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Monsoon Variability and Agricultural Drought Management in India

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Introduction

A ROUNDTABLE DISCUSSION on the topic "Generating Responses to an Uncertain Monsoon" was organised by the Observer Research Foundation (ORF) in New Delhi on August 1, 2012. The chief guest on this occasion was Mr. Harish Rawat, Hon'ble Member of Parliament and the then Union Minister of State for Agriculture and Parliamentary Affairs. Mr. Surendra Singh, Advisor ORF and former Cabinet Secretary to Government of India chaired the discussion. Select subject experts and scholars participated in the discussion, including Dr. L.S. Rathore of India Meteorological Department; Dr. Ravender Singh of Indian Agricultural Research Institute; Dr. V.U.M. Rao of Central Research Institute for Dryland Agriculture; Mr. Bharat Sharma of International Water Management Institute; and Ms. Sambita Ghosh of The Energy and Resources Institute. This publication offers a summary of views presented by the participants. It describes the impact of monsoon aberration on agriculture, and provides information on options available for managing agricultural droughts in India.

Importance of Monsoon

Monsoon is generally defined as the seasonal reversal of winds and the associated rainfall. In India, such changes in climatic conditions are experienced two times in a year. When moisture-laden winds flowing in the south-westerly direction from the Indian Ocean causes rainfall over the Indian sub-continent during June to September, the phenomenon is termed as South West (SW) Monsoon. Most parts of the country receive rain from SW Monsoon. However, due to topographical barriers, certain areas over the Indian peninsula do not experience much rain, as the wind is diverted to other places due to the presence of Western Ghats.

A striking reversal of winds from south-west to north-east direction is observed during mid-October which is followed by rainfall activity during October to December. Dry cold winds collect moisture from the Bay of Bengal and release it over south-east peninsular parts of India, including Tamil Nadu, coastal Andhra Pradesh, and Puducherry which receive less rainfall from SW Monsoon. This is known as the North East (NE) or retreating Monsoon.

The south-west monsoon brings about 80% of rains in the country. Its significance may be understood from the fact that more than 55% of farmers in India depend on adequate and well distributed timely rains from SW monsoon for raising good crops and growing feed for livestock. As 60% of agriculture in India is rain-fed and the produce supports 40% of the population, monsoon is often said to be the driver of Indian agriculture. It is realised that timely arrival, consistency, and sufficiency of monsoon rains is most essential. In this respect, it is noted that while India receives relatively high quantum of rainfall on its land compared to many other countries, the rains are uncertain and unevenly distributed in time and space. For example, in the same season, some States in the country are reeling under floods and some other are facing drought. This happens every year and only the number of drought affected districts differs.

Furthermore, the onset of monsoon is sometimes delayed which affects the sowing of many rain-fed crops. On other occasions, the monsoon may begin on time, but many mid-season breaks occur leading to crop failures, and often farmers have to re-sow their crops. In such cases, the poor farmers face enormous losses as they not only lose their time, labour and inputs, but also have to invest again on seeds and inputs for the second time in the same season with no guarantee of success. The rain-fed farmers are generally poor and have little resources; they also do not get adequate credit from the financial institutions.

The erratic nature of the monsoon, therefore, causes a lot of hardship to the farmers, the general population as well as livestock, and such conditions have an adverse impact on the economy. In the absence of sufficient rains, the flows in the rivers are poor, the reservoirs are not filled up, canals remain dry, and the farmers cannot transplant crops like paddy.

Monsoon Aberration and Impact on Agriculture

As mentioned above, monsoon occurrence varies. Sometimes, onset may be delayed or immediately after onset there is a long break. At times, onset and distribution may be very good, with almost one month dry belt in-between. Furthermore, monsoon sometimes withdraws early in the first or second week of September.

Temporal data show that during the period 1877-2009, India experienced 24 major droughts and the severe drought years were 2009, 2002, 1987, 1972, 1918, 1899 and 1877. Insufficient and uneven rainfall leads to loss of certain crops. Some resistant varieties may sustain for 20 or 30 days, but some may not even for 10 days.

In 2002, rainfall deficit was 19% due to which 29% of country's total area was affected, and there was a loss of 24 million tonnes of food grain. The 2009 drought was the third worst since 1901, when a rainfall deficit of 23% was recorded and about 59% of the area was affected. But in 2009, the food grain loss was about 10-15 million tonnes, which is less than what was recorded in 2002. This happened due to variability in the occurrence of monsoon. Thus, while kharif crops suffered huge loss, good rain received during the rabi (winter) season compensated for the overall loss in food grain production.

The effect of rainfall deficit on kharif crop production may be explained here (Table 1). In 1972-73, 24% less rainfall was received which led to a 9.76% decline in rice production. In 1974-75, when rainfall deficit was only 12%, decline in rice production was 11.29%. Similarly, in 1979-80, with 19% less rainfall, a 27% decline in rice production was recorded. This may have been due to uneven distribution of rainfall.

A State-level analysis reveals that in the drought-prone State of Andhra Pradesh, total decline in the yield of kharif food grains increased from 17% in 2002-03 to 25% in 2009-10. In the States of Chhattisgarh, Gujarat, Madhya Pradesh and Rajasthan, a decline during the same period was not observed. But in 2012, many farmers were not able to sow the millets in Karnataka and in Gujarat due to less rainfall.

Table 1: Impact of Deficit Rainfall on All-India Rice Production

Deficit Rainfall Years	Monsoon Rainfall (% Departure from LPA)	Decline in Rice Production (%)
1972-73	-24	9.76
1974-75	-12	11.29
1979-80	-19	27.02
1982-83	-14	13.01
1986-87	-13	5.40
1987-88	-19	12.26 (Compared year: 1985-86)
2002-03	-19	29.69
2009-10	-22	11.33

Source: indiastat.com.
Note: LPA - Long Period Average.

Drought Management Initiatives and Experiences

In India, the Ministry of Agriculture is the nodal agency for drought management. It prepares crisis management plans, which are updated every year depending on the likelihood of the weather pattern each year. Also, State governments have their own agencies to deal with problems created by monsoon deficiencies.

The Indian Council of Agricultural Research (ICAR) and Department of Agriculture and Co-operation (DAC) under the Ministry of Agriculture have taken several steps to help the farmers cope with uncertain monsoons. These and other initiatives are described below.

Drought probability analysis has been carried out for the entire country, based on which moderate and severe drought-prone districts are identified. This helps the administration in taking advance action in case of deficient rainfall. Several crop varieties, which have a short duration and can tolerate drought, have been evolved, and are distributed to farmers through the Krishi Vigyan Kendras (KVK). Availability of timely information about the occurrence of rains is most essential, and the India Meteorological Department (IMD) gives advance forecast on the pattern and behaviour of the monsoon. However, it is realised that the prediction of the tropical Indian monsoon is quite difficult and many times it is not possible to predict the pattern well in advance.

In addition, the ICAR has undertaken a variety of steps for agricultural drought management, including preparation of crop contingency plans (CCP) at the State/regional level and weekly bulletins, conduct of awareness programmes for farmers, setting up of district level agro-meteorological (agro-met) advisory services, and use of climate resilient technologies. With respect to the State/regional level CCPs, the experience has been that these plans do not provide sufficient details and thus it was thought appropriate to have such plans at the district level. So far, 320 district CCPs covering 14 States have been finalised by CRIDA, and work on 152 plans is in progress. Each plan presents the district agricultural profile (based on numerous parameters such as agro-climatic zone, rainfall, land use, soil, sown area, irrigation, crops, livestock, etc.), and explains strategies for weather-related contingencies.

A weather forecast response and dissemination mechanism has been established through the integrated agro-met advisory service, which is operated by IMD in collaboration with ICAR and State agriculture universities. 130 agro-met field units have been set up in State agriculture universities to whom IMD supplies forecast information on a real time basis twice a week. At the unit level, weather forecast is translated into advisories suggesting farmers about the crop specific and animal specific management actions they are supposed to take in view of the given rainfall or temperature scenario.

A radio show time slot of four times a week, and print media columns are some of the initiatives for dissemination of information on weather forecast. During the Eleventh Plan period, when district-level forecast-based agro-advisories were started, an IT-based information dissemination system was put in place. There are now about 70 websites through which this information is being disseminated. Furthermore, about 3.3 million farmers are being reached through mobile phones.

Short crunched SMS messages and one-minute voice messages are also being sent. The SMS message is repeated and voice message is given to about a million farmers. This work is being done with the help of various intermediaries like IFFCO Kisan Sanchar Limited, Thomson Reuters, and some companies. The companies have started selling their product to farmers for a price but now a proposal has been submitted to the government that the information should be provided free of cost.

In the Twelfth Plan period, about 10 million farmers are being targeted to whom the information would be sent. To achieve this goal, other intermediaries including ITC, Nokia, who are willing to join hands, would be involved. Android-based applications wherein certain users can fetch the information from the source are also being developed.

The government of India is also making seeds available of a variety of crops that can be planted late, and providing other inputs like fertilizers and machinery so that the farmers are able to plan short-duration crops in case of further delay in monsoon. Besides this, the empowered group of ministers has decided to enhance subsidy on seeds and give subsidy on diesel to the farmers of the drought-affected areas. The group has also decided to extend help in the provision of drinking water and irrigation to the drought-affected States. Even in the irrigated areas of Punjab and Haryana, farmers are being provided subsidy on diesel and extra power allocation for pumping groundwater to save their crops.

In various parts of the country, there is evidence of different approaches being followed for drought management. Examples are conservation furrows and additional inter-culture in Ranga Reddy, sand application (after ploughing) to cultivated land for conserving moisture in Kurnool, application of sand mulch in Bijapur, in-situ moisture conservation leading to 25-40% yield benefit over farmers' traditional practice, rainwater harvesting, trenching, agro-forestry and agri-horticulture for minimising impact of droughts, and crop diversification for higher profitability.

Some factors are, however, responsible for poor drought management, such as poor recognition of drought, inaccuracy in monsoon prediction, delayed and inadequate action by administration, non-availability of advisory information below district level, non-participative planning, poor implementation of drought relief measures, poor inter-departmental cooperation, etc. Moreover, there are numerous management problems with regard to contingency crop plans, availability of drinking water, employment and nutritional security, livestock management, and timely release of relief funds. Two important areas of concern are described below in greater detail.

Forecasting of Monsoon

In India, it is possible to forecast weather for only up to 4 or 5 days, whereas in extra-tropical regions this can be done for up to 2 weeks. This is due to the intrinsic nature of atmospheric processes. As uncertainty is an integral part of weather and climate, the occurrence of monsoons has always been uncertain. To generate information about monsoon, data on various temporal ranges and special domains are needed on both real time basis, as well as in futuristic time and space.

First, the initial condition (or the current status) needs to be defined through observing systems. In this task, difficulties are faced in generating data as there are vast gaps in observing systems around the globe. The oceans cover more than two-thirds of the earth's surface from where not much observation can be gathered. Data collection from mountain and desert regions is also hampered due to topographical constraints. Then, there are poor countries that cannot maintain the meteorological networks.

Therefore, indirect methods of observing atmosphere such as satellite and radar based observing systems through remote sensing are used. Again, observing meteorological parameters through remote sensing techniques is not easy, and estimates of certain radiative properties are derived and then translated into temperature, wind, etc.

The current global model run at the IMD is of 30 km. horizontal resolution and 62 vertical layers of atmosphere. At each grid point, the values of different meteorological parameters, i.e., temperature, pressure, humidity, wind speed and direction, are assigned. This is a herculean task, because there are no observations, but still the values have to be defined. Huge computational power, or a super computer, is therefore needed to generate information on weather and climate. While doing so, there is some amount of error due to reasons mentioned above.

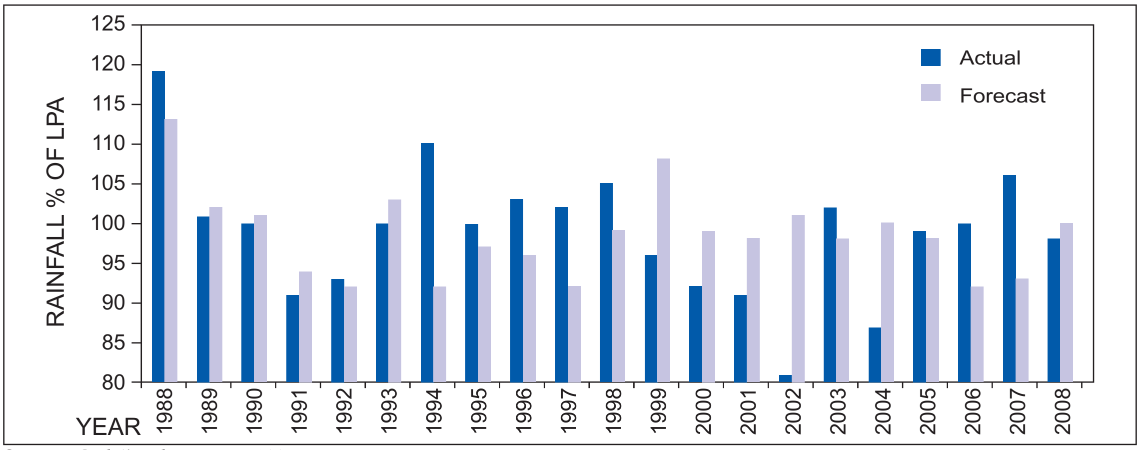
According to practitioners, weather forecasting is basically an initial value problem. At the time of defining initial conditions, there is an 'x' amount of error and when the forecast model is run, this error propagates. A doubling of error happens in tropical regions in 4 or 5 or 6 days depending upon season and reason. This doubling of error in extra-tropical regions takes place in two weeks because of the intrinsic nature of the atmosphere. In extra-tropical regions, the weather systems are unidirectional, i.e., they move from west to east. Once formed, they last for a number of days and it is easy to predict them. Whereas in tropical regions, there are radiative force-driven weather systems that all of a sudden dissipate after giving intense weather.

With this basic paradigm, IMD predicts both medium and long term monsoon. The medium-term prediction is fairly good with the skill of prediction being 80% and higher. Whereas in long range prediction, i.e., season as a whole or monthly scale, different types of problems are experienced. For example, while predicting weather in medium range, the global circulation model is run and it is easy to carry forward the atmospheric memory up to 5 or 7 days in the tropics. Whereas when the model is run in long range, then it is an entirely different experience.

Since the atmosphere does not have memory in that timeframe, different predictors are identified which have a strong correlation between rainfalls during monsoon. These predictors are primarily located in different parts of the globe and mainly over the oceans because oceanic temperatures seem to be better correlated and have a stronger memory. Now there are models which are able to simulate both oceans and atmosphere and couple them, and therefore, it is possible to start generating forecast products using numerical weather prediction techniques.

In 1994, 1999, 2002, and 2004, the prediction error was prominent (Fig. 1). Research shows that in almost 50% cases, El Nino has its effect on the Indian monsoon, but there can also be other reasons for rain deficit. Hence in 2007, IMD introduced a new statistical forecast model by incorporating the El Nino effect.

Fig. 1: Accuracy of Rainfall Prediction in India



Source: Gadgil and Rajeevan, 2008.

The government is now launching a monsoon mission in which improvement of observing systems is being contemplated. The aim of this initiative is to improve models, particularly the coupled models, and also to generate numerical weather forecast—both medium and long-range. Presently, forecast is issued at the district level in the medium range. With enhancement of the spatial domain, it would be possible to generate block-level forecast during the Twelfth Plan period.

One limitation of the statistical model which is being used for generating long-range monsoon forecast is that there is a huge decadal variability in the rainfall pattern. Though monsoon comes without fail, there is huge intra-seasonal and inter-seasonal decadal variability. Such conditions create problems as it may be the case that the relationship between predictors and predictants is developed today, and after 10 years it is learnt that these predicts are no more related to the precipitation processes. So, the relationship between predictors and rainfall processes during monsoon changes with time. Therefore, models identifying new predictors which are having a better correlation on concurrent and real time basis have to be constantly upgraded.

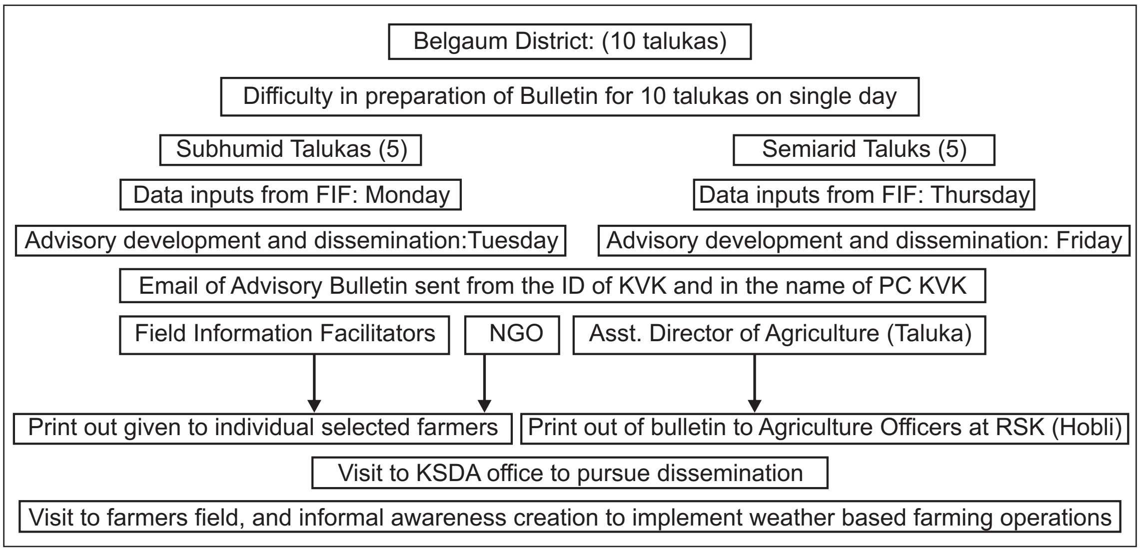
The IMD, in collaboration with DAC, ICAR and state agriculture universities, has developed a system by which both at planning and field level, information is generated for use of planners and farmers. The experience of the system may be briefly described here. In 2009, the total deficit of monsoon was 22% and all four months were deficient. At different points in time, several problems were faced due to less rainfall received including what to sow, when to sow. The contingent plan was to initially go for late sowing crops, then late sowing short-duration crops, and then for some fodder crops and short-term pulses. The strategies further changed in mid-term, and towards terminal part of monsoon. Due to these adjustments, the loss in production of food grains was minimised. Data show that during that drought period, harvest was about 218 billion tons, with paddy and core cereals recording a shortfall of about 11 million tons and 7-8 million tons respectively. These statistics were considered commendable and it was felt that the agriculture system could respond to the information generated by the meteorological department. This may be called as a good nexus between user agency and information generating agency as the arrangement has helped in responding to such deficit situations arising out of erratic monsoon.

In 2012, a forecast of 96% of long period average (LPA) was given at the beginning of the season with plus or minus 4%. A deficiency of about 8% was contemplated in the month of April. As the monsoon unfolded for the month of June, the overall deficiency was 29%. July ended with 13% deficiency and overall seasonal deficiency stood at 19%. However, in the beginning of August it was submitted that some problem will be faced during the terminal part of monsoon, i.e., September, since El Nino was slightly coming to warming face and forecasts which were available to IMD in the month of April were indicative of the fact that this warming will be of the order of 0.5 to 0.7 degrees celsius over the central equatorial pacific. Overall, a deficiency between 10 and 15% was predicted in early August 2012. However, at the end of the four-month SW monsoon season, the actual showers received were around 93% of LPA. For the year 2013, the IMD has predicted a normal monsoon, i.e., 98% of LPA.

Agro-Meteorological Advisories

A national level estimation of a 20% deficit rainfall does not mean anything for the farmer. Even within the district, there is a lot of variation in rainfall occurrence. It is, therefore, realised that blanket agro-met advisories at district level are grossly inadequate, and hence block and village level advisories would be needed. In order to achieve this objective, a pilot project has been initiated in Belgaum district of Karnataka. The 10 talukas (administrative divisions) of the district are divided into two categories (sub-humid and semi-arid) for convenience in data generation. Field information facilitators (FIFs) have been appointed who undertake field visits for collecting information on weather and agricultural operations. Based on information received from IMD every Tuesday on district level weather forecast, and the data generated by FIFs, advisories and bulletins are prepared by subject specialists in KVKs who sit together and finalise the agro-met advisories. This is followed by dissemination of advisories by FIFs, NGOs and the Assistant Director of Agriculture to farmers and agricultural officers (Fig. 2).

Fig. 2: Development and Dissemination of Agro-met Advisories



Source: Presentation of Dr. V.U.M. Rao, CRIDA.
Notes: (a) FIF – Field Information Facilitators, KVK – Krishi Vigyan Kendra, KSDA – Karnataka State Department of Agriculture; (b): The Agricultural Extension Centres set up at Hobli (sub-block) level are called Raita Samparka Kendras (RSK).

Managing Agricultural Droughts

Agricultural drought is a condition in which there is insufficient soil moisture available to the crop. This situation occurs when there is deficit rainfall over cropped area, which eventually leads to poor cropping, less food production, increase in food prices, and many other problems. The small and marginal farmers are the worst hit by water deficit conditions.

It is widely agreed that drought is not a disaster but a management risk and, therefore, with proper management many problems created by drought can be mitigated. Some approaches, strategies and technologies suggested by scholars and practitioners to combat the uncertainty of monsoon are briefly described below:

Forecasting of weather: There is a need for accurate and early forecasting of weather to allow farmers and agencies dealing with droughts to prepare in a timely manner. In 2012, there was a delay in monsoon forecasting in India, even though some institutions like the Japan Agency for Marine-Earth Science and Technology and the International Research Institute for Climate and Society at Columbia University had been ringing warning bells as early as February.

Crop planning: Crop varieties for dry land areas should be of short duration, drought tolerant/resistant, which can be harvested within rainfall periods and have sufficient residual moisture in soil profile for post-monsoon cropping.

Crop substitution: Traditional crops/varieties, which are inefficient utilisers of soil moisture, less responsive to external inputs and low yielders, should be substituted by more efficient ones.

Cropping systems: Increasing the cropping intensity by using the practice of inter-cropping and multiple cropping will help in more efficient utilisation of resources.

Fertilizer use: Dry land soils are not only thirsty but also hungry. Therefore, application of fertilizers should be done in furrows below the seeds. A proper mixture of organic and inorganic fertilizers improves moisture holding capacity of soils and enhances drought tolerance.

Alternate land use: All dry lands are not suitable for crop production. Some lands may be suitable for range/pasture management, ley farming, dry land horticulture, agro-forestry systems including alley cropping. Therefore, the purpose for which the land is to be used needs to be appropriately recognised.

Cattle camps and fodder supply: To prevent the distress sale of cattle during drought years, the State governments organise cattle camps in the affected regions and protect animals against starvation and diseases by transportation of fodder and feed. These activities need to be efficiently carried out.

Rainwater/stream water harvesting and implementation of small irrigation projects: There is significant yield gap in rain-fed dominated districts at the time when drought occurs. By investing in rain water harvesting and small irrigation projects, the increase in yields can be enormous.

Rainwater management: Efficient rainwater management can increase agricultural production from dry land areas. Application of compost and farmyard manure and raising legumes add organic matter to the soil and increase the water holding capacity. The water, which is not retained by the soil, flows out as surface runoff. This excess runoff water can be harvested in situ by proper land treatment or stored in dugout ponds and recycled for supplemental irrigation.

Watershed management: Watershed management is an approach to optimise the use of land, water and vegetation in an area. Its practise could help provide solution to droughts, moderate floods, prevent soil erosion, improve water availability and increase fuel, fodder and agricultural production on a sustained basis.

Groundwater development: Groundwater levels are rapidly declining. The dug wells and recharge wells can be very easily converted into a form of recharge structure where water received during monsoons can be stored.

Linking of river basins, underground taming of floods: Work on interlinking of surplus and deficit basins should be given priority. Wherever a good amount of runoff is available, or if it is made available to those areas which are deficient, it can solve water shortage problems to a very large extent. At the same time, efforts must be made to store the large quantities of flood waters under the ground and to transport this water to the deficit States, for which appropriate technology needs to be developed.

Development of information system at local-level: There is a need to build a strong information system at the village level for the benefit of farmers, which requires decentralisation of responsibility and capacity building of people at the local level.

Conclusion

The monsoon wind, which brings rainfall during a year, is an important weather phenomenon in India. All forms of life–people, flora and fauna–depend greatly on rains received during the monsoon season. Time series data on the occurrence of rainfall during monsoon show significant inconsistency in the quantum of rainfall received as well as its spatial distribution from year to year. Thus, excessive rainfall often leads to flooding and havoc, while its deficiency has numerous social, economic and environmental implications. In view of the fact that both scenarios adversely affect the country's life and economy significantly, efforts are being made by the government to address the challenges created by uncertain monsoon.

The information presented in this publication pertains to the impact of inadequate rainfall received during the south west monsoon season on the agricultural sector in India. Based on an appraisal of various drought management initiatives and experiences, an attempt has been made to describe critical areas of concern, as well as the approaches, strategies and technologies needed to combat drought-related adversities. The important lessons emerging from this review are listed below:

- Greater thrust should be laid on development of a drought-proofing model instead of the presently adopted relief-based model, which is a fire-fighting kind of approach.
- Timely information about the occurrence of rains should be made available.
- There is a need for generating monsoon forecast at the block-level.
- Blanket agro-meteorological advisories at district-level are grossly inadequate, and there is a need for block and village level advisories.
- Crop contingency plans should be prepared for all districts in the country.
- Further improvements are needed in the areas of crop planning, crop substitution, cropping systems and fertilizer use.
- Rain/stream/ground/flood waters need to be efficiently managed.

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Dr. Rumi Aijaz is Senior Fellow at the Observer Research Foundation in New Delhi. His education and professional experience has been in the field of social sciences, and the research undertaken covers a range of topics including socio-economic and ecological characteristics in human settlements, role of small scale industries, women empowerment and, urban governance.

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