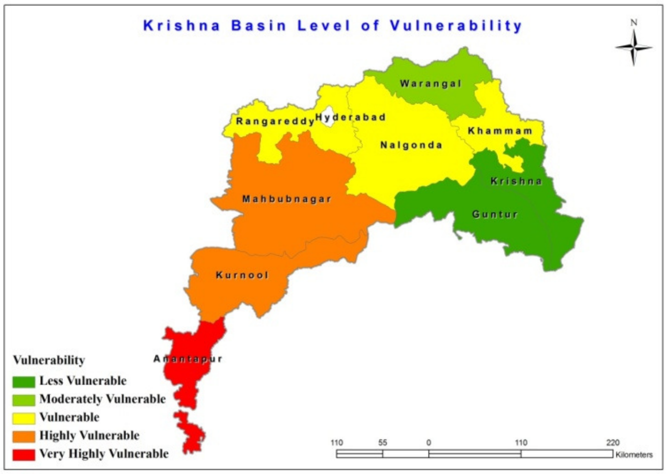

Figure 27. Classification Krishna River Basin, Andhra Pradesh districts in terms of Vulnerability

The important goal of such vulnerability assessment is to create index of overall vulnerability form a suite of indicators. Krishna River Basin in Andhra Pradesh was selected (9 districts, Figure 26) to construct the vulnerability index. Seventeen variables were selected for the vulnerability index, where it covers exposure (5 variables), sensitivity (4 variables) and adaptive capacity (8 variables).

Principal Component Analysis is used in the present study. The Eigen values and the corresponding eigen vectors were computed using MATLAB software package. These Eigen values cumulatively account for 87.3% of the total variation of all the 17 indicators. The first Eigen value alone accounted for 45.3% of the total variation. Most of the indicators have strong correlation with the Eigen vector scores. Also most of them possess expected signs. For example, in the case of number of severe droughts, the correlation coefficient is 0.732 which is highly significant and higher the number of severe droughts more will be vulnerability.

The results indicate that out of the 9 districts, Anantapur district occupies rank 1 in terms of vulnerability under all the three components and also overall vulnerability. The second rank is occupied by Kurnool in terms of sensitivity, adaptive capacity and over all vulnerability. Krishna district is least vulnerable among the districts belonging to Krishna basin. It has a very vulnerability index of - 3.612.

The results can help in making further studies on the currently vulnerable and non-vulnerable districts which are similar in terms of non-climate variables. Climate change variables would be taken as the "treatment" variables, adaptation measures as the "response" variables, with the aim of identifying which districts had the largest adaptation response to harsh climate conditions. This would provide indications for follow-ups in currently less vulnerable districts.

8.6. Carbon sequestration as climate change adaptation strategy in rice cultivation

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Introduction

Microalgae and cyanobacteria are photosynthetic microorganisms that are responsible for at least 50% of the photosynthetic biomass production on Earth (Walker *et al*., 2005). Microalgae contain about 50% carbon in their biomass. In most cases, all of this carbon can be obtained from atmospheric carbon dioxide. Consequently, algae are attracting interest as vehicles for sequestering carbon dioxide produced in various environmental and anthropogenic activities (Doucha e*t al*., 2005; Ono and Cuello, 2004). Use of algae for carbon dioxide absorption may have advantages over higher absorption may have advantages over higher plants, as microalgae generally grow faster than plants.

Carbon sequestration

Microbial-based technologies, specifically those utilizing photo autotrophs, represent a promising solution for long-term CO_2 sequestration. Much of the carbon that is represented in the global carbon cycle is sequestered primarily as calcium and calcium-magnesium carbonates. In many cases, the carbonates are of biogenic origin, some precipitated by bacteria, cyanobacteria, and fungi. The microalgae are capable of using free CO_2 and bicarbonate ions as a source of inorganic carbon during photosynthesis, transporting them across the fine plasmatic membrane where they accumulate in the cell as an inorganic carbon reservoir for photosynthesis. The bicarbonate is converted into CO_2 by the enzyme carbonic anhydrase (Zak *et al*., 2001; Badger and Price, 2003).

Mitigation of CO_2 emission

Under ClimaRice project we attempt to quantify Algal Carbon Sequestration in rice soil eco system for minimizing the Global Warming Potential. The main objectives of this study are estimating the bio mass generation potential of selected algal strains under in vitro and in vivo condition, estimation of carbon sequestration potentials of Cyanobacterial strains under in vitro and in vivo condition and studying the correlation between algal carbon sequestration and reduction in Global warming potential in rice soils.

Conclusion

Employment of cyanobacteria for point-source CCS via calcification offers promising strategies for calcification offers promising strategies for reducing anthropogenic CO_2 emissions. However, much research is urgently needed to further our understanding of the biochemical and physical processes in cyanobacteria that promote calcification and that will allow us to select or design strains with optimized properties for specific applications and conditions using genetic engineering or directed evolution. We must investigate calcification at elevated CO_2 levels and understand how photosynthetic light harvesting and photo protection can be improved in cyanobacteria. We need to identify the genes involved in calcification. Finally, it should not be expected that calcification by cyanobacteria and microalgae present an alternative to geological CCS.

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8.7. Predicting GHG Emission from Paddy Ecosystem using DNDC model and developing Adaptation Strategies

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Introduction

The DNDC (Denitrification–Decomposition) model simulates carbon and nitrogen biogeochemical cycles occurring in agricultural systems. Originally developed as a tool to predict nitrous oxide (N_2O) emissions from cropping systems, DNDC has since been expanded to include other ecosystems such as rice paddies, grazed pastures, forests, and wetlands, and the model accounts for land-use and land-management effects on N_2O emissions.

Description of the DNDC model

The Denitrification-Decomposition (DNDC) model (Li, 2000) is a generic model of C and N biogeochemistry in agricultural ecosystems. The model simulates C and N cycling in agro-ecosystems at a daily or sub daily time step. It consists of six interacting sub models: soil climate, plant growth, decomposition, nitrification, denitrification and fermentation (Li *et al.*, 1997). In DNDC, SOC resides in four major pools: plant residue (i.e. litter), microbial biomass, humads (or active humus), and passive humus. Each pool consists of two or three sub-pools with different specific decomposition rates.

The DNDC model has been widely used over the last10 years by many researchers (Brown *et al.* 2002; Butterbach-Bahl *et al*., 2004; Li *et al*., 1997, 2000, 2004; Smith *et al*., 2002, 2004). Simulated results showed that DNDC was able to simulate the basic patterns of NO, N_2O, CH_4 and NH_3 fluxes simultaneously. This feature could be valuable in assessing the net effect of the changing climate or alternative agricultural management on either the atmosphere or agriculture.

Recently the DNDC model has been modified for predicting GHG emissions from paddy rice ecosystems (Li *et al*., 2004). The majority of the modifications focused on simulations of anaerobic biogeochemistry and rice growth as well as parameterization of paddy rice management. The modified DNDC model was used for estimating emissions of CO_2, CH_4 and N_2O from all of the rice paddies (Li *et al*., 2004). In the present study this modified model was further refined to simulate emissions of CO_2, CH_4, and N_2O under the conditions found in rice paddies of Tamil Nadu, India.

Application of the DNDC model to predict emissions of CH_4 from Cauvery basin Models are increasingly used to examine the potential impacts of management and climate change in agriculture. Our aim is to assess the applicability of the De Nitrification- De Composition (DNDC) model in rice cultivation. The DNDC model is being tested against seasonal and annual data sets of nitrous oxide and methane fluxes from paddy fields of the Cauvery Delta Zone, Tamil Nadu. Previous field measurement of CH_4 emissions from the rice fields are compared with simulated DNDC-modeled CH_4 emissions from the majority paddy soils data.

Conclusion

The DNDC model can be used to assess the impact of potential greenhouse gas mitigation strategies not only on the targeted gas but also on crop production and other environmental factors. In regional mode, DNDC can be used to develop regional and national inventories and assess the changes in greenhouse gas emissions with expected changes in management and climate. It is also being applied to the development and verification of mitigation strategies as these become available.

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8.8. Farmers Adaptation to Machine Transplantation in AP

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IWMI, Hyderabad

Paddy is a labour intensive crop and requires about 90 labour days during one season. Timely availability of labour for various activities is becoming a problem for farmers in AP. This can be attributed to several factors, including migration of laborers from villages to nearby

Figure 28. Machine planting

towns and cities in search of employment. With agriculture becoming risky due to frequent weather changes (droughts and floods), people in rural areas find it more secure to get a job in urban areas. The other factor is the ongoing government welfare programs that hire rural people. A recent phenomenon observed in Andhra Pradesh is the use of mechanical harvesters and transplanters brought into the market by private firms.

Figure 29. Machine transplantation -Kharif 2010

Figure 30. Manual transplantation - Kharif 2010

Most small scale farmers cannot afford them due to high cost and technical skills needed to operate them. However, the main advantage with the machine transplantation is that it addressed the problem of labour shortage, reduces the nursery preparation cost & time.

ClimaRice II project initiated machine transplantation in Doppalapudi, PonnurMandal for *Kharif,* 2010 and Rangareddypalem, Narasaraopet Mandal on a pilot basis in *Kharif* 2010 and 2011.

In the pilot project, the major observations noticed during the validation of technology was, that number of tillers were relatively higher compared to the manual transplantation, resist lodging during heavy floods and also increase the panicle number. The yield of paddy was found to be higher by 2 - 4 qt/acre compared to the manual transplanting (Praveen, 2011 and field observations).

This needs to be further validated in more areas. Farmers in Guntur district were quite enthusiastic to promote machine transplantation (discussions with project team in August 2011) in their villages. Some farmers groups also expressed interest to invest partly in purchasing transplanters and operate them on their own, in partnership with government department. The main outcome of this initiative is to develop a public-private partnership model, in this the farmer-private agro-industry partnership that can be furthered tried in other areas. Further up scaling is possible, with the cooperation of the State Agriculture Department, Farmers Groups and private agro-industries. ClimaRice 2 can act as moderator to develop such partnership models. Several models can be worked out with the active involvement of farmers.

Reference

Praveen Kumar, N.S. 2011. Assessment of Vulnerability index and adaptation strategies in Rice Production due to the climate change under Krishna River basin of Andhra Pradesh. Master student thesis submitted to the Acharya N G Ranga Agricultural University.

8.9. Farmers adaptation to direct sowing in paddy- a promising measure to address frequent delays in the onset of monsoons in Andhra Pradesh

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The direct seed sowing is an age-old practice for the last 20 years, practicing in the tail end and semi-dry climatic conditions. Farmers in Guntur and Krishna districts have been shifting to Direct sowing of Paddy recently due to the delayed monsoons under Krishna river basin**.** ClimaRice II team is currently reviewing the practice in several villages in Guntur district, with the objective of documenting farmers experiences, success and failure rates, challenges farmers are facing, and possible improvements with the involvement of the Government agencies and the Agricultural University (Lam Research Station in Guntur) areas where it is needed will be explored.

Figure 31. Direct seed sowing Vs manual transplantation at Modukur village

Direct sowing is a practice where broadcasting of seeds is done directly in fields before or immediately after pre monsoon showers. This method helps to reduce the water losses by percolation, and cost of labour. The method does not require nursery and transplanting of seedlings. Thus even if the monsoon is delayed, farmers can still afford to raise a crop, using Direct sowing method. The sowing of seeds is done by means of tractors at a depth of 2-3 cm. Depending on the irrigation water availability fields need to be irrigated at 45 60 days after sowing and turn into wet system. Hence, the direct seeding method uses less water, labour and cost of cultivation with comparatively equal grain yields over farmers practice. Nonetheless, weed is more in the direct seed sowing (based on farmer's experience). Famers have recommended using pre-emergence herbicide (Pendimethalin 1 liter/acre) to overcome the problem Moreover the crop comes to early harvest. The average yield reported by the farmers is 22 qt/acre. Possibility of timely sowing facilitates the farmers to take up second pulse crop in time.

The project is also planning to prepare a manual together with other agencies on Direct sowing, and share with farmers at the capacity building workshop that will be organized in April 2012 at the Lam Research Station.In addition, policy and management guidelines will be prepared together with agricultural and irrigation departments and the options for further scaling up the practice in areas where it is needed will be explored.

7.10. Epicollect: Linking Climafarmers and Scientists through smartphones and web application

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A single central database, accessed through a website, can provide the tools for the submission, visualization and analysis of data collected by many users from many different locations. Epicollect software developed by Imperial College, London gives the opportunity to link the operational area of ClimaRice project (Cauvery Delta Zone) to TNAU through web server (www.epicollect.net) and smart phones. The ClimaRice project funded by the Royal Norwegian Embassy, New Delhi is in operation at Cauvery Delta Zone of Tamil Nadu coordinated by Agro Climate Research Centre, TNAU, Coimbatore. The field experiments on rice epidemiology, rice production management strategies to sustain rice production are going on in seven districts of CDZ through six coordination centres. The daily status of the field experiments is being monitored at the main centre (TNAU, Coimbatore) through this Epicollect software. The data of the field experiments are downloaded from the main centre and used for analysis.

EPICOLLECT

There are three options available on Epicollect on the mobile phone namely 'New Entry', 'List Entries' and 'Display Map'. Selecting 'New Entry' creates a new data record within the phone's on-board database and assigns a unique ID to the record. The latitude, longitude and altitude of the current position of the user are returned from the GPS unit of the phone. Three new options are now available, 'Photo', 'Data' and 'Store'. Selecting photo allows an image to be taken using the phone's camera, which is assigned to the record. Selecting 'Data' displays the data entry screen, which can contain any standard form field (text fields, list boxes, check boxes etc.). These fields correspond to those created when defining the project database structure. Data can be entered via an onscreen keyboard (using the touch-screen) or via the hardware keyboard should this be part of the phone. Following data entry, the 'Confirm' button returns the view to the Entry screen. Selecting 'Store' saves the current record to the phone's database along with the date and time that the record was created. Subsequently, this process is repeated to create further records. The 'List entries' option allows all records stored within the phone's database to be viewed and amended if necessary. From this screen, data can be synchronized with the central database with confirmation of successful data transfer. The 'Display Map' option allows all records stored locallyon the phone to be displayed on a map using the in-built Google Maps application. (David *et al*, 2009).

Results and Discussion

Using the Epicollect software totally five databases were created on Epicollect server.

www.epicollect.net/project.html?name=BRBEDE01

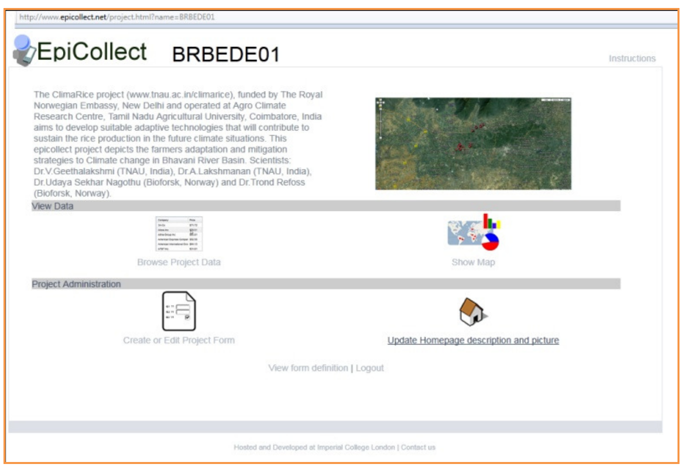

Figure 32. Epicollect Home page of ClimaRice

Each database comprises of forms on farmers profile, location (Geo coordinates), details of field experiments and observations. Each farmer's field is assigned with unique field ID for each experiment. The researchers at the coordination centres make observations at field and record it in the corresponding forms and synchronized on web. This data can be accessed from any part of the world with internet facilities.

The speed of the internet is too slow in some of the remote villages and hence the synchronization couldn't achieve at these places. For this the collected data were stored on the mobile and synchronized on accessing to the faster internet.

Figure 33. Farmer details mapped in Google earth

Conclusion:

The Epicollect software provided the platform to publish the field data immediately after making observation and these data uploaded at the different experiment fields of Cauvery River Basin were downloaded at the main centre at the same time. Thus Epicollect software is proved as a effective tool link the different fields to the researchers through web application and mobile phones.

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David, M. A., M. H. Derek, J. F. Edward, Fada'a al-Own, G. S. Brian. 2009. EpiCollect: Linking Smartphones to Web Applications for Epidemiology, Ecology and Community Data Collection. PLOS one. 4(9): p68-69.

8.11. Suitability of short duration rice cultivar - IET7564 for changing climate: Experience from Climafarmer

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IET7564 is the short duration rice variety that can be described as "***Wonder Rice***" owing to its shortest duration and ability to withstand drought. This variety was demonstrated as a well performing short duration (75 days) variety in 1980s in Thanjavur district but its importance was neglected as there was no water scarcity during that period. Mr. Ranganathan, (CDDS) identified the potential of this variety and in coordination with ClimaRice scientists carried out basic research on this wonder rice.

Figure 34. IET7564 during harvest

First this variety was test verified at field level for its potential. This variety IET7564 and another short duration cultivar IET756 (received from DRR, Rajendranagar, Hyderabad) were screened along with other ruling short duration varieties (ADT39 and ADT43 which were of 105 days duration) in Cauvery Delta Zone during "*Kuruvai, 2009*" (*Kharif*) season. This new variety IET7564 started maturing earlier than the other ruling varieties and was harvested in 75 days with an yield of 3.240 tonnes of grain per hectare.

The results of these experiments were disseminated in the stakeholders workshop held at TNAU, Coimbatore and ADAC&RI, Trichy and the seeds of this variety were sent to different dissemination centres of ClimaRice project (SKVK, Karur, ADAC&RI, Trichy, TRRI, Kumbakonam and SWMRI, Thanjavur) for trial purpose.

Figure 35. IET7564 variety - a close look

The crop was sown in Kuruvai, 2010 at all dissemination centres and harvested in 73-77 days. The average yield was 3.150 tonnes per hectare. The seeds of this variety have been given to selected progressive farmers of Cauvery delta zone and the performance of this variety is further studied.

Conclusion:

The climate change is influencing rice production significantly due to monsoon uncertainties. This short duration rice variety can be cultivated effectively during delayed monsoon and also as a summer crop.

8.12. Importance of farm mechanization in Rice based cropping systems in Cauvery basin.

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Soil and Water Management Research Institute, Thanjavur

Even though technologies and machineries are available for supplementing human labour in rice cultivation, the adoption of machinery under field is less than 10 per cent. This is also applicable to pulse and oil seeds.

Figure 36. Sowing of Pulse seeds using Turbo-seeder

The adoption level of machinery on seed sowing, fertilizer application and weed management is less than 0.5 per cent or even nil in pulse and oilseeds.

Figure 37. Growth of pulse crop cultivated under RCT at Maturity

The low production and productivity of pulses in CDZ are due to low plant population, high incidence of weeds, high cost of weed management and terminal moisture stress under rice fallow situations.

Adoption of improved technologies in existing cropping sequence as well as changing cropping sequence is highly remunerative to the farming community. The happy seeder machine helps in placing the pulse seeds along with fertilizer three or four days after the harvest of the paddy crop, cuts the standing straw and keeps as mulch that overcomes the poor population maintenance. The crop establishment has been good due to variation in soil micro climate, low weed incidence and better carbon recycling that lead to higher production and productivity of pulses in rice fallow situations.

Figure 38. Pulse crop cultivated under RCT at Maturity

The Soil and Water Management Research Institute is imparting training to the farming community on eco friendly agro technologies and farm mechanization through ClimaRice. The results shows that land leveling through laser land leveler and sowing the seed in the standing mulch crop by Turbo happy seeder in combination with other agronomic practices resulted in the addition of 1.75 tones of organic matter to the soil, and helped to achieve an average pulse yield of 900-1250 kg/ha with a WUE of 9.8 kg/ha/mm.

8. 13. Barn yard millet-The Millet for Changing Climate

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Kudiraivali (*Echinochloa frumentacea* L) is minor millet suited for cultivation under rain fed condition. It has the special feature of drought resistance and can withstand water logging up to 2 weeks. It has field duration of 70 – 80 days. It is used as reclamation crops on land that is too saline for rice. It is the very quickest crop among all millets. To validate this millet a field trail was taken up at ADAC&RI, Trichy during July 2011- to Oct 2011. Barnyard millet variety, CO 1, was taken as the test variety. The soil type was non saline sodic soil with pH 8.5. A seed rate of 8 kg / ha was adopted and seeds were sown in lines with a spacing of 30 cm x 10 cm. Thinning was done at 20 days after sowing (DAS) and the thinned plants were used for planting in the gaps, One weeding was done at 30 DAS.

Figure 39. Barnyard millet experimental field at ADAC&RI, Trichy, India

A fertilizer dose of 60:30:30 kg / ha NPK was applied. Out of this 50 percent N and full P and K were applied basally. The remaining 50 percent N was applied in two splits during tillering and grain filling stages.

Irrigation was given at sowing and life irrigation at 3 days after sowing. Afterwards irrigation was scheduled at 50 % available soil moisture. Growth attributes and yield attributes were recorded at harvest stage.

Growth characters viz., plant height, number of tillers / plant and Dry matter production / plant were recorded in ten plants and mean value found to be 160 cm, 6 and 110 g respectively. Yield attributes viz., panicle weight and number of fingers per panicle were recorded and found to be 30 g and 62 fingers / panicle respectively. A grain yield of 900 kg / ha was recorded and farmers can sell the seeds at a rate of Rs 20/Kg.

From the above study, it can be concluded that barnyard millet could withstand continuous water logging and also moisture stress condition. Pest and diseases did not affect the crop and water requirement was 300- 400 mm. A cost of cultivation of Rs 7000/ha was incurred. Hence farmers can get a net income of Rs.11, 000/ ha within a period of 70 - 90 days.

Clima Rice

ClimaVoices

ClimaRice has created huge awareness among farmers on climate change impacts and adaptation technologies.

- Nagarajan, Ariyoor, Trichy

I am a ClimaFarmer and currently cultivating rice under SRI.

- R.P. Gopalakrishnan, Thirumangalam, Trichy

I am trained on Integrated Pest and Disease Management in rice through ClimaRice Project.

- S. Indhiragandhi, Thirumangalam, Trichy

Azolla is a very good alternative livelihood source to farm families.

- Tamilchelvan, Karatumadam, Trichy

Barnyard millet is a wonderful alternate crop in case of monsoon failures. ClimaRice has provided seeds and technologies for Barnyard millet cultivation.

- L.S. Narayanan, L. Abisekapuram, Lalgudi

The short duration rice cultivar IET 5764 is a suitable variety for summer & Kuruvai seasons. This variety needs to be popularized.

- S. Renganathan, Mannargudi

Planting single seedling in SRI is difficult and machine planting should be implemented.

- Muthurani, Nachaloor, Trichy

I use Azolla as biofertilizer and animal feed. Thanks to ClimaRice for providing Azolla mother culture.

- Selvi, Ammapattai, Tanjore

Climate change affects all crops and please extends the research to other major crops.

- Rajagopal, Thirumangalam, Trichy

Thanks to ClimaRice for the training to our WSHG on bio control agent (*Trichoderma sp*) to manage diseases in rice.

- V. Saraswathi, Thirumangalam, Trichy



Farmers face multifold challenges in Agriculture & Climate Change intensifies the problems.

ClimaRice is a small initiative to help the farmers in sustaining productivity under changing climate.



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Newsletter Compiled by Dr. A. Lakshmanan, Dr. V. Geethalakshmi, Dr. Nagothu Udaya Sekhar, Mr. L. Gurusamy and Mr. V. Muthu

Photo courtesy: Ragnar Vega Pedersen (Bioforsk) and Dr. A. Lakshmanan (TNAU)