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Climate Adaptation and Mitigation through ICT Innovation - Exploring Potentials for Forecasting Pest and Disease Risks in Rice

CLIMARICE II: "Sustaining rice production in a changing climate"

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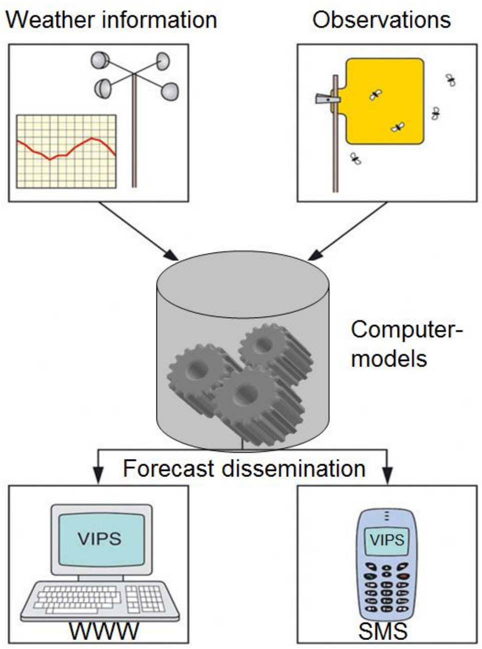
ClimaRice II has explored the potential for climate adaptation and mitigation through online dissemination of pest risk forecasts to rice farmers. Weather-driven mathematical models incorporating scientific insights on the biological responses of plant pests to climate can be linked to automatic weather station networks to provide pest risk forecasting / forewarning / early warning to rice farmers



Conceptual framework for ICT-based plant pest risk forecasting. Courtesy of VIPS, the Norwegian pest risk forecasting system.

Climate adaptation and mitigation by reducing crop losses to plant pests

Whilst it is well known that the processes of plant growth, pest population dynamics and plant disease epidemiology, are all weather driven processes, and thus that crop protection against pests must **adapt** to climate change, is it less well known that reducing crop losses to pests can **mitigate** climate change. The Intergovernmental Panel on Climate Change (IPCC) has reported that agriculture is responsible for over a quarter of total global greenhouse gas emissions [3]. Loss of crop yields to plant pests and diseases therefore causes unnecessary greenhouse gas emissions and consequently the emissions per unit food produced increases with increasing losses to pests. In this way, a reduction in crop losses to pests will reduce greenhouse gas emissions from food production. In other words, in the field of crop protection, climate change **adaptation** and **mitigation** are two sides of the same coin.

Current and historical crop losses to pests

The great Bengal famine in 1943 where millions of people lost their lives due to rice crop failure, represents one of the world's worst experiences on the devastating impacts caused by a rice plant disease [11].Despite the great improvement of pest management practices, still the current losses caused by diseases, insect pests and weeds takes on average above 30% of the production for crops in general and 37% for rice in special [7]. For Indian agriculture, ***"Development of monitoring tools and forewarning systems"*** is identified as one of the key strategies for ***"Effective Pest Management"*** [1].

Online service linking scientists and farmers

The ClimaRice II exploration of the potential in ICT innovation through forecasting of pest and disease risks, are based on the reasoning that farmer's daily adaptation to the day-to-day variability in weather is a short term analogy to the need for adaptation to long term changes in climate. While it is uncertain what the effects of climate change actually will be, it is certain that climate change will affect crop-pest interactions [10,11]. Therefore, any new scientific insights, strategies and tools that can be used to adapt to weather variability, both within-season and between-season, are also relevant for the adaptation to future climate change. Specifically, the objective was to assess the potential for establishing a pest and disease forecasting service for rice farmers in Tamil Nadu state, partially building upon the more than 50 years of experience in pest risk forecasting of the Norwegian partner Bioforsk.

Approach

The exploration of the potential for a state-wide pest and disease forecasting service in Tamil Nadu approach was divided in two parts. One part assessed the organizational and infrastructure matters, and another part assessed the scientific foundation involving:

1) Prioritization and selection of rice pests and diseases of highest interest with regard to forecasting according to the following criteria:
    a. impact
    b. scientific knowledge
    c. emerging awareness
2) Review of the scientific knowledge of climate responses of the selected pests, including eventually internationally or nationally published mathematical models integrating such knowledge, as well as locally developed thumb-rules regarding pest response to weather.
    a. Model listing
    b. Model evaluation and validation
    c. Model selection

Key findings - infrastructure

Tamil Nadu Agricultural Weather Network (TAWN) currently counts 224 automatic weather stations that have been established in recent years by the Government of Tamil Nadu under the National Agricultural Development Project (NADP). This forms the main infrastructure foundation for the potential development of a state wide service for forecasting risks of pest and disease attacks in rice.

Automatic weather station maintenance

Pest & disease forecasting concepts

Automatic Weather Stations are weather measurement equipment that automatically takes electronic measurements of specific weather elements such as air temperature, wind speed, rainfall, solar radiation, soil temperature, soil moisture, leaf wetness and air humidity. which as are needed to understand the processes of plant growth and plant pest development. Automatic weather stations normally also have the capacity to automatically transmit the data for remote/central storage and use.

Automatic Weather Station plot in Coimbatore

Models for pest & disease forecasting are synthesized scientific knowledge of the biological responses to weather and other environmental conditions of pest and disease organisms formulated into mathematical logics or equations. The models are driven by weather and/or biological data inputs to output predictions about the risk of pest and disease attacks.

Dissemination of pest risk forecasts refers to real time dissemination of predictions of the risk of attacks by a specific pest or disease in specific crops. The emergence of mobile networks opens new opportunities for adapted and locally relevant dissemination of pest risk forecasts, while more advanced mobile devices allows for more interaction between farmers and science.

Key findings - policy & organizational

Organizational aspects such as stakeholder interests and responsibilities, policies as well as practical routines were identified as important aspects to consider for a successful implementation to take place.
The current operation of the weather data management part of TAWN is based on in-house servers located at Tamil Nadu Agricultural University. The development and maintenance of the software components of the weather data management system is provided by an external consulting company, currently delivered by the company GeoEdge Inc.

Other technical matters were studied and no incompatibilities or other major technical constraints were identified. The database storage of the weather data is based on the open source licensed database server MySQL, which is capable of delivering weather data to any kind of processing system as it has a high level of standards support.

There was detected one policy issue related to weather data usage that would need clarification. If the computation of pest forecasts were to be carried out abroad, i.e. based on cloud computing service due to the need of high computing capacity, a cloud computing approach might have the result that weather data would need to be brought outside India. If the conclusion is that this is not allowed policy, selection of high computing capacity services within India would be a good option.

Key findings - rice pests & diseases

Prioritization and selection of rice pests was done in collaboration with Dept. of Plant pathology and Dept. of Entomology at TNAU. According to the above criteria, the following organisms were given priority:

Disease priority	*Insect pest priority*
Rice Blast	Leaf folder
False Smut	Brown plant hopper
	Leaf mite

Rice blast is caused by *Magnaporthe grisea* (Hebert) Barr and is an important disease of rice which accounts for serious yield losses in all rice growing areas of India. The symptoms of the disease appear on the leaf, node, and neck of the panicle and grains of the rice plants. For rice blast TNAU regularly collects disease incidence data that could be used for model validation. The protocol follows the “Blast disease Scoring” at TNAU which involves both assessment of blast of leaves and blast of neck/panicle.
Leaf blast protocol: Twenty five leaves are selected at random in each microplot and the disease intensity is graded as:

Gr.	Intensity
0	No lesions
1	Small brown specks of pinhead size without sporulating centre
2	Small roundish to slightly elongated, necrotic grey spots, about 1-2 mm in diameter with a distinct brown margin and lesions are mostly found on the lower leaves
3	Lesion type is the same as in scale 2 but significant number of lesions are on the upper leaves
4	Typical sporulating blast lesions, 3mm or longer, infecting less than 2% of the leaf ares
5	Typical blast lesions infecting 2-10% of the leaf area
6	Blast lesions infecting 11-25% of the leaf area
7	Blast lesions infecting 26-50% of the leaf area
8	Blast lesions infecting 51-75% of the leaf area
9	More than 75% leaf area affected

Neck blast/panicle blast: Twenty five hills will be selected at random in each microplots and the disease intensity will be graded as:

Gr.	Infected panicle
1	Less than 5%
3	5-10%
5	11-25%
7	26-50%
9	More than 50%

Potential disease incidence percent (PDI%) is then calculated [5]:

$$PDI = \frac{Sum\ of\ individual\ rating}{Total\ number\ of\ plants} \times \frac{100}{Maximum\ disease\ grade}$$

For rice blast there is a vast literature on existing prediction models to build upon [4]. The review of available models concluded that BLASTAM would be the best choice, while it would also be of interest to consult nationally developed and already operative models such as RBPRED [5].

For rice pests the following criteria is used at TNAU to determine whether development of a pest in the rice crop has reached the economic threshold level:

Pest	Criteria
Thrips	Rolling of terminal 1/3 to ½ area of first and second leaves in 10% of the plants or 25 Nos/5 sweeps
Stem borer	10% dead hearts, 2% white ears 2 egg masses/sq.m.
Gall midge	10% silver shoots
Leaf folder	4-5% of damage leaves in vegetative phase.5-6% of damaged leaves at flowering and after
Whorl maggot	25% of damaged leaves
Green leaf hopper	60-25 sweepings or 5/hill in the vegetative phase 10/hill at flowering and after 2/hill in tungro endemic area
White leaf hopper	60/25 sweeping
Brown plant hopper	1/tiller
Earhead bug	4/sq.m.
Case worm	10% damaged leaves

Pilot service not established in Climarice II

In the initial stage of the project, Climarice II investigated the possibilities to establish a pilot service pest & disease risk forecasting service within the timeframe of the project, in addition to the explorative analysis briefed here. Several options were then considered. Although the consultancy company was assessed to have the programming competence necessary for system setup and development, the option of engaging an external consulting company to set up the pilot pest & disease forecasting service would not lead to in-house build-up of competence at the partner institution TNAU. According to the project objectives of capacity building and technology transfer this option was not found appropriate. Neither was it found appropriate to contribute a full setup of a pilot service from the Norwegian partner side, as that would have had the same consequence of no in-house capacity build-up on the partner institution side. Thus, there were made attempts to get the necessary competence recruited at TNAU, with initially promising results. However, the timing coincided with political elections in Tamil Nadu State which resulted in a change in the TNAU leadership causing the initial promises of recruitment not being followed up from the TNAU administration side. Based on this outcome it was concluded that establishment of a pilot service was not possible to achieve within the project frame.

Conclusions and recommendations

Establishment of a plant pest & disease forecasting service based on the infrastructure represented by the Tamil Nadu Agricultural Weather Network is highly feasible and in line with key strategies identified for Integrated Pest Management in India [1]. There is a clear potential for both climate change adaptation and mitigation if farmers get access and takes up the use pest & disease forecasting technology. In addition there are clear food security and environmental safety benefits associated with this technology due to its potential to reduce unnecessary pesticide use. However, the private incentives for establishment and operation of such technology are still limited, and government action will thus be required for realisation in the short term.

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ClimaRice II Project (2009-2013)

ClimaRice II is an integrated project that aims to test and validate climate change adaptation techniques related to rice production, in close co-operation with farmers and local agencies in two study areas in the Cauvery River Basin, Tamil Nadu, and Krishna River Basin, Andhra Pradesh, in India.

The overall goal is to contribute to the regional and national adaptation strategies to sustain rice production and ensure food security amidst changing climate. The partners are:

- Bioforsk - Norwegian Institute for Agricultural and Environmental Research (Project Co-ordinator)
- Tamil Nadu Agricultural University, Coimbatore, India
- International Pacific Research Institute, Hawaii, USA
- International Water Management Institute, Hyderabad, India

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