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Invited Article

Climate Change- Weather Health Indices As Tools and Services in Agriculture

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Farmers are the back-bone of India and the entire nation depends on them for food requirements. However, when the farmers lose confidence in their noble profession and resort to extreme steps like suicides, surmounting of this tragedy will be a daunting task for policy makers. In India 11, 772 farmers committed suicides. Of which the state wide incidents include, Maharastra - 3146 (26.72%); Andhra Pradesh- 2014 (17.10%); Madhya Pradesh- 1090 (9.25%); Karnataka 1403 (11.19%) and other states - 4119 (38.02%). At the same time one of the major challenges the human kind facing is to provide an equitable standard of living for the current and future generations: adequate food, water, energy, safety, shelter and a healthy environment. Human induced climate change and increasing climate variability as well as other global environmental issues such as land degradation, loss of biological diversity, increasing pollution of the atmosphere and fresh water and stratospheric ozone depletion threaten human ability to meet these needs. Therefore, the science of climate change and variability and their likely impacts on agriculture assumed significance.

Definitions

Climate Change: Climate change is defined as 'A change is the state of the climate that can be identified by changes in the mean and or the variability of its properties and that persists for an extended period typically decades or longer".

The climate change may be due to:

- Natural internal processes
- External forcings
- Persistent anthropogenic changes

Any one or combination of the above processes cause changes in the composition of atmosphere or land use (Murthy 1996).

Climate variability: Climate variability is defined as "Variations in the mean state and other statistics of the climate on all temporal and spatial scales beyond that of individual weather events".

The climate variability may be due to:

- Natural internal processes within the climate system (internal variability)
- Variations in natural or anthropogenic external forcings (external variability) .

Climate change - Global Processes and Effects

I. Human activities

A. Land Use Change

(a) Urbanization
(b) Deforestation
(c) Land conversion to agriculture
(d) Increase in impermeable surface

B. Fossil fuel burning

A. Industry
- Chemicals
- Cement

B. Energy production
- Heating
- Electricity
- Power plants

C. Transport
- Plane traffic
- Shipping freight
- Trucking freight
- Cars

D. Agriculture
- Fertilizers
- Chemicals

II. Climate Change Processes:

A. Enhanced Greenhouse effect
- Carbon cycle disturbances
- CO_2
- CH_4
- N_2O

A. Global Warming (average temperature rise)
(a) Ice Caps melting (Sea level rise)
(b) Precipitation changes

(c) Cloud cover changes
(d) Ocean circulation upheaval
- Salinity
- Water temperature

(e) Gulf stream modification
(f) Monsoon disturbances

III. Disasters

A. Environmental refugees
- Droughts
- Cyclones
- Floods
- Tsunami
- Wild fire

B. Biodiversity losses
- Coastal wetlands disappearing
- Coral bleaching

C. Casualties
D. Economic losses
E. Diseases spread
- Infectious diseases (vector change)
- Diarrhea
- Cardio-respiratory diseases

F. Subsistence farming and fishing at stake
- Malnutrition
- Traditional lifestyles
- Coastal wetlands disappearing

Temperature changes on the Earth

Instrumental observations over the past 157 years show that temperatures at the surface have risen globally, with important regional variations. For the global average, warming in the last century has occurred in two phases, from the 1910s to the 1940s (0.35°C), and more strongly from the 1970s to the present (0.55°C). An increasing rate of warming has taken place over the last 25 years, and 11 of the 12 warmest years on record have occurred in the past 12 years. Above the surface, global observations since the late 1950s show that the troposphere (up to about 10 km) has warmed at a slightly greater rate than the surface, while the stratosphere (about 10-30 km) has cooled markedly since 1979. This is in accord with physical expectations and most model results. Confirmation of global warming comes from warming of the oceans, rising sea levels, glaciers melting, sea ice retreating in the Arctic and diminished snow cover in the Northern Hemisphere.

Precipitation Changes on Earth

Observations show that changes are occurring in the amount, intensity, frequency and type of precipitation. These aspects of precipitation generally exhibit large natural variability, and El Nino and changes in atmospheric circulation patterns such as the North Atlantic Oscillation have a substantial influence. Pronounced long-term trends from 1900 to 2005 have been observed in precipitation amount in some places: significantly wetter in eastern North and South America, northern Europe and northern and central Asia, but drier in the Sahel, southern Africa, the Mediterranean and southern Asia. More precipitation now falls as rain rather than snow in northern regions. Widespread increases in heavy precipitation events have been observed, even in places where total amounts have decreased. These changes are associated with increased water vapour in the atmosphere arising from the warming of the world's oceans, especially at lower latitudes.

Changes in Extreme Events (Heat waves, Droughts, Floods and Hurricanes)

Since 1950, the number of heat waves increased and widespread increases have occurred in the numbers of warm nights. The extent of regions affected by droughts has also increased as precipitation over land has marginally decreased while evaporation has increased due to warmer conditions (Murthy 1999) . Generally, heavy daily precipitation events that lead to flooding have increased. Tropical storm and hurricane frequencies vary considerably from year to year, but evidence suggests substantial increases in intensity and duration since the 1970s. In the extra-tropics, variations in tracks and intensity of storms reflect variations in major features of the atmospheric circulation, such as the North Atlantic Oscillation.

A prominent indication of a change in extremes is the observed evidence of increases in heavy precipitation events over the mid-latitudes in the last 50 years, even in places where mean precipitation amounts are not increasing. For heavy precipitation events, increasing trends are reported as well.

Sea Level- Rising

There is strong evidence that global sea level gradually rose in the 20th century and is currently rising at an increased rate, after a period of little change between AD 0 and AD 1900. Sea level is projected to rise at an even greater rate in this century. The two major causes of global sea level rise are thermal expansion of the oceans (water expands as it warms) and the loss of land-based ice due to increased melting. Satellite observations available since the early 1990s provide more accurate sea level data with nearly global coverage. This decade-long satellite altimetry data set shows that since 1993, sea level has been rising at a rate of around 3 mm yr^{-1}, significantly higher than the average during the previous half century. Coastal tide gauge measurements confirm this observation. Global sea level is projected to rise during the 21st century at a greater rate than during 1961 to 2003.

The scenario in Andhra Pradesh

Climate change is inevitable. It is happening. It is visibly seen in polar regions. More so, near coasts it is impacting agriculture. A.P. is one of the few States in India that have vast coast line. Climate change and variability must be studied in relation to their influence on agriculture on priority in A.P. The State of Andhra Pradesh is bifurcated on 2nd June, 2014 and 13 Districts (9 coastal and 4 Rayalaseema) are allotted to A.P. These 13 districts are broadly located in area extending from 12.37 to 19.54 North Latitude and 76.50 to 84.54 East Longitude. The State has 6 agro climatic-zones. The Krishna zone and Godavari zone are together called "*the bejeweled rice bowl of India" and "Annapurna*". The North Coastal zone is primarily agrarian and the soils are red with clay base. Rice, millets and sugarcane are the main crops. In Southern zone and the scarce rainfall zones the principal crop is groundnut. Even though rice is the main crop in high altitude and tribal zone the millets and mesta are also cultivated. In addition, animal rearing, fisheries and dairying also provide income to the farmers. However, every district and agro-climatic zone are negatively impacted by weather related disasters viz., droughts, floods, cyclones etc (Murthy 2003).

During the decade of 2004-2014 the crops in all the districts faced number of weather disasters and problems and farmers suffered declined crop yields, widening yield gaps in comparison with best yields in the country, associated with climate change and variability. The cost of cultivation of rice increased from Rs.22,500/ha in 2004 to 65,500/ha in 2014 (Murthy 2016). The farmers are in deep distress due to failures of crops and heavy indebtedness. Therefore, they are committing suicides. The number of suicides from 1994 to 2003 was 310 whereas from 2004 to 2014 they were 1,943.Economic losses related to extreme weather events viz., droughts, floods, cyclones etc., have raised 3-4 folds in A.P. over the past 20 years. Due to weather calamities, in the last six years (2008-09 to 2013- 14) an area of 15.16 lakh ha was affected in 13 districts of newly formed Andhra Pradesh indicating that seventy five percent of the area is prone to natural calamities. The goal of achieving the climate resilient and enhanced crop yields has become a big challenge due to climate change and variability. In addition, the use of ICTs and weather based decision support systems is the lowest in agriculture in Andhra Pradesh. Due to the insecure conditions and increasing uncertainty and un-sustainability of crop production, the younger generations are not coming forward to take up agriculture as a profession. This problem must be tackled. One of the best attempts could be developing weather/ climate related technologies and making available the same to the farmers and all stake holders of agriculture in the State (Murthy 2016).

Research findings

A pioneering and trend setting weather based technology was developed by the scientists of IARI to predict the incidence of mustard aphid in which farmers and policy makers are getting immensely benefited. It was also observed that semi-log equations are best suited mathematical/ statistical techniques in explaining the relationship between yield and pest incidence. The quantitative district level forecast up to 5 days now being in use is a wonderful beginning in 2008 by IMD. The weather parameters covered are seven and weekly cumulative rainfall forecast is also provided. The value addition done by RMC and MC are also very good. The ANGRAU is additionally providing information on management of crops/ animals.. There is a need to further add value by integrating

agromet advisory with ADMIS and creating additional awareness among all stakeholders of the information. It is also appropriate to involve students of agriculture and agricultural polytechnics in the whole process.

Research results indicate that the cost of cultivation of crops could be reduced by 10% and enhancement of quality by 2 % when farmers are sensitized to use weather as a non monetary input in all agricultural operations (Murthy and Reddy, 2009). This clearly indicates that capacity of the farmers and all stake holders of crop production in A.P. have to be enhanced through roving seminars on "Weather- Climate- Farmers". Towards this direction, the first step is that the scientists must develop and provide the weather based technologies that strengthen the hands of farmers. These technologies shall not only be cost effective but also protect their agricultural production environment and resource base from degradation. At the same time these technologies must reach the farmers through modern means *viz.,* weather based ICTs for speedy and effective utilization by them in which the roving seminars play a key role. Therefore, building weather based ICT for the State is the need of the hour to prepare farmers and all stake holders of agriculture to respond appropriately to these events.

Weather elements- Crop production

The economy of any nation, more so the under developed and developing countries depend largely on the amount and distribution of *rainfall* received every year. This is a very valuable agricultural input because rainfall is the major source of water which is essential for plant growth and development. However, rainfall is considered adverse when a) Excess b) Scanty and c) Untimely. The excessive amounts of water in the soil alter various chemical and biophysical processes. Free movement of oxygen is blocked and compounds toxic to the roots are formed, due to drainage problem. Soils with high rate of percolation are unsuitable for cultivation as plant nutrients can be removed rapidly. Heavy rains directly damage plants on impact or interfere with flowering and pollination. Top soil layers are packed or hardened which delays or prevents emergence of tender seedlings. Floods submerge crops, silt-up fields, tank bunds and river embankments are washed off. The scanty rainfall is synonym with "Inadequate rainfall" or "Drought". The influence of drought can be observed not only on phenology but also on phenophases of crop plants. Water limitation from seedling emergence to maturity in all the cereals is very damaging. Water stress/ drought during flowering reduces the size of inflorescence, effect fertilization, grain filling and reduce final yield. Plants show wilting symptoms. Cell division and enlargement are very sensitive to drought stress, which results in stunted growth. Untimely rains refer to rainfall received too early or too late in the season with the result that normal agricultural operations are upset. Too early rains do not permit proper preparation of seedbed due to heavy rains. Too late rains delay sowings and pest and disease attack cause colossal losses. Wet spells during flowering and harvesting result in poor fertilization and subsequent loss in yield.

Solar radiation is the prime most weather element that influences the agriculture. It controls the organic life by heating the earth and atmosphere and also provides the energy required in photosynthesis for the conversion of carbon dioxide and water into primary source of food (carbohydrates). It was found that photoperiod influences the flowering and growth of shoots in cereal crops. However, it was emphasized that cloudy weather and defective insulation results in risks like retardation of crop growth, pollen burst and flower drop in soybean. These findings are in conformity with research on cereals, pulses and oilseed crops in western India. However, the excessively cloudy weather during wet season is often considered a serious limiting factor for rice production (Murthy *et al.,* 2002).

Air temperature influences rates of biochemical reactions in crops (approximately double with each 10°C rise in temperature) leaf production, expansion and flowering. The agro-meteorological studies on *soil temperature* are primarily conducted to know its influence on crop production. It was concluded in India that both cold and heat waves and abnormal soil temperatures are risks to crop growth and development.

Humidity is an important factor in crop production and is closely related to rainfall and temperature. It is of great importance in determining the vegetation of a region and affects the internal water potential of plants there by

determine the water requirement of crops. Very high or very low relative humidity is not conducive for higher yields.

The significance of *wind* on crops and animals was reported by several authors and it was reported that the moderate *wind turbulence* promotes the consumption of carbondioxide in photosynthesis and prevents frost by disrupting the temperature inversion. It was reported in Coimbatore that wind is the most important factor for the dispersal and migration of some insects into an altogether new area. Wind dispersal of pollen and seeds is natural and necessary for both agricultural crops and natural vegetation. Studies on harmful effects of winds in eastern India indicated that at sustained high speeds (12-15 m S-1) the plants assume a low and dwarf like form, whilst the intermittent high wind speeds results in gales, hurricanes *etc*., and damage fully established orchard crops. Under these higher wind speeds the shape of the orchard trees alter giving rise to the characteristic wind shaping of trees in exposed positions. Leaves become smaller and thicker. Breakage occurs and bushes and trees subjected to natural (seasonal) pruning. The direct mechanical risks of wind are the breaking of plant structures, lodging of cereal crops, and shattering of seed from panicles.

Weather Health

The association among "soil" "plant" and "weather (atmosphere)" by virtue of a common process or component in agricultural crop production is known as "soil-plant- weather continuum". For agricultural purposes, "soil" is defined as "A dynamic natural body or the solid portion on the surface of the earth in which plants grow". Agricultural crop is defined as "Plants carefully selected and developed over many years and sown on cultivable land to produce food for humans, animals, materials etc". The term "weather" is defined as a state or condition of the atmosphere at a particular place and given instant of time. Crop production strategies involve all these three components.

Murthy's "Weather Health" Concept

In "soil-plant- weather -continuum" both soil and plant contain "water" and "air". It was established that these two have "life" and scientific terms "soil health" and "plant health" are in vogue. However, both "water" and "air" are "weather elements". Therefore, weather has "life" and "weather health" for crop production is defined as "The potential force through which weather elements perform their several and cooperative functions optimally for better crop health to produce potential yields". It was observed that to further determine that weather has "life" there by "Health" all the weather elements have:

- Characteristic state or condition
- Constitute existence
- Participate and facilitate metabolism, growth, reproduction etc.
- Responsive to stimuli

***The hypothesis*:** Weather has "life" there by "health". If the weather health is good/ optimum, then optimum agricultural crop yields are possible and vice- versa.

Murthy's "Daily Weather and Agriculture" Concept

To observe the "weather health" the "daily weather and agriculture" concept can successfully be used which is both an agricultural meteorological "tool" and "service". In this concept the farmers observe "weather health" as follows:

· They collect daily weather data available in the news papers along with pictorial diagrams and paste on white sheets chronologically.

· In addition, the farmers also obtain information on weather from radio, television, internet, mobile telephones etc., (where ever available) and record the same at appropriate points on the white sheets and observe its influence on crops. After observing the trends of weather and its influence on crops the "Weather health" is determined. Based on "Weather health" the management options for all agricultural operations viz., ploughing, fertilizer application, sowing, inter-cultivation, spraying of chemicals, top dressing of fertilizers, etc., will be adopted by the farmers. Enough recommendations are made available in the book entitled "Weather- Agriculture", "Technical handouts" etc., in local language.

This operational agricultural meteorological tool and service involves "no money" because the news papers are bought by the farmers/villagers for learning and enriching themselves on several

issues (political, entertainment, medical etc.). In Asia daily news papers are very inexpensive.

Murthy's Comparison Concept

The Comparison Concept takes into account the past 7-10 days of weather as also the forecast for 7-10 days issued, their (past and forecast) derived parameters (GDD/HTU/PTU) as the basis for forewarning. These derived parameters are compared with the scenarios of past seasons or years and a suitable set of common similarities on crop yield, incidence and vigor of pests and diseases and their influence on crop performance are arrived. This scientific information helps to determine both ongoing and future scenarios of occurrence/incidence and vigor of pests and diseases, crop yields etc. This concept is also useful to develop thumb rule/s. Farmers adopt appropriate management options by following technical handouts.

Weather Health Indices for climate change: Growing Degree Days (GDD) Heliothermal Units and Photothermal indices as tools and services for climate change adaptation and mitigation

In "Weather health" and "Daily weather and agriculture" concepts, as also in the preparation of "Weather- Agriculture" book and technical handouts in local Telugu language, in addition to rainfall probabilities the GDD concept was successfully used. In India, the degree day concept has been widely adopted and used for cereal crops like rice to relate crop growth, phonological development, yield and pests and diseases (Murthy 2007).

By definition "Degree days are summation of mean temperatures over a base temperature". The GDD is also known as "Heat units" "Thermal units" "Effective heat units" "Growth units" etc. The accumulations are made on daily basis and are also accumulated between any two phenological events of crop plants or dates.

The concept assumes that:

- There is a direct and linear relationship between growth of a crop plant and air temperature
- A crop requires a definite amount of accumulated heat energy for optimum crop yields
- The biotic potential of an agricultural crop plant is dependent on the heat requirement for its growth, development, reproduction, grain yield etc

The Canonical form for Calculating GDD

Degree Days (^{0}D) = {(T max +T min)/2 – T base} where

- "T max" and "T min" represent the daily maximum and minimum temperatures respectively.
- "T base" is the base temperature

Usually Degree Days are expressed as "^{0}D" to distinguish from temperature units (Murthy, 2002)

The Base Temperature

The base temperature is one below which the internal metabolism activities of crop plant cease to function. Though the base temperature varies from crop to crop, it is constant for a specific crop. In India during *Kharif* season (South West monsoon crop season) the base temperature is taken as 10 degrees centigrade and for *Rabi* (North east monsoon season crop) the base temperature is taken as 5 degrees centigrade

Advantages/Importance of GDD

The GDD is a small and simple concept of relating plant growth, development and maturity to the air temperature. The growth of plant is dependent on the total amount of heat to which it is subjected during its life time. The GDD are useful in many ways:

- In guiding all the agricultural operations, land use planning etc
- To forecast crop harvest dates, yield and quality
- In forecasting labour required for agricultural operations
- Introduction of new genotypes in new areas
- In predicting the likelihood of successful growth of a crop in new areas.

Modification to GDD

To further enhance the biological meaning and wider area coverage of GDD applications in "Weather health" and "Daily weather and agriculture" concepts the following modifications are suggested (Murthy, 1995).

- Converting GDD into HTU and PTU

- Helio thermal units: GDD X number of actual sunshine hours.
- Photo thermal units: GDD X day length (hours the product of degree day and day length or any day)
- Incorporating an upper temperature threshold
- Using only the maximum or minimum temperature or position of the day

Incorporating functions for other environmental factors that affect phenology or the process being considered.

The need of the hour for A P

Climate resiliency in agricultural systems needs to take into account two main categories of information products:

i) Climate information products that are based on the understanding of the climatology of the region, the drivers of climate variability such as the EL Nino Southern oscillation (ENSO) phenomenon and seasonal climate outlooks and

ii) Weather information products that are developed based on monitoring of current conditions and short term (1-3 days) forecast.

There is a need to provide critical and timely climate information and weather information products through ICTs to farmers in order to enhance and sustain crop productivity and reduce losses from meteorological and hydrological risks and uncertainties like droughts, floods, cyclones etc. Certain agrometeorological tools, services, products etc., shall be housed on an interactive web. As on date no such attempt was made not only in A.P. but also anywhere in India. THIS IS A PIONEERING/ INNOVATIVE SCIENTIFIC WORK WHICH IS THE NEED OF HOUR FOR A.P.

The solution/s:

Keeping the above issues in view the solutions are:

1. Development of **user friendly web site** ***ADMIS****:* A farmer friendly and interactive web site "Agricultural Disaster Management Information System (ADMIS)" which houses weather based ICT tools, services, products *etc*.,has to be developed. The ADMIS will provide data (archived historical and current data) and information and deliver products and services to farmers and all the stake holders of agriculture to better manage weather and climate risks. Contents on the influence of weather/ climate on farming in general and crops in particular shall be pooled, developed and posted on ADMIS regularly after thorough editing by experts. A few software on weather and agro climate based decision support systems, tools, products and services have to be developed and housed on ADMIS and the same shall be disseminated through modern ICTs. In addition, capacity building of all stakeholders of farming shall be enhanced through roving seminars (Murthy, 2010).

2.Information products: Information products which include crop weather/ climate risk maps; data on area, production, productivity; both biotic and abotic stresses; market intelligence *etc*. shall be digitized and archived. Development of crop monitoring products and decision support tools such as GDD Calculator, HTU monitor *etc*., shall be included in the ADMIS web site .

3.Information dissemination: Development of mobile applications based on data from ADMIS; Production and dissemination of information through local TV channels, FM radio, production and dissemination of publications, dissemination of information through Murthy's Daily Weather and Agriculture (MDWA) and Murthy's Slate and Pencil Technique (MSPT), other contemporary products such as hand held geo-positioning devices, Dissemination of Agro-advisories through bulk SMS in 'Telugu' and 'English' languages; Voice SMSs for specific purposes viz. pests & disease control; handouts and pamphlets on IPM, INM etc., shall be made available to all stakeholders (Murthy and Stigter, 2003 and Murthy, 2016).

• Products of IMD, WMO, FAO *etc*., that would benefit crop production system in all the 13 districts including climate- weather risk maps, reference indices for drought, seasonal outlooks etc., shall be made available on ADMIS

• More importantly, the decision support tools shall be communicated to farmers in user friendly, timely and easy formats in local (Telugu) language

The ADMIS will help bridge the gap between the sources of weather and climate information and the farming community. This is

possible by taking advantage of an extensive network of national, regional, district and local government offices, agricultural educational institutions, farmer organizations, NGOs striving for farmers well being to help dissemination of this information.

4. Analysis of weather data: There is a need to analyze the weather/climate data of 13 districts of A.P. and identify the hot spot districts for agricultural related weather disasters (droughts, cyclones, floods etc.) under changing climate. The increasing frequency of natural disasters, viz., droughts, cyclones, floods etc., and the growing climate variability and climate change are having an impact on natural resource base, crop yields and incomes of the farmers. The level of skills of farmers is insufficient to cope with these new and aggravating problems. Hence, there is a clear need to train all users of climate information and equip with services to effectively deal with these problems. The first step in this direction is to analyze the weather data of all the 13 districts of A.P. by using appropriate mathematical/ statistical techniques, indices in vogue, research findings etc. Based on this work the hot spot districts for agricultural related disasters (droughts, floods, cyclones etc.) have to be perfectly identified. Information available in the text books/ journals/ research results *etc*., have to be compiled and edited to suit to the requirements of all stake holders. Products such as books, booklets, pamphlets, brochures *etc*., shall be attractively printed and distributed to as many stakeholders as possible and placed in e-form on ADMIS.Crop specialist scientists, experts in the disciplines from academic institutions, research establishments shall be consulted in finalizing the above mentioned content. The specialists (4-6 members) shall meet at monthly intervals.The contents shall be made available both in English and Telugu.

5.Communication: It is important that the farmers get the information on agro-meteorological services which are easily understandable and in time through a quick communication system. Effective communication and information about disasters, risks and uncertainties is a major challenge in the developing and under developed countries. Reliable communication networks connect the scientific and technological advances of the developed countries with these nations. The internet, digital satellite technology, wind-up machines, computers *etc*., are new possibilities for rural areas in the under developed and developing world. The mobile phones, facsimile, e-mail, wireless technologies *etc*., which are available in the developed countries offer greatest potential and must be recommended for the developing countries and under developed countries. Internet can accomplish accurate, timely, useful and cost effective information to the rural areas. The Radio and Internet (RANET) system is an innovative system which brings new communications and technologies together and delivers operational agro-meteorological services on risks and uncertainties of weather and climate over a distributed network in Africa. Capacity building of farmers on weather related issues of crop production make the farmers self reliant to produce higher yields.

6.Organizing the roving seminars on "Weather - Climate- Farmers" : To sensitize and to make all stakeholders of crop production in the district self reliant on weather/ climate related issues for enhanced crop production in each of the 13 districts roving seminars shall be organized. Typically farmers from 2-3 villages representing small, marginal large holdings gender *etc*., shall be selected. Content on influence of weather / climate on farming; introduction to weather terminology, natural disasters *etc*., shall be developed and taught as per the needs of the stakeholders.

The steps involved in organizing the roving seminars are:

- Gather information on the major crops/ cropping systems in the district
- Collect the long term daily climatic data for the district from IMD *i.e*., rainfall, maximum and minimum temperatures etc.
- Analyze the climatic data for long term trends
- Prepare fact sheets on the climate of the district and how the crops/cropping systems are influenced by the climate
- Prepare information charts for use in the Roving Seminars
- Develop the agenda for the seminars and train the trainers from farming community/ district level officials of agriculture, animal production *etc.*

- B. Sc (Ag) students undergoing Rural Agricultural Work Experience Programme (RAWEP), Experiential Learning Programme (ELP), Polytechnic students undergoing Participatory Agricultural management Programme (PAMP), Participatory Seed Production Programme (PSPP) *etc.,* shall also be involved.

In these roving seminars the knowledge, skill, capacity *etc*., of famers / farm women/ students/ all stakeholders shall be enhanced on identified and need based climate resilient agro technologies in a focused way. Special attention shall be given for creating awareness and disseminating information through IMD agromet advisories.

Conclusion

"Weather health indices" are useful as tools and services in the thirteen districts of Andhra Pradesh. A beginning is made by the author in this direction that can be seen at website "murthy whm.in"

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