Climate Change

Vulnerability & Adaptation Experiences from Rajasthan & Andhra Pradesh

WFMC A Weather-based Farming Model for Communities

Case Study

INDIA

intercooperation
Natural Resource Management
Rural Economy
Local Governance and Civil Society

MSSRF

AFPRO
Action For Food Production

iNFRAS

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Swiss Agency for Development and Cooperation SDC

The `Vulnerability Assessment and Enhancing Adaptive Capacity to Climate Change in Semi Arid Regions in India' (V&A) programme in brief

The Swiss Agency for Development and Cooperation (SDC), recognising the risks that climate variability and change pose to livelihoods of rural communities in semi-arid regions of India, supported a process-oriented pilot programme on '*Vulnerability Assessment and Enhancing Adaptive Capacity to Climate Change in Semi Arid Regions in India' (V&A)*. The programme was implemented in the period from 2005 to 2009 in two semi-arid regions in India, namely Udaipur district in Rajasthan, and Mahbubnagar district in Andhra Pradesh. The overall goal of the V&A Programme was to secure the livelihoods of rural poor and vulnerable communities by promoting adaptation measures that enhance their capacity to better cope with adverse impacts of climate change and by improving their disaster preparedness.

The programme had **three specific inter-linked objectives:**

- **Objective 1:** To build community level capacities with regard to best practices and technologies in the agriculture, water and energy sectors.
- **Objective 2:** To optimise the service delivery system and services at selected sites in semi-arid areas in India.
- **Objective 3:** To promote policy dialogue and advocacy at different levels.

A range of field activities, some of them building on and aligned to traditional local adaptation practices, were tested in the particularly climate sensitive sectors of water, agriculture, rural energy and livestock. The field interventions helped identify measures and mechanisms for reducing the vulnerability to climate hazards of the poorest social groups in these regions. The emerging lessons were analysed with a view to informing policy processes at state, national and international levels by demonstrating a way forward for integrating development strategies with climate change adaptation.

The programme built on the collaboration between various actors with complementary strengths. A National Consortium, for overall management of the programme, comprised three partners, namely **M.S. Swaminathan Research Foundation (MSSRF), Action For Food Production (AFPRO),** and the **National Institute of Agriculture Extension Management (MANAGE).** An International Consortium for backstopping, quality assurance and facilitation of continuous exchange with ongoing international policy processes was constituted by **INFRAS** and **Intercooperation (IC).**

Mahabubnagar district in Andhra Pradesh and Udaipur district in Rajasthan were selected for implementation of the programme, as rural communities in these districts are among those most vulnerable to climate variability and are likely to be highly impacted by climate change. A multi-stakeholder process and a set of pre-defined criteria, including manifestation of climate hazards and evidence of social organization at village level, helped identify two villages for programme implementation in each district, namely **Kothur** and **Srirangapur** in Mahbubnagar district of Andhra Pradesh and **Amda** and **Kundai** in Udaipur district of Rajasthan.

For further details on the V&A pilot programme and a detailed analysis of the vulnerability of the communities selected for implementation of the programme, see the '*Introduction*' or visit the V&A programme website www.climateadapt.net.

Climate Change

Vulnerability reduction and adaptation to climate change in semi-arid India

WFMC **A Weather-based Farming Model for Communities**

Case Study
INDIA

V&A

Climate Change

Vulnerability reduction and adaptation to climate change in semi-arid India - A Weather - based Farming Model for Communities
The use and sharing of information contained in this document is encouraged, with due acknowledgment of the source.

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Terminology/Definitions

Agro-met Observatory: The collected weather data from the surface meteorological observatory are used for developing local agro advisories for practicing weather based agriculture.

Climate: Average weather or the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to 1000 or 10,00,000 years. The classical period is 30 years as defined by World Meteorological Organisation

Climate Change: The statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period, typically decades or longer.

Climate Risk Manager: Trained selected village community members who operate, develop and communicate agro-advisories for crop and livestock management. They can be also called as Climate Manager or Climate Risk Reduction Manager.

Climate Risks: Malevolent effect from weather elements on crop and live stock economical losses. According to the intensity of the weather elements, the loss may go up to 100 per cent like as in case of severe cyclone, drought etc.

Climate Variability: Variations in the mean state and other statistics (Standard Deviation`, extreme weather events) of the climate on all temporal and spatial scales beyond that of individual weather events.

Control Farmers: Farmers who practice crop management based on their own experience with little or no weather consciousness.

Cropping System: Pattern of crops taken up for a given piece of land or order in which the crops are cultivated on a piece of land over a fixed period and their interaction with farm resources and other farm enterprises and available technology, which determine their make-up (Ganga Saran et al., 1989).

Drought: The phenomenon that exists when precipitation has been significantly below normal, causing serious hydrological imbalances that adversely affect land resource production systems.

Dry Spell: A period of at least 15 consecutive days during which not a single wetting rain has fallen.

Extreme Weather Event: An event that is rare within its statistical reference distribution at a particular place.

Humidity: The condition of atmosphere in respect of its water vapour content.

Maize Grain Equivalent Yield: In a cropping system study, to compare the efficiency of a particular cropping system with the other cropping system, the sequential crop yields of the particular cropping system are converted in to base crop yield. In this study, maize is the base crop and hence the wheat yield is converted in to maize grain yield by taking price factor of the base and sequential crops grain yield.

Maximum Temperature: The highest temperature attained, usually in the thermometer screen or on the ground, during a period of time (between 2.00 and 2.30 pm).

Minimum Temperature: The lowest temperature attained, usually in the thermometer screen or on the ground, during a period of time (between 5.00 and 5.30 am).

Partial Budgeting: This is commonly used to estimate the cost of returns of making relatively small (marginal) changes to an enterprise within the existing organisation. This is to assess the economic viability of the component technology tested. In this study it is weather based farm decisions. This budget includes reduced cost and reduced return and added cost and added return to screen the particular technology from the control to assess the economical viability of the technology (Van der Veen and Gozales, 1986).

Rainfall: The total liquid product of precipitation or condensation from the atmosphere as received and measured in a rain gauge over 24 hours at 03GMT (UTC).

Return Above Variable Cost (RAVC): Grain yield x price of the commodity = total variable cost. This is also called as net return.

Total Return: Grain yield x price of the grain.

Total Variable Cost: Cost of production - fixed cost.

Agro-met Farmers: Farmers who did manage crops based on weather information or weather based thumb rules. These farmers are also called in this study as agro-met adopters.

Vulnerability: 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.

Weather: The state of the atmosphere with respect to wind, temperature, cloudiness, relative humidity, pressure etc., at a given time or day-to-day change in the atmosphere.

Executive Summary

With the objective of building local level capacities of the farming communities to cope with agro-meteorological crop production risks, under the Swiss Agency for Development and Cooperation program 'Vulnerability Assessment & Enhancing Adaptive Capacity to Climate Change in Semi-arid Regions of India, the M. S. Swaminathan Research Foundation along with national partners Action for Food Production, Shayogh Sansthan, Vikas Sansthan and Eco-club experimented with the establishment of **village level mini agro-met observatories** in selected project villages namely, Kothur and Srirangapur in Andhra Pradesh and Kundai and Amda in Rajasthan on a pilot scale.

The underlying hypothesis was that the data collected from the meteorological instruments by the community over a period of time would help the community to develop weather based thumb rules for taking appropriate farm decisions based on simple weather parameters like rainfall, wind speed, temperature and relative humidity.

To validate the strength of agro-met information for farm decision making an in depth case study was undertaken at Kundai village of Udaipur district of State of Rajasthan.

About 10 farmers, considered to be 'Agro-met Farmers' who used the agro-met data extensively for their farm operations and a set of 'Control Farmers' played a key role in demonstrating the utility value of the locally generated information besides providing useful insights on the how the enhanced capacity of the local communities, well managed local institutions help broadening the understanding of climate risks and in providing in-situ solutions. A variety of information was gathered from both the 'Agro-met' and 'Control' farmers practicing cropping system of maize (Kharif)-wheat (Rabi) through a pre-tested questionnaire and personal interviews at various stages of the crop production process.

Analysis of data revealed that by adhering to farm decisions based on data generated from the mini observatory, the 'Agro-met' farmer group did record a benefit cost ratio of 1.2, from the cropping system of maize-wheat, while it was 0.96 for the 'Control' farmers. The partial budgeting analysis also indicated that there is an estimated positive change for the 'Agro-met' farmer group.

The agro-met experiment proved to be an example of a new knowledge based community empowerment that enhances its coping capacity. Thus the knowledge developed is useful to understand the role of both simple technological improvements that the local communities could relate to with appropriate training and the significance of sensitizing people to adverse impacts of climate change will help manage climate risks more prudently at the local level. Time frames to assess the effectiveness of adaptation strategies at field level should perhaps be longer than the four year span of the V&A project. It will be important to monitor and quantify impacts over a longer period so that the lessons and insights drawn could be extrapolated for wider implications at the national and international levels.

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Numerous organizations and individuals contributed in a substantive way to the successful completion of this project. We gratefully acknowledge the local communities and the field level workers of local NGO partners Sahyog Sansthan, Vikas Sansthan and Eco- club India for their untiring work which enabled to broaden our understanding of field realities. We record our thanks to the AFPRO units of Rajasthan and Andhra Pradesh and their head office for their efficient coordination and support. We acknowledge the efforts of Intercooperation and INFRAS for their valuable guidance as back stoppers. We owe a great deal to Prof. T. N. Balasubramanian for his meticulous contributions in designing, executing and overall guidance of the study. Helpful contributions and comments were received from fellow colleagues on the draft report.

Our sincere thanks are due to Swiss Agency for Development and Cooperation (SDC) for their dedicated support both in terms of generous financial assistance extended to the project as well as for their intellectual contribution in shaping the project and its components.

Above all, we would like to go on records to express our gratitude to Prof. M.S. Swaminathan for his overall guidance and vision in shaping this project and in particular for constantly reminding and motivating the project team to bring the larger objectives closer to the needs of the farming communities as the chairman of the Project Steering Committee.

We hope this publication will help us to appreciate how much has been learned over the last few years, and show us where we can successfully concentrate our collective efforts to bring forth rural prosperity in the context of the looming climate threats.

-A. A. Nambi

1. Introduction

1.1 The context

It is a known fact that agricultural production is highly dependent on weather and is adversely triggered by climate risks. In the recent past, climate risks such as droughts, floods, storms, tropical cyclones, cold and heat waves have caused major losses in the agricultural sector (Sivakumar, 2005). Communities that are most exposed to these risks are those with limited infrastructure in the villages and with limited access to technological and financial resources. There are also many opportunities that can assist in coping with agro-meteorological risks (Meinke and Stone, 2005). One of the most important strategies is to improve the climate knowledge of the community and enhancing their adaptive capacity through the use of climate based technologies. Planning, early warning and well-prepared response strategies based on locally generated weather information are the major tools for preventing and mitigating losses. Nevertheless, decision-making in agricultural production is a complex process in which many risks need to be addressed for an informed decision to be made. Farmers face many types of risks related to production, marketing, legal, social and human aspects. The risks arising out of environmental factors have a direct link with the prevailing weather condition particularly in a monsoon dependent country like India.

Figure 1: Village level mini agro-met observatory

In India, the India Meteorological Department (IMD), Indian Council of Agricultural Research (ICAR), State Agricultural Universities (SAUs) and other organisations have established surface meteorological observatories. However, these observatories have been installed only up to *taluk* (an administrative unit of a district) scale in the State. No village level agro-meteorological observatories have been established in the country so far for the benefit of the farming community. In the absence of village level meteorological data, the medium and short range weather forecasts of the National organisations are of limited utility to the village community.

Figure 2: Training of Weather Station Managers

Hence, the concept of "seeing is believing and practicing is learning and skill development" can be demonstrated by establishing village level agro-met observatories. This is possible through installation of two or three crucial meteorological apparatus to measure the vital weather parameters that are required for farm decision-making. The weather information collected would provide opportunities to the farming community to develop weather-based thumb rules for crop and livestock management rather than for weather prediction for which a large volume

Figure 3: Weather data being collected from agro-met observatory

of weather data, Cray computer and other skill sets are needed.

1.2. Significance and outline of the study

The objectives and significance of this venture were (i) to review the opportunities for farmers to cope with agro-meteorological risks and uncertainties, (ii) to build the capacity of the local communities to practice weather based farming, (iii) to augment their crop yields by using locally generated information and by keeping track of the usefulness of specific data to relevant agronomic practices, and (iv) to enable the local communities to develop location-specific weather based thumb rules for efficient crop management.

A model village level mini agro-meteorology observatory to measure five weather parameters (rainfall, minimum temperature, maximum temperature, wind speed and relative humidity) was established in each of the four villages of the SDC supported programme on 'Vulnerability Assessment and Enhancing Adaptive Capacity to climate change in semi-arid regions of India'.

2. Relevance and Applications in Agriculture

2.1. National and Regional scenario

Recently unfavorable weather conditions in the State of Himachal Pradesh hit the mango crop causing an estimated loss of Rs 250 crore and the State Government introduced a crop insurance scheme for mango in Una and Kangra districts of the hill state (Shimla, August 18, 2009).

Farmers in Bihar's Vaishali district worry a lot as inadequate rains have resulted in parched farms and fear is mounting that their saplings may dry if it doesn't rain soon in the monsoon season of 2009. Cracks have developed in the land. Crops are infected by pests because of scarcity of water. For the last two years floods have razed their crops and this year they are troubled by drought.

These are some examples of impending weather risks. If they had their own agro-met observatory and weather thumb rules, the losses described above could have been minimised.

Weather monitoring, either by scientists from IMD and other partners or by local communities, is very important for minimising the climate risk especially, in the era of climate change. Hence establishing infrastructure like agro-met lab at village level would empower the community to monitor their local weather by themselves, which is a Herculean task for Met- scientists who are working with coarse resolution models.

Since 1945, IMD is providing weather services for farmers and in the year 1976, IMD started the Agro-meteorological Agricultural Advisory Service (AAS) from its State Meteorological Centers, in collaboration with Agriculture Departments of the respective State Governments. This was not very effective and hence from 2007, IMD launched an integrated agro-met service in collaboration with various institutes. Currently, this service provides three kinds of agro-met advisory bulletins, at

National, State level and District levels. But at village level, the advisories are seldom used because of the lack of confidence and this led to the establishment of village level, community based agro-met observatories.

The Government of India is concerned about improving the agricultural economy of the country, notwithstanding the existing status of infrastructure. More inputs would be required for more vulnerable areas if development were to be carried out in a balanced manner across India and all the existing services must be geared for that purpose. Agro climatic analyses at the local level can help in selection of crops and cropping practices by matching their weather requirements with seasonal crop-phenological events, endemic periods of pests and diseases and hazardous weather can be avoided.

2.2. Importance of farm decision-making in semi-arid agriculture

The semi-arid regions have a high potential for agricultural productivity enhancement through irrigation as compared to other climates (arid, sub-humid, humid and per-humid). Under semi-arid climate, the annual rainfall meets only 50 per cent of the annual potential evapotranspiration and there is always a deficit of rainfall and hence an increased response to irrigation. Response farming (farming based on seasonal climate forecast) is well suited for this climate, but in India there is a dearth of research in this area. The Indian experience indicates that, agricultural productivity could be improved with weather forecast (long, medium and short range forecasts).

The medium and short range forecasts put out by the National organisations are seldom accessible or used by village communities. Indigenous weather knowledge helps the farming community to take farm decisions in the absence of weather forecast information at the village level. If this indigenous weather wisdom of the community, after validation, is blended with scientific met data recorded at village level mini observatories, the derived output can serve as an effective decision tool for weather based farm decisions by the community. This not only enhances the input efficiency, but also increases the productivity by minimising risks and cost of cultivation. Some examples of weather based farm decisions are furnished in Annexure II.

3 Village Level Mini Agro-met Observatory

3.1 The Objectives

The objectives for the establishment of mini agro-met observatories were:

1. To provide a hands-on experience in weather data recording to the community.
2. To understand the local climate through collection and interpretation of data.
3. To train and equip a few members of the community to become 'Climate Risk Managers' in the long run.
4. To plan weather based agricultural activities using 'the thumb rules' developed and thereby enhancing the adaptive capacities to climate variability.
5. To create a visible impact among the farm communities and encourage them to participate in the process.

The observatory provides daily weather data on the basis of rainfall, wind speed, maximum temperature, minimum temperature and both morning and evening relative humidity. This information is useful for farm decisions as detailed below:

Rainfall data for sowing and irrigation scheduling decisions; Wind speed for pesticide spraying and propping decisions; Maximum, minimum temperatures and Relative Humidity (both maximum and minimum) for pest and disease out break and irrigation scheduling decisions

3.2 Selection of the Appropriate System and Commissioning

Development of weather consciousness among the farming community can lead to the practice of weather based sustainable agriculture. From among the various types of agro observatories - climatological, hydrological and agro-meteorological, available in India, the village level observatories offers the best value for money.

Figure 4: Participatory planning of Intervention, Kundai Village

Figure 5: Participatory Planning among Villagers, Amda Village

Establishment of agro-meteorological observatories like the '*Principal and Ordinary*' types demand more space and money. Between the Automatic Weather Station (Electronic mode), Data Collection Platform (IMD owned) and Manual types available in India, the manual type is more suitable as it is less complex and is relatively inexpensiveness. One mini agro-met manual observatory each was established in the four pilot villages under the V&A programme.

The lay out plan of the mini village level observatory is given in Annexure I. Its specifications are provided in Table 1.

Table 1: Details of the mini observatory:		
Size of the observatory	:	8 x 3 M (24m2)
Shape of the observatory	:	Rectangular
Instruments required	:	Non recording rain gauge (200cm2) (one)
	:	Anemometer (one)
	:	Maximum thermometer including spare (two)
	:	Minimum thermometer including spare (two)
	:	Wet and dry bulb thermometers including spare (each two numbers)
	:	Single Stevenson Screen (one)

Two observations are taken each day at 7.00 and 2.00 IST. This is converted into the local time based on the longitudinal position of the observatory site.

Name the Village	Timing of Observations		
	Morning	Rainfall	Evening
Amda	7.37	8.30 a.m.	2.37
Kundai	7.34	8.30 a.m.	2.34
Kothur	7.17	8.30 a.m.	2.17
Srirangapur	7.16	8.30 a.m.	2.16

The observatories were commissioned in March 2007, the exact dates for each village are:

Kundai : 16.03.2007

Amda : 18.03.2007

Srirangapur : 24.03.2007

Kothur : 26.03.2007

3.3 Capacity building for climate risk managers/weather messengers

Two women and men each from the four project villages were selected and trained along with the technical staff from of the local NGOs. The training focused on:

(a) recording weather data from the observatory in a register

(b) interpretation of weather data

(c) development of thumb rules based on weather data collected and field crop observations

(d) preparation of agro-advisories, and

(e) dissemination within the community.

Figure 6: Weather Manager displaying the weather data on the notice board

Besides the above, the 'Climate Risk Managers' were trained to maintain the instruments on a day-to-day basis. They were also trained to computerise the weather data collected. The decisions that were and can be taken based on the absolute value of weather elements are given in Annexure II.

4. Fundamental Processes and Variables

4.1. Key variables

Crop-weather interaction exists in nature and with benevolent weather, the crop productivity is always positive. Malevolent / adverse weather, as a result of antagonistic interaction, brings down the crop productivity. To deal with such adversity, it is imperative to measure the absolute value of weather elements through the establishment of village level mini agro-met observatories. An observatory would provide quantified weather information on rainfall, maximum temperature, minimum temperature, wind speed and relative humidity, which are essential to develop weather based thumb rules rather than for predicting / forecasting the future weather.

4.2. Observation times

There is a standard time to record weather elements at the observatory which is determined by the longitudinal position of the project villages and the location of the observatory sites.

4.3. Data processing for thumb rule development and farm decisions

Data collected must be processed and interpreted to make effective use of the information for farm decision-making. With different statistical and mathematical tools it is possible to translate the data into farm decision rules. A few examples are given below:

Rainfall:

(i) Coefficient of variation (CV):

In India the monsoon plays a vital role in influencing rainfall occurrence in different geographical regions. Because of this, Indian rainfall has both spatial and temporal variability which leads to greater risk to water related enterprises. To sustain any activity, the variability of the rainfall has to be assessed and quantified. Among many tools available, computation of coefficient of variation (CV) seems to be reasonable and simple to assess the variability of a data set. With reference to rainfall over years for a particular station, it is possible to get yearly, seasonal, monthly, weekly and daily data sets. Each time-series data needs variability verification for use in agriculture. Normally the CV would be higher for a location where the annual rainfall is lesser (< 500 mm).

CV = (SD / Mean) x 100

where, CV= Coefficient of variation expressed in percentage

SD = Standard deviation of the data set

Mean = Average value of the data set

Based on experience, the following threshold level CV are to be considered for dependability.

Yearly rainfall data set = the CV must be lesser than 25 per cent for dependability.

Seasonal rainfall data set = the CV must be lesser than 50 per cent for dependability.

Monthly rainfall data set = the CV must be lesser than 100 per cent for dependability.

Weekly rainfall data set = the CV must be lesser than 150 per cent for dependability.

Daily rainfall data set = the CV must be lesser than 250 per cent for dependability.

Whenever the computed CV for a data set is more than the threshold level, the Initial Probability (IP) of rainfall may be taken into consideration. For agricultural planning purposes either 50 or 70 per cent IP value must be considered.

(ii) Initial probability (IP):

Initial Probability indicates the minimum quantity of rainfall to be expected for a particular time series data set (yearly, seasonal, monthly, weekly and daily). For computing IP the following simple model can be used.

IP = n x p / 100

where, IP= Initial Probability expressed in percentage

n = Sample size

p = Probability required

For computing the IP, the following steps may be used

Step 1 : Take the data and arrange according to the years

Step 2 : Irrespective of the years arrange the data in the descending order

Step 3 : Use the model and compute the value

Step 4 : From the descending order data by using the value from step 3, pick out the value which indicates the IP value

(iii) Conditional probability (CP):

Conditional Probability indicates the probability level at which a particular amount of rainfall is required to carry out farm operations for a particular place by using specified time series weekly data. CP is useful for weekly rainfall data analysis in order to take farm decisions like sowing, hand weeding and hoeing, fertiliser application and harvesting especially for dry land, since all the farm operations are at the mercy of rainfall events.

Conditional probability is worked out from the following model

CP = Mean weekly rainfall for a particular standard week (-) required quantity of rainfall for deciding farm operation / SD.

Where CP = Conditional Probability

Mean Weekly Rainfall = this has to be computed for 52 meteorological standard weeks separately for each week based on 30 years data.

Required quantity of rainfall = Rainfall > 25 mm (2 to 3 days continuously): Sowings can be taken up in dry lands

Rainfall >12 mm: Fertiliser application in dry lands

Rainfall = 10 to 12 mm: Hand weeding and hoeing in dry lands

Rainfall = 10 mm: Plant Protection

(iv) Onset and withdrawal of monsoon rain:

Computing onset and withdrawal of monsoon rain would aid to understand the crop length of growing period of a village. The knowledge on probable date of commencement and end of the rainy season can be used for planning various agronomic operations like computing length of growing period. This minimises the risk to crops to be sown and aids in optimum utilisation of limited resources like water, fertiliser and labour. In deciding a criterion for commencement of sowing operation, two basic requirements are to be looked into:

i. Identification of sustained rain spell, which more or less represent the transition from pre-monsoon to monsoon condition.

ii. The spell so chosen that the rain that falls should percolate in the soil up to a reasonable depth and also build up sufficient soil moisture profile.

Scientists at IMD have identified the commencement of sowing rains for black cotton soil area of Maharashtra. They had taken the criterion of a 7 days spell with a total rainfall of 25 mm with not less than five days of 1 mm or more rainfall each day as the commencement of sowing rain. The major lacuna of this criterion is that it does not consider evaporation besides 1 mm being too meagre for a rainy day.

Subsequently three more criteria have been fixed to define the date of onset of effective monsoon rain. They are:

i. The first day rain in the seven days (week) spell is not less than 'e' mm (e is the average daily evaporation).

ii. The total rain during the seven days spell is not less than (5e + 10) mm.

iii. At least four out of these seven days are rainy days (> 2.5 mm rainfall each day).

To determine the onset and withdrawal of seasonal rainfall for a location / village the procedure developed by IMD (1943) has to be adopted. In this method, the dates of normal onset and withdrawal of monsoon rainfall are arrived at on the basis of normal 5 days rainfall totals. The mean of 5 days total rainfall from past 30 years has to be computed especially for the month of June and July for onset and September for withdrawal of Southwest monsoon and October and December for Northeast monsoon and plotted in a graph sheet separately. The 5 days period in which there is a sudden spurt in total rainfall, compared to earliest 5 days totals, with sustained rainfall thereafter is taken as the onset, wherein the middle date of the above 5 days total is taken as the date of the normal monsoon onset.

Similarly, the middle date of 5 days period in which there is a marked decrease in rainfall, followed by less or no rainfall, is taken as the normal withdrawal of the monsoon rainfall. The mean 5 days potential evapotranspiration corresponding to the 5 days rainfall can also be plotted in the graph sheet for the obtaining precise information.

The only lacuna in this method is that it is not possible to identify the number of wet and dry spells between the onset and withdrawal of monsoon rain.

Temperature

(i) Relative temperature disparity (RTD)

This is a very good indicator to assess the role of high night temperature. If high temperature prevailed at night, it induces night respiration in the crop and hence there is a loss of stored starch. If this situation occurs at the transition period between vegetative and reproductive stages the crop may not flower.

The following model can compute the RTD.

$$RTD = \frac{\text{Maximum Temperature} - \text{Minimum Temperature}}{\text{Maximum Temperature}} \times 100$$

If the RTD value is higher for a particular day, week, month, and season, this situation is favourable for crop growth for all regions except hilly region.

4.4 Communicating agro-meteorological information

Agro-meteorological information is a part of a continuum that begins with scientific knowledge and understanding and ends with the evaluation of the information. Intermediate processes are collection of data, changing data into useful information and dissemination of information. In order for the information to be useful, it must be accurate, timely and cost effective.

Rural and farming communities represent the "last mile of connectivity". The effectiveness of ICTs for agro-meteorological information dissemination can be enhanced by linking them to other communication media which are more accessible to farmers such as village knowledge centers, community radios etc., to get a 'multiplier effect'.

As communication technologies are constantly advancing, there cannot be one ideal way of disseminating agro-met information. The chosen technology / via media should be suitable to the local conditions and accessible by the local communities. Nevertheless, the timely relay of agro-met information is very critical to make valuable farm decisions. Hence, evaluation of the impact of information and the information delivery systems can be part of the design and has to be constantly reviewed to provide meaningful information and to have a quantifiable basis to improve the system.

Figure 7: Climate risk managers being trained to computerise the weather data collected

Training of agro-meteorologists and local facilitators like the 'Climate Risk Managers' is critical for the process. The training should include an appreciation of complex interactions of biotic and abiotic factors. In addition to the traditional training it is necessary to provide a larger perspective to the transformation of data into useful information.

The information needed for diverse groups of end-users growing crops or raising animals is basically the same. One should be cognizant of the fact that the differences arise from the human and financial resources available to act up on this information and the methods of information dissemination. The same information may be used differently by a large farmer with considerable resources as compared to a small farmer. These differences must be considered in designing any information dissemination system. There is also a need to address and discuss the question of motivation for users to access and use information. Like any other business, farmers would want to be successful and hence motivation should be linked to the benefits tied to the information provided i.e. the enhancement the agricultural productivity and thereby incomes.

Figure 8: Weather data disseminated on the notice board

Under the V&A project the 'Climate Risk Manager' (CRM) of the village mini agro-met observatory records weather data at the prescribed time and disseminates it through notice boards at various locations within the village. The data collected is discussed with members of the 'Smart Farmers' Club' constituted under the V&A programme. The 'Climate Risk Manager' prepares agro advisories for field crops grown in the village using the weather data collected and communicates it to farmers for appropriate action. Interpersonal communication has a critical role in dissemination of information. 'Weather Messengers' are also used in communicating weather information to the neighbouring villages. Sometimes the CRM sends emergency weather messages through SMS using mobile phones.

In this project there was an intention to use Village Resource Centers and Village Knowledge Centers, conceived and promoted effectively elsewhere by the M.S. Swaminathan Research Foundation, but they could not be put to effective use due to various institutional and technical bottlenecks.

5. V&A Programme case study

5.1 Rajasthan

5.1.1 Pilot Villages

Amda village in Jadhol block of Udaipur, located in western Aravalli region and Kundai village in Vallabhnagar block situated in the eastern plain areas of the district were selected for project implementation based on certain predetermined criteria and stakeholder consultations. These two different zones exhibit climatic variability and accordingly the adaptive measures differ with socio-economic, land use, water resources and livelihood patterns. For this case study, the agromet observatory at *Kundai* village has been chosen.

Figure 9: Kundai Village

Kundai Village, Vallabhnagar Block

Kundai village is located towards eastern plain areas of Udaipur district. It has a heterogeneous population of about 150 households living in six scattered localities. About 60 per cent of the villagers practice agriculture and agriculture based livelihood, while the rest 40 per cent are either engaged as daily wagers or carry out some small businesses in nearby towns. The total area of Kundai village is 628 ha, out of which 320 ha i.e. more than 50 per cent land falls under the wasteland category. Rain fed and irrigated lands constitute 16 and 10 per cent respectively.

The main rainfed *(Kharif)* crops grown in the village include maize, sorghum and urad, whereas the winter *(Rabi)* crops comprises wheat, barley, and mustard. Farmers derive supplementary income by maintaining livestock, mainly, cows, buffalo, sheep and goats. Kundai village has no major water reservoirs; however, four small water-harvesting structures have been constructed under different development programmes. A small percentage of dug wells provide water for irrigating about 63 ha of land. About 14 wells in the village have electric pumping facility and the rest use the traditional bullock motes to draw water for irrigation.

Figure 10: Rain fed crop of Kundai Village

Along with several other initiatives carried out in Kundai under the V&A programme an agro-meteorological observatory was set-up with the consent of the village council and the local people. Through a village resolution a piece of land was allotted to construct the agro-met observatory. The observatory houses simple instruments like Stevenson Thermometer, rain gauge, and an anemometer. Two 'Climate Risk Managers' (a man and a woman) were selected and trained in recording and interpreting data. The CRMs were trained to make important decisions based on the weather data. They kept daily records and disseminated the information through notice boards and word of mouth. These CRMs periodically discussed the weather information and its use in the village meetings. Through their constant motivation many of the farmers came forward to use the locally generated information for their farming activities. The CRMs kept track of farmers who have used the weather information in terms of its application during different seasons and different crops.

Based on CRM's advice, about a dozen farmers went for early sowing of maize under rainfed during *Kharif*, 2008 with the receipt of southwest monsoon while others in the village took up late sowing because they felt the received rain was not sufficient for sowing then. The farmers who went in for early sowing following the advice of the CRM harvested satisfactory maize grain yield, while the grain yield was lesser for the farmers who had opted for late sowing of maize. Further, for the farmers who had taken up early sowing of their *Kharif* (summer) maize there was a triggering of a sequence resulting in early sowing of the wheat in the following *rabi* (winter) season. This resulted in early sowing of the next crop (maize) as well under irrigated condition as compared to the other set of farmers who followed the same cropping system but had not followed the CRM's advisory. The farmers who sowed late could not sow their second crop of wheat in time which not only led to the need for more number of irrigation for the wheat crop but also gave lesser yield of wheat.

In order to further understand the validity of weather based farm decision making in the frame of the current case study, a questionnaire was developed and administered (Annexure III).

The underlying ***hypothesis*** of the study was that the *locally generated weather information from the village level agro-met observatory would improve the effectiveness and efficiency of the dominant cropping system of maize-wheat in terms of yield, input efficiency etc.*

The objective was to understand how best the early sowing of *kharif* maize under rainfed condition improved the productivity of the cropping system of maize-wheat with agro-met information.

5.1.2. Sampling procedures and study materials

Ten farmers, henceforth called agro-met farmers (T), were selected at random from the category of farmers who took up maize sowing during July 2008 *(Kharif)* based on the agro-advisory provided by the CRM for sowing. They were from the hamlet of Darjia Talai and a few other neighbourhood ones. Similarly another set of ten farmers from the same village were selected as Control farmers (C). They also sowed maize but using their own experience. A questionnaire was developed to collect information individually from the 20 farmers and pre-tested and refined. Relevant information was gathered by the local NGO, Sahyog Sansthan and AFPRO and analysed by MSSRF, Chennai. The quality of the data was checked and processed for interpretation.

Cropping system and component technologies: In the cropping pattern under study, maize-wheat is adopted by 90 per cent of the households in the village. The first crop of the cropping system was maize *(Kharif)* followed by wheat *(Rabi)*. Maize crop is mostly sown as rain-fed either in the last week of June or the first week of July with the 'sowing rain'. If any dry spell occurs during the cropping season, one or two life saving irrigations are administered to stabilise the productivity. After the harvest of the *Kharif* crop farmers sow wheat as irrigated dry crop during *Rabi* (mid of November) season.

First crop maize: This crop was sown by all the agro-met farmers (T) with the receipt of 50 mm rain on 11th July 2008, while the control farmers (C) undertook sowing on different dates from the last week of June 2008 onwards. All the farmers of both agro-met and control used *desi* variety of maize except one farmer from control and two farmers from agro-met groups who used hybrid cultivar of maize (15 per cent). Along with compost, both the group of farmers applied N and P at the rate of 10 and 20 kg respectively / ha. No pesticide was applied by either group. Gap filling, to maintain the population of the crop, was not undertaken by either of the two groups.

Second crop wheat: This was sown during mid-November after the harvest of the maize crop. All 20 farmers (both agro-met and control) sowed improved wheat cultivar. The rate of fertilizer application was 20 and 40 kg of N and P respectively. No farmer applied any pesticide to their crop. Control farmers provided five irrigations to wheat, while four irrigations were provided by agro-met farmers (T).

Rainfall: The rainfall recorded at the village mini observatory was 553.1mm for the entire crop duration of maize in 23 rainy days. This computed to 330 mm as effective rainfall, which is only 50 per cent of the maize crop water requirement. During the second crop period of wheat, no rainfall was recorded and the crop was managed by the residual soil moisture stored from the kharif season rainfall and irrigations given as indicated elsewhere of the report.

5.1.3 Results and observations

The maize grain yield obtained by ten farmers each of Agro-met and control group is given in Fig.11 & 12.

Figure 11: Maize Grain Yield (kg/ha)

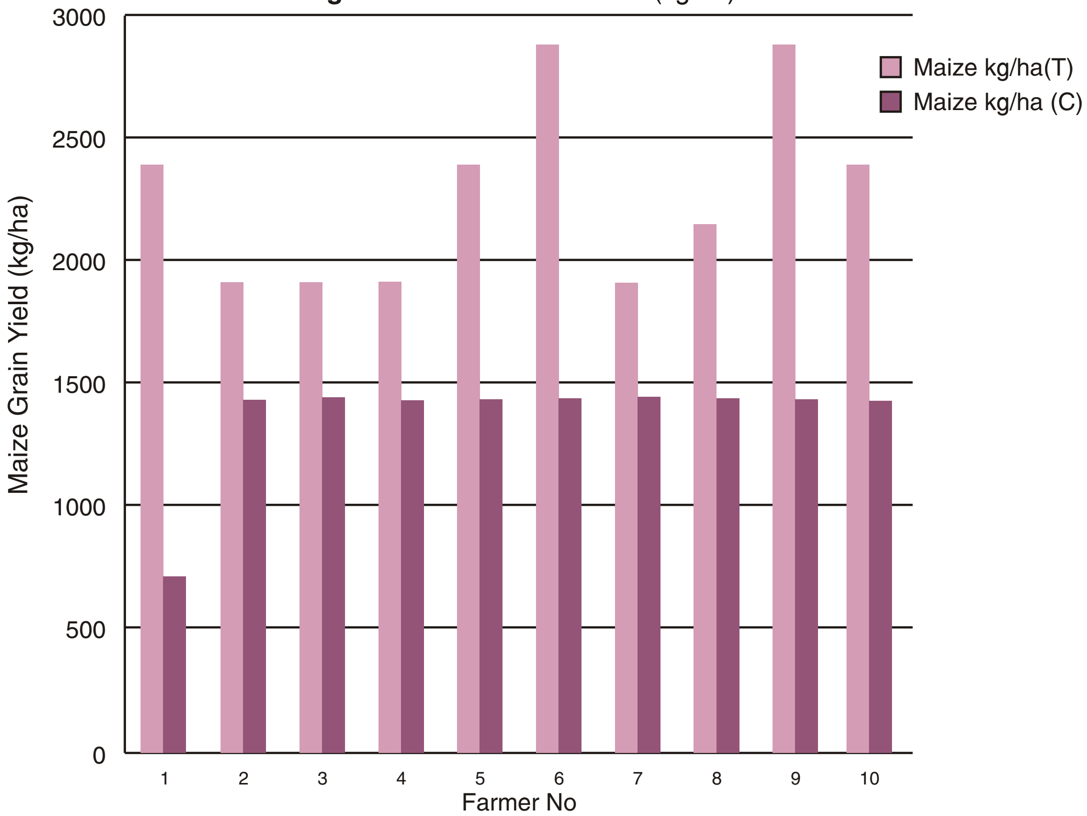
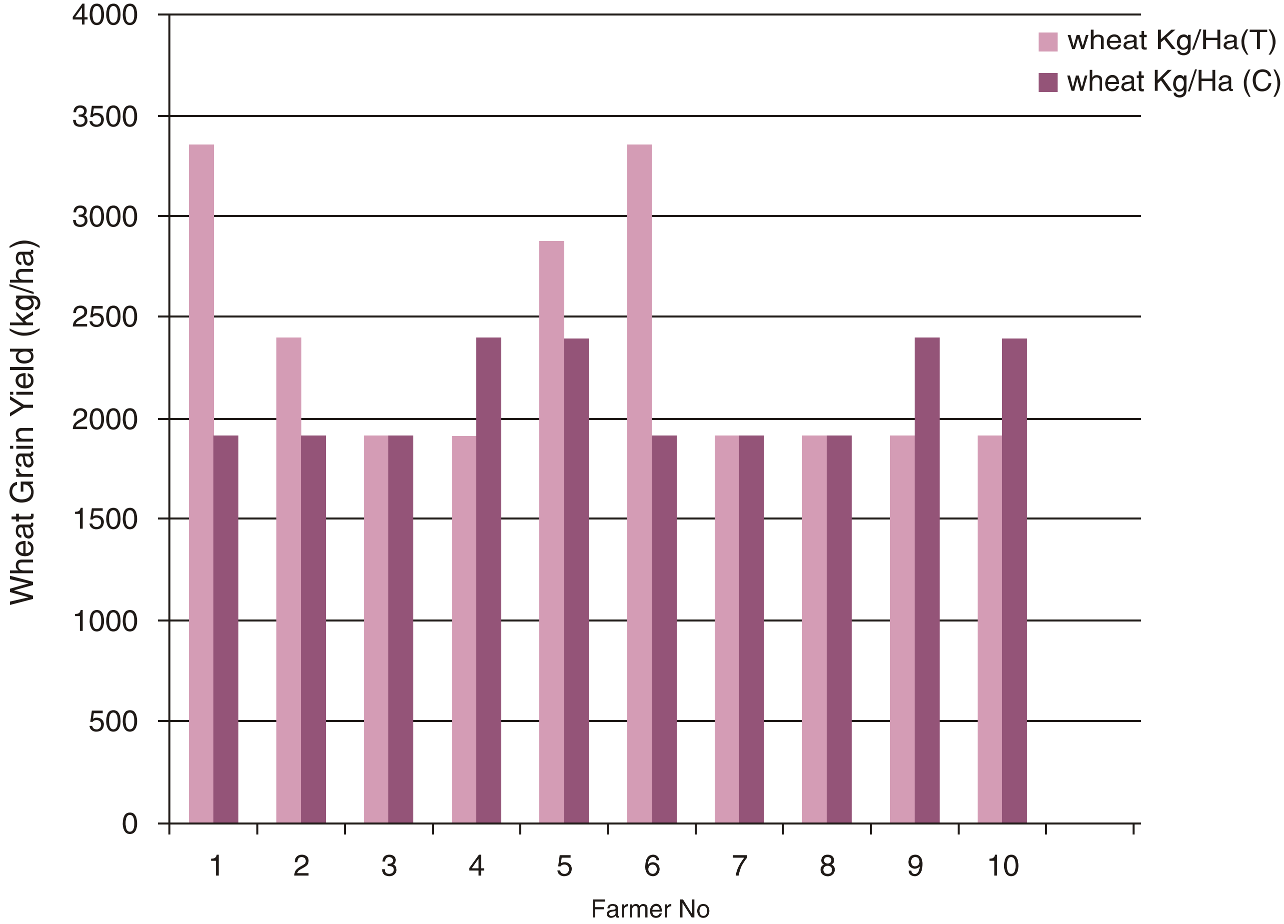
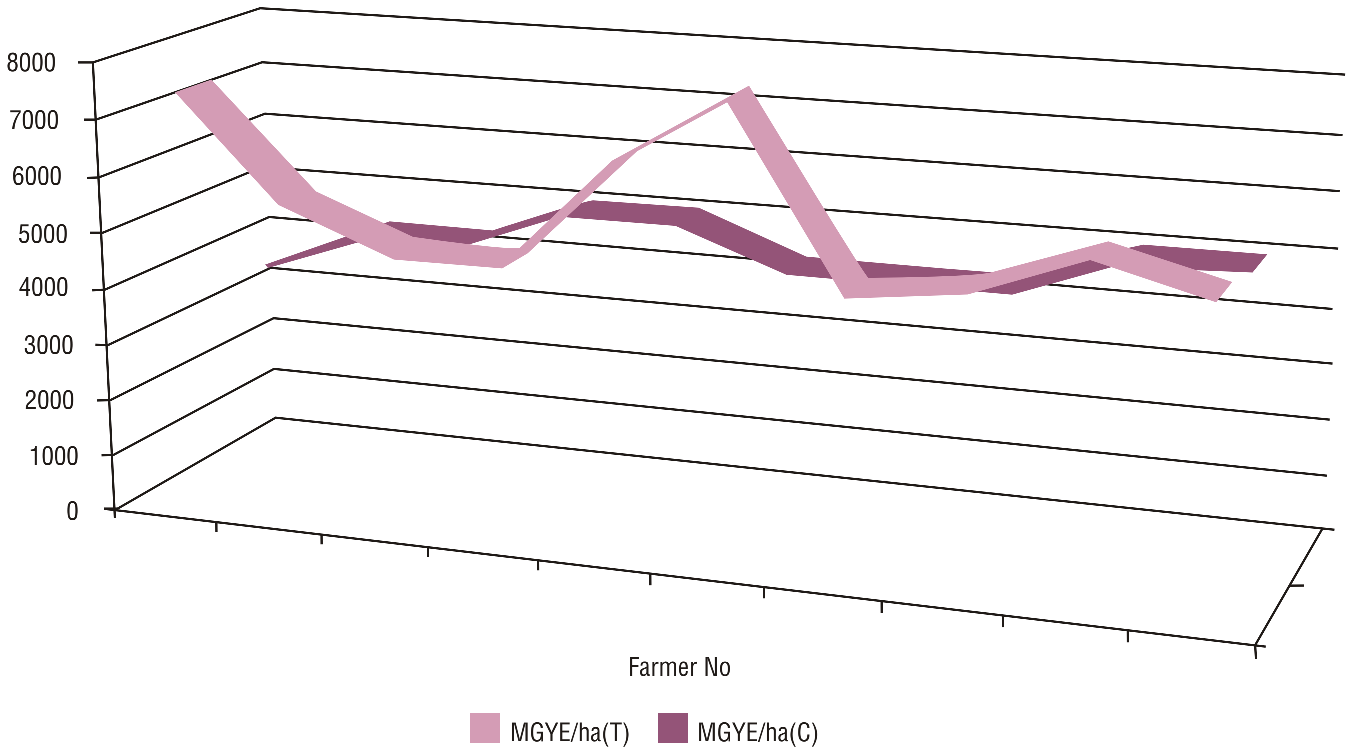


Figure 12: Wheat Grain Yield (kg/ha)



The perusal of the graphs in Fig.11 & 12 reveal that the yield difference between Agro-met and Control farmers is larger for maize grain yield, while it is relatively lesser for wheat grain yield. The maize grain yield equivalent drawn for both Agro-met and Control farmer is given in Fig.13.

Figure 13: Maize Grain Yield Equivalent (kg/ha)



The information from Fig.13 reveals that the difference that was noticed in respect of maize grain yield between Agro-met and Control farmers can also be seen in this parameter also.

The scattered diagram drawn for maize grain yield equivalent for the ten farmers of Agro-met and Controlled is given in Fig.14 & 15.

Figure 14: Maize Grain Yield Equivalent (kg/ha)-T

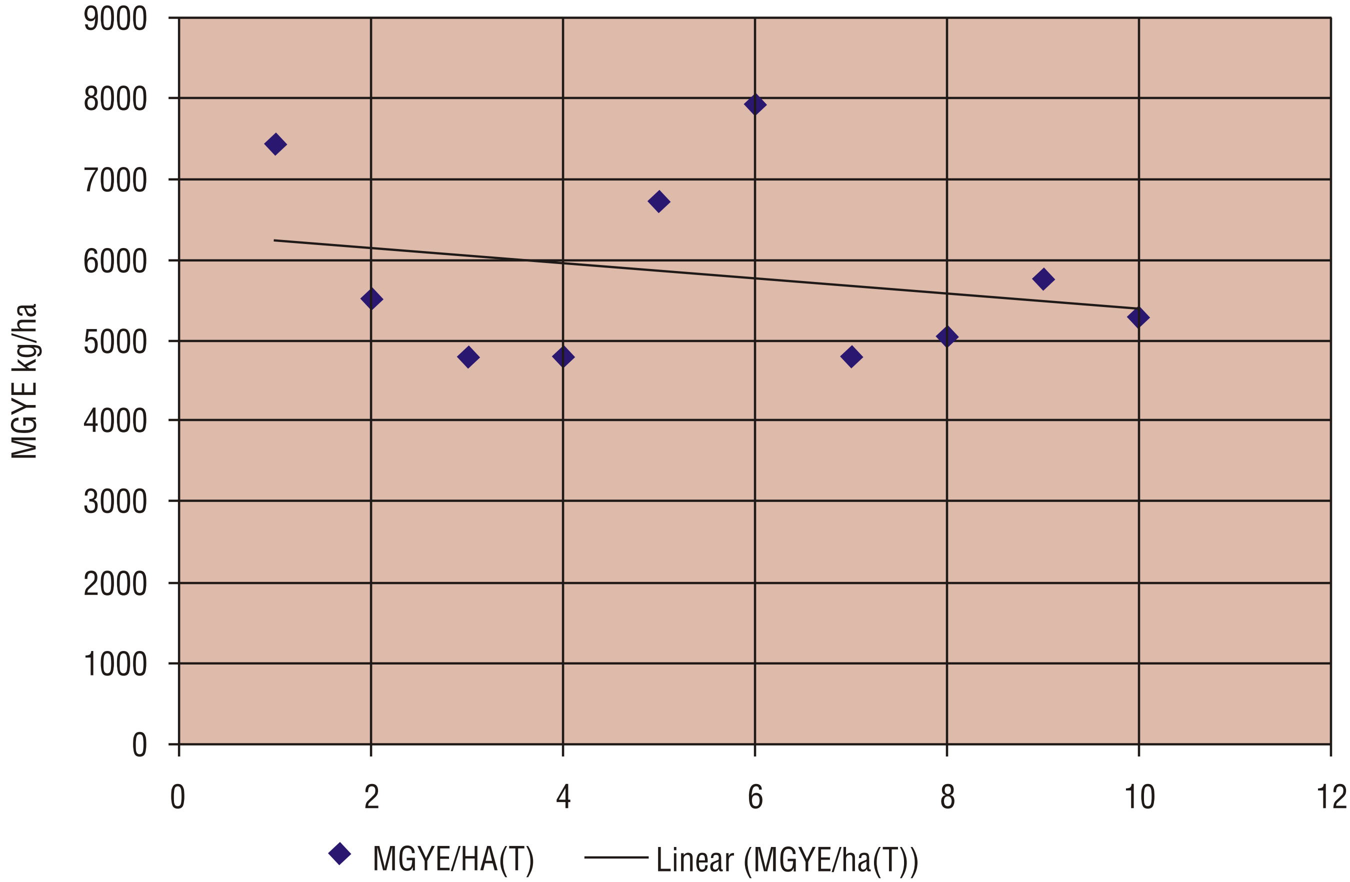
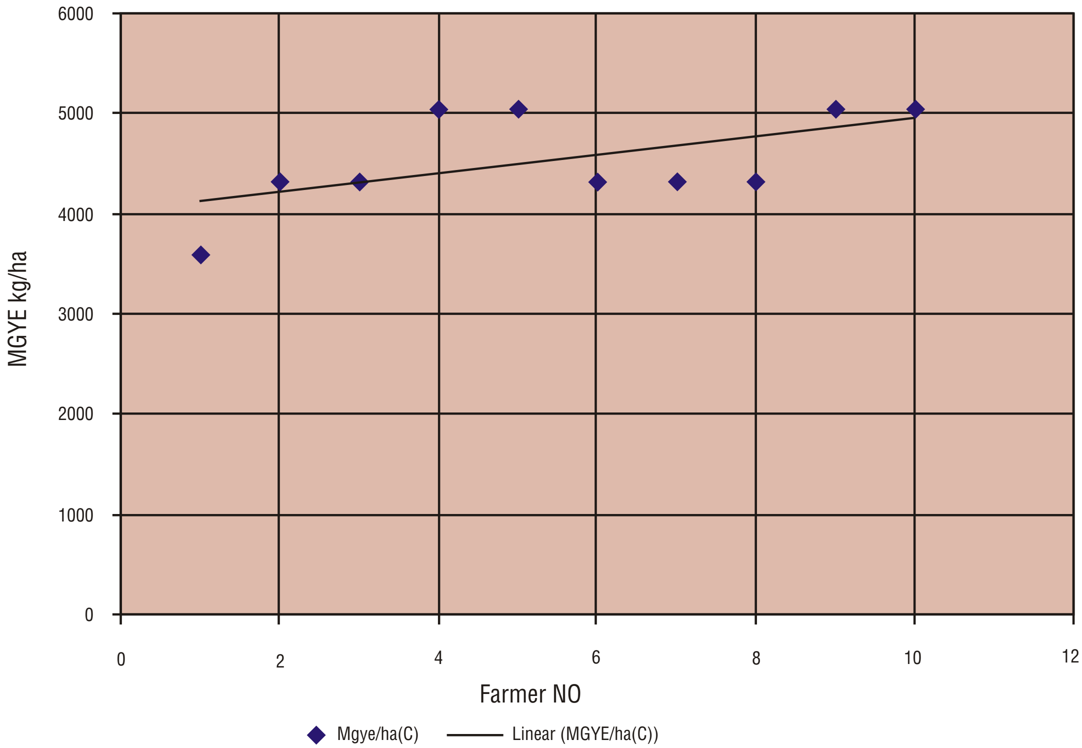


Figure 15: Maize Grain Yield Equivalent (kg/ha)-C



The maize grain yield, wheat grain yield and maize grain equivalent yield recorded by the two groups of farmers are presented in the Table 2.

Table 2: Mean grain yield of maize, wheat and maize grain yield equivalent yield (kg/ha)

Particulars	Agro-met farmers (T)	Control farmers (C)	Per cent of increase
Maize grain yield	2280 (17%)	1368 (17%)	66.0
Wheat grain yield	2352 (26%)	2112 (12%)	11.0
Maize grain equivalent yield	5808 (20%)	4536 (11%)	28.0
Maize stalk yield	1776	1536	16.0
Wheat straw yield	2064	1824	13.0
Figures in parenthesis indicate the coefficient of variation for the data set.			

From the data of the Table 2, it is observed that the mean yield increase for the Agro-met farmers (T) was

66 per cent for maize grain yield, 11 per cent for wheat grain yield and 28 per cent for maize *grain equivalent yield* over the control farmers (C). It is interesting to observe that the first crop maize yield increase was *six times* that of the second crop, wheat for the agro-met farmers (T). The Agro-met farmers took up sowing with enough soil moisture as a result of sufficient rainfall and this might have maintained the required maize plant population per unit area as compared to the control farmers. This was the reason for higher yield obtained by the farmers under "T" group. In respect of the second wheat crop the yield increase obtained by the T group farmers was 1/6th of the increased yield obtained from maize crop, since the wheat crop was raised with irrigation and sown by the farmers by the mid of November by the two groups studied. Five irrigations were administered by the control farmers (C) for wheat crop, while it was four irrigations for the agro-met farmers (T). Under the cropping system of maize-wheat, the agro-met farmers (T) did save one-irrigation for their second crop of wheat as compared to the control farmers, because of the weather based farm decisions for the management of the cropping system. Though there was one irrigation less for wheat for the "T" group farmers, the yield was not compromised. On the contrary, there was an increase in yield up to 11 per cent. The Coefficient of Variation (CV) obtained for the data set also confirmed this variation.

5.1.4. Economic Analysis

Assessing the economic viability of a cropping system is very important for effective comparison, in addition to assessing for technical feasibility and socio-cultural acceptability. The economic analysis of the cropping system for the agro-met and control farmers is furnished in Tables 3 to 5.

Table 3: Enterprise budgeting of the Cropping System (INR/ha)

Particulars	Agro-met farmer (T)	Control farmer (C)
Total return from maize grain	18240.00	10944.00
Total return from maize stalk yield	3552.00	3072.00
Total return from maize crop	21792.00	14016.00
Total return from wheat grain	28224.00	25344.00
Total return from wheat straw yield	8256.00	7296.00
Total return from wheat crop	36480.00	32640.00
Total return from the cropping system of maize-wheat	58272.00	46656.00
Cost of cultivation for maize / ha	20880.00	20880.00
Cost of cultivation for wheat / ha	27360.00	27360.00
Total cost of the cultivation of the cropping system of maize-wheat	48240.00	48240.00
Net return from maize/ha	912.00	(-) 6864.00
Net return from wheat/ha	9120.00	5280.00
Total net return from the cropping system of maize-wheat	10032.00	(--) 1584.00

* Maize Grain Rs.8/kg; Wheat Grain Rs.12/kg; Maize Stalk Rs.2/kg; Wheat Straw Rs.4/-kg

The result from the Table 3 indicate that the agro-met farmer group (T) could get a total return of Rs 58,272 from one hectare of the said cropping system of maize-wheat at a total invested cost of Rs 48,240 and this translates into a Benefit-Cost (BC) ratio of 1.2 while the BC ratio for control farmer group is 0.96. This indicates the non viability of the cropping system management by the control farmers. The Return above Variable Cost (RAVC) is provided in Table 4.

Table 4: RAVC (INR / ha)

Particulars	Agro-met farmer (T)	Control farmer (C)
Total return of the cropping system	58272.00	46656.00
Total variable cost	48240.00	48240.00
Return above variable cost	10032.00	(-) 1584.00

The total variable cost of the agro-met (T) and control (C) farmer group is the same, since in the case of agro-met group the farm decision is either postponed or advanced based on the weather information and the decision is always flexible with the weather. The RAVC for the agro-met farmer group for the cropping system is Rs 10,032, while it is negative for the control group farmers.

The partial budget drawn between the two groups for weather based farm decision is given in Table 5.

Table 5: Partial budgeting (INR/ha) for comparing (T) vs (C) group farmers

A	B
(i) Added cost Rs.0	Added return Rs.11616.00
(ii) Reduced return Rs.0	Reduced cost Rs.0
Sub-total A: Rs.0	**Sub-total B: Rs.11616.00**
Estimated change (B-A) = 11616.00 0 = Rs.11616.00	

The result from partial budgeting indicates that by adopting weather based farm decisions for the cropping system of maize-wheat, the 'T' group farmer could get Rs 11,616 as an estimated positive change as compared to the farmers of group C.

5.1.5. SWOT Analysis

The SWOT analysis is carried out for mini agro-met observatory and presented in Table 6.

Table 6: SWOT Analysis for the mini agro-meteorological observatory

Strength	Weakness	Opportunity	Threat
• Real time weather data available to the farmers • Helps in enhanced farm decision making • Helps to reduce climatic risks • Increased income and enhanced livelihood to the farmers	• Weather prediction not possible • Local politics affect the functioning • Lack of automatic weather sensors • Lack of trust on the inputs provided by the "Climate Risk Managers".	• Scaling up of mini observatories in all the villages of the project district • Provide real time weather data to the farming communities across the country • Community preparedness to meet the malevolent weather • Spreading the weather message to neighborhood village	• Lack of resources for the maintenance of the agro-met facility after the project period • Uncertainty of monetary support to the "Climate Risk Managers" after the project period • Physical damage to the instruments by weather, people and animals

The analysis shows that the agro-meteorology observatories gave real time weather data to the farmers and they can make farm decisions wisely to improve their farm income and livelihood by avoiding climatic risks (Strength). With smart farm decisions using the weather data, the farmers can save precious time and resources. Since the data can be collected locally, the farmers' confidence on the data and information are high. The limitations include the inability to forecast weather for a long period of time with the data generated, the danger of local politics as most often the resources and decision making power are vested with the party in power which has some spillover effect on the maintenance of the agro met centre and other interventions taken up under the V&A programme in the respective villages, and some lingering skepticism about the advice provided by the 'Climate Risk Managers'.

However, opportunities exist to establish many such mini agro-meteorology observatories in all villages of the country and farmers could benefit immensely by using the locally generated daily weather data for their day-to-day farming activities. This information could be communicated to neighborhood villages through a small cadre of "weather messengers". Finding resources for the maintenance of the agro-met facility, providing monetary support to the Climate Risk Managers beyond the project period and the physical damage caused by children and animals to the observatory are some of the problems.

6. Key lessons and implications from the case study experience

The results of the case study indicate that there is greater scope to stabilise farm income if crop management is practiced based on weather information. In other words, weather based farm decisions always sustain crop productivity and farm income. The key lessons from the case study are captured as follows:

- Farmers should unite as a group and take farm decisions based on weather data from the local observatory, after thorough discussions among themselves. The existing mechanism of "Smart Farmers' Club" could play a critical role in this process.
- Climate Risk Manager should come forward to take the responsibility of preparing and communicating the agro advisories on a regular basis.
- Inculcating climate / weather consciousness among the community will enable achieving maximum benefit from weather based farm decisions.
- Climate Risk Managers need periodical training (both pre and post season).
- Motivation of the local communities is vital. The demonstration effect particularly from the gains of practicing weather based farming will be crucial.
- Strengthening local institutions like the Smart Farmers' Club (SFC), is vital to support weather based farming at the community level.
- Though formal dissemination mechanisms like the Village Knowledge Centers (VKC) is generally agreed to be a vital mechanism to help leapfrog the communication process, this requirement may not be applicable in all circumstances. There are additional aspects to be considered such as the terrain, local capacities, technology and inter-institutional relationship etc., which are key factors

for the success of the dissemination process.

- In the climate change context, agro-met is one of the most valuable adaptation options at the local level.

7. Limitations of the study

The study is limited to a small group of farmers chosen from a village. The effectiveness of agro-met as an 'adaptation option' is amply demonstrated at a micro-level. Scaling up is an issue that need serious consideration. The study should be further extended both temporally (across time periods) and spatially (across agro-climatic zones) and across different cropping systems and crops, to bring more perspectives on the functional aspects. Training is critical in generating and interpreting relevant weather information suitable for local farming conditions. The motivation of the climate risk managers should be sustained and the willingness to constantly update his/her knowledge base is very important. The envisaged linkage of agro-met observatory with village knowledge center would have made the endeavor more meaningful and the reach of information wider.

8. Conclusions

The village level agro-met observatory and the utility value of such small infrastructure has been adequately demonstrated as an effective climate change adaptation tool in the context of managing climate risks at the local level. In this sense the case study result is an eye opener to all concerned, including development practitioners, researchers, NGOs, rural communities etc. It was established through the case study that weather based farm decisions indeed lead to profitable agriculture without substantial additional investment. As a pilot effort the case study has provided some valuable clues and pointers. Up-scaling and exploring avenue for convergence with ongoing government efforts is vital for wider reach of the benefits. The case study will serve as a good example of community based adaptation and has a larger implication for the National Mission for Sustainable Agriculture and other National Missions, as a workable model under the National Action Plan on Climate Change.

9. References:

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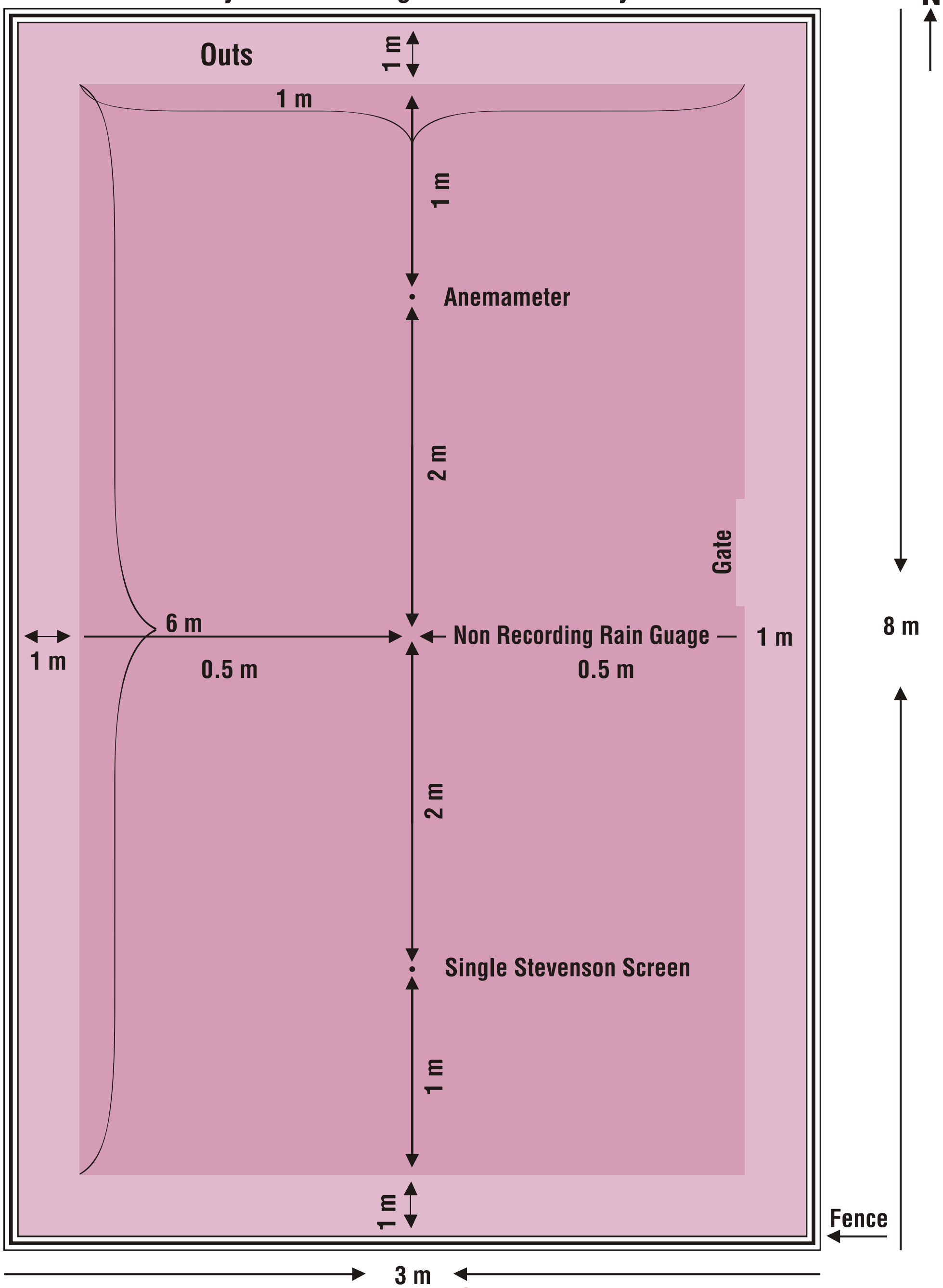
Annexure I

Layout for Mini Agromet Observatory



Layout designed and tested at different places at Coimbatore by Prof.Dr. T.N. Balasubramanian, Prof. & Head, Dept. of Agricultural Meteorology, TNAU, during 2000 and found suitable

(A) Weather Based Farm Decision Making Tool

Annexure II

I. Rainfall

Rainfall amount received (mm)	Farm Decisions
50 mm	Postpone irrigation
25 to 50 mm (continuously for two to three days)	Sowing can be taken up under dry land / rainfed situation
12 to 15 mm	Fertiliser application under dry land can be done
10 to 12 mm	Hand weeding and hoeing can be done

Don't spray chemical pesticides when it rains. Occurrence of rain one hour after pesticide chemical application may not affect the efficacy of the chemical sprayed. Similarly application of pesticide one hour after rain may enhance pesticide effect, but soil must be amenable for walking for application.

(B) A Tool for Short Range Forecast

II. Wind Speed

Wind Speed km / hour (kmph)	Farm Decisions
< 5 kmph	Pesticide application and dusting can be done
> 30 kmph	Propping to sugarcane and banana must be done; irrigation interval gets reduced and hence demands more irrigation water

III. Temperature

Temperature (0c)	Farm Decisions
Seasonal temperature > 32^{0}c / day and continues for a week	Systemic insecticide application against sucking pest
Seasonal temperature < 20^{0}c / day and continued for a week	Systemic fungicides application against diseases

IV. Relative Humidity (RH), Temperature, and Cloud Cover

RH, Temp and cloud cover	Farm Decisions
Evening RH > 60 per cent for a week with minimum temperature < 20^{0}C	Plan for fungicides application
Overcast cloud cover for a week	Plan for management of Brown Plant Hopper (BPH)

From June to September and also from April to May it is possible to develop short range/ now cast based on the afternoon agro-met reading whether it will rain or not on the day of observation with 55 per cent probability.

For getting rain ***(55 % P):***

1. Afternoon RH must be > 60 per cent
2. Wind speed must be < 5 kmph
3. The maximum temperature of the day must be > 30 degree C
4. The minimum temperature must be > 20 degree C

Questionnaire to assess the importance of weather based decision (Kundai Village) **Annexure III**

Objective: At Kundai village during June / July 2008, with the receipt of 50 mm rain, certain farmers went for maize sowing in the cropping system of maize-wheat in dry land / rainfed land / partly irrigated land. These farmers did harvest higher maize grain yield and could sow the second crop of wheat in time with lesser irrigation water.

Hence, this questionnaire is designed to examine the merits of this agreement of the agro-met information based farming as against the regular farmers (Control Unit).

No. of farmers to be interviewed under early sowing with rainfall (Agro-met) : 10

No. of farmers to be interviewed under control (Control) : 10

Questionnaire

1. Name of the farmer and address

I Crop- Maize

2. Whether s/he belongs to early sown group (A) or control group (B) (pl. tick any one)
3. No. of acres sown under maize
4. Maize variety / hybrid sown (with Name) and its duration
5. Date of sowing of maize crop
6. What motivated you for this early or delayed sowing of maize crop?
7. Was it based on agro-met data or interpersonal communication?
8. Whether fertiliser applied or no to maize crop?
9. Whether pesticide applied or not to maize crop?
10. Important pest and disease noticed in maize crop
11. Was there any life saving irrigation given to maize due to dry spell during maize season?
12. If so no. of irrigation given
13. Source of irrigation
14. Total rainfall received from sowing to harvest of maize
15. No of the rainy days for this rain amount received (Rainy day is equal to a day with > or = 2.5 mm rainfall)
16. Date of harvest of maize
17. Maize grain yield obtained (after drying) ------------------ kg/ acre
18. Stalk yield obtained --- kg/acre
19. Cost of cultivation / acre (Rs)
20. Total income / acre (Rs)

21. Net income / acre (Rs)
22. Any input saved and if so details with name and quantity?

II Crop- Wheat

23. Variety of wheat and its duration sown after the harvest of maize
24. No. of acres sown under wheat
25. Date of sowing of wheat crop
26. Whether fertiliser applied or no to wheat crop?
27. Whether pesticide applied or not to wheat crop?
28. Important pest and disease noticed in wheat crop
29. Was there any saving of irrigation given to wheat because of early planting of wheat after maize
30. If so no. of irrigation saved
31. Source of irrigation
32. Total rainfall received from sowing to harvest of wheat
33. No of the rainy days for this rain amount received (Rainy day is equal to a day with > or = 2.5 mm rainfall)

33 a. whether frost occurred?

33 b. if occurred, how many times?

33 c. any loss noted

34. Date of harvest of wheat
35. wheat grain yield obtained (after drying) ------------------ kg/ acre
36. Stalk yield obtained --- kg/acre
37. Cost of cultivation / acre (Rs)
38. Total income / acre (Rs)
39. Net income / acre (Rs)
40. Any input saved and if so details with name and quantity
41. over all response of the farmer
42. Interviewer remarks on the observations made

Case Studies:

Vulnerability Assessment and Enhancing Adaptive Capacity to Climate Change in Semi Arid Regions of India (V&A) Programme