Disaster Preparedness using IT Tools: Case Studies on the use of ICT and GIS Derived tools for Micro-Level Drought Preparedness

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***Abstract*— With natural calamities such as drought becoming a recurrent phenomenon, Science-based interventions using GIS-based tools to predict the severity of drought in an area can potentially contribute to mitigation efforts.**

***Keywords*— GIS, micro-level drought prediction, drought preparedness, ICT4D**

I. INTRODUCTION

The science and technology panel of UN convention to Combat Desertification and Drought (UNCCD) has recommended the adoption of a communication system that combines top-down with bottom-up approaches like community mobilization to enhance preparedness rather than provide relief.

The Virtual Academy for the Semi-Arid Tropics (VASAT)[1] was born out of this need to enhance drought preparedness among rural families as they are the most affected.

VASAT uses a blend of innovative methodologies embedded with Information and Communication Technology (ICT) based approaches to foster drought preparedness among rural families through rural knowledge centres. We have been conducting a series of studies for the past three years, where we use GIS-based techniques to forecast micro-level drought vulnerability of villages in Adakkal *Mandal*, Andhra Pradesh State, India. Adakkal is situated within the latitudes 16^o 28' 28.3" to 16^o 41' 1.98" N and longitudes from 77^o 2' 47.34" and 78^o 2' 46E".

II. PARTNERSHIP AT THE CORE: COMMUNITY-BASED WOMEN'S ORGANISATION AND ICRISAT

Adakkal is a *Mandal*[2] of 21 villages covering 16 hamlets in Mahabubnagar district of Andhra Pradesh State in India. Adakkal's economy revolves around semi-arid agriculture and livestock. Out of 14,616.40 ha of cultivated land, around 11,440 ha are cultivated under rainfed conditions[3]. More than 70% of the population are small and marginal farmers. Adakkal is in a low rainfall region and its average rainfall was 550 mm, more than 90 percent of it occurring during the period between June to October. Similar to other SAT regions (Ryan and Spencer, 2001) Adakkal also depends on livestock comprising approximately 70,000 sheep, 9000 cattle and 8000 goats to survive the vagaries of the local climate. However, there has been noticeable lack of drought coping and support systems in the locality. Large scale out-migration has become the principal drought-coping mechanism of the people in this area, while suicides among the farm families have occured since 2004 (Gaharwar, 2005).

The Adarsha Mahila Samaikhya (AMS- the Adarsha Women's Welfare Organization in English) is a federation of all-women micro-credit groups that functions in Adakkal. It has a membership of about 5200 women, covering all the 21 villages in the locality. AMS has been operating in this area since 1994 to address various development issues of rural families resident in this area. With the support of the State Government, AMS sought the partnership of ICRISAT to establish an information-based program to combat drought and to mitigate its impact. The activities in this regard take place under the umbrella of the VASAT project.

III. ROLE OF ICT - BASED TECHNIQUES TO ENHANCE DROUGHT PREPAREDNESS:

ICRISAT, with support from the State Government, set up an internet-connected hub in the AMS premises using a low cost connectivity arrangement and further supplied a small number of PC's to support the local operations. ICRISAT has set up Village Knowledge Centres in eight villages each with its own set of PC's and Internet facilities, and plans to extend this facility to all the 21 villages in the region shortly (Figure 1). These rural knowledge centres are operated by AMS volunteers and ICRISAT involves in capacity building and strengthening. AMS volunteers maintain a record of all agricultural queries and their responses/solutions provided by ICRISAT experts.

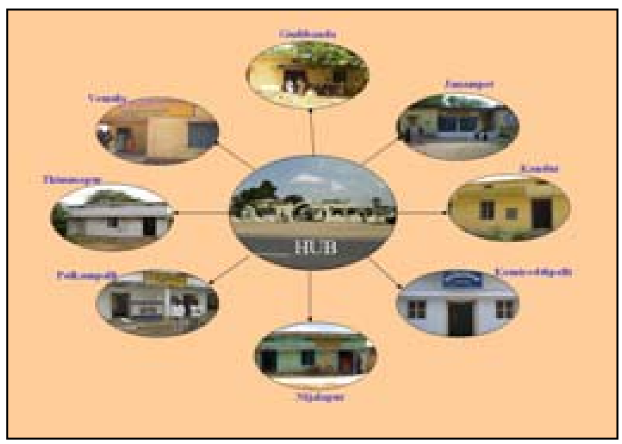

Figure 1: Hub and Spokes

ICRISAT was engaged in an extended communication appraisal, using a participatory learning framework, for over a year in 2003-04 to find out the types and strengths of information linkages between various sources and people operating in the area of agriculture in Adakkal *Mandal* (Figure 2). This study yielded interesting results from the points of view of rural residents in that area, macro and meso-level knowledge-based development organizations had a very limited reach with the village community. Mass media, rural development offices of the local government and agricultural input companies appeared to have strong linkages while natural resource management based education and research institutions and local banks had weaker linkages. The

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[1] http://vasat.icrisat.org/

[2] A mandal is the administrative headquarters for a group of villages

[3] Hand book of Statistics 2006-2007 Mahabubnagar District

strongest linkages were found to occur within the community, which implied that the primary pattern of knowledge transfer was horizontal and between sources with relatively limited contemporary knowledge of agricultural production practices. The linkages with the agricultural extension processes with the rural residents were assessed to be generally weak. Surprisingly, input suppliers and other agricultural traders were about the most important source of information. Market, climate, employment and wages emerged as some of the most important information needs of the community.

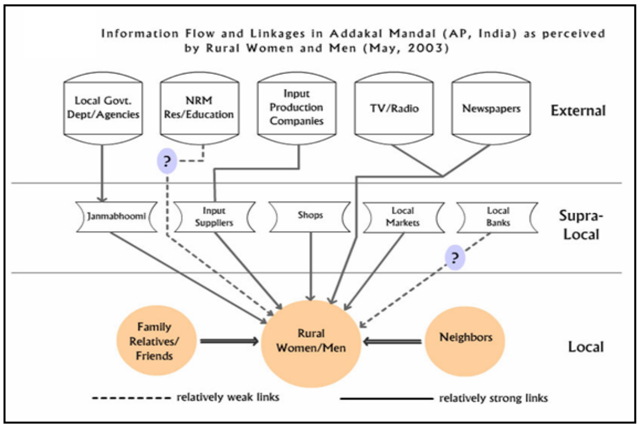


Figure 2: Information flow and linkages in Adakkal Mandal

An early realisation was that a spectrum of information services, rather than those covering only the rural production aspects, would be useful to obtain local buy-in into the management of new information services. Secondly, a process of facilitation would be a valuable input in enabling information access by the rural families, whose familiarity with PC-based information systems was extremely limited. ICRISAT has since helped the AMS members manage the information hub and in designing a information service providing local weather, wages, market information and occasionally other services such as access to school examination results. Production-related information was always presented as an auxiliary service rather than primary. The regularity of this wider range of information was essential in rendering the ICT-based information service to be perceived as a reliable source for any information including agricultural production-related information.

A structured experiment on varying values of prominence of technology and the intermediary revealed that equal prominence of intermediary and technology has a greater impact on farmer-participants.

IV. SUPPORT THROUGH VIDEO CONFERENCING:

Since March 2007, VASAT has been using a two-way video-conferencing facility provided by the Indian Space Research Organization via the National Remote Sensing Centre to assess changes in the effectiveness of query-responses when a new digital medium is used (Figure 3). Initially the video conferencing was conducted for two hours per week and from November 2008 we have increased the frequency. During these sessions experts from ICRISAT train the AMS volunteers about the package of practices of different crops grown in that area. The training is provided in Telugu, the local language, with the help of PowerPoint[4] presentations and videos. The complex queries that arise during these sessions are noted down and are uploaded on to an online forum (www.aaqua.org), which has features to enable any registered expert to view the queries and answers. The answer is then communicated to the AMS volunteers during subsequent sessions. In addition to this, experts from ICRISAT give special sessions on new technologies in agriculture.

Figure 3: An expert using videoconferencing to interact with farm communities

V. THE DROUGHT VULNERABILITY ASSESSMENT FRAMEWORK

An initial method developed at Indian Institute of Technology, Bombay was adapted by ICRISAT as the base for developing this micro-level drought vulnerability maps. This framework uses GIS derived tools to predict the effect of a varying rainfall on the water availability of that region.

This methodology has been refined over the past two years after it was successfully demonstrated during the 2007 *kharif* season in Adakkal *Mandal*, Mahabubnagar District (Dileepkumar *et al*, 2007). Thematic maps showing the village boundaries were digitized from the geo-referenced cadastral maps that were obtained from Central Survey Office, Hyderabad. The status of degradation of surface water bodies or tanks were assessed in terms of surface area, silt accumulation and encroachment on the reservoir bed are verified and codified into the thematic maps using GIS-based tools. Further, the demand and availability of water in that village is estimated. Water demand is calculated by considering the water requirement for human, livestock and agricultural uses. The water availability in surface water bodies is calculated depending upon the runoff resulting from the rainfall. From the above data the water deficit and water available for each village is estimated. This information is

[4] Microsoft Powerpoint

further entered into the attribute data of each village and choropleth maps showing the drought vulnerability variation of each village is generated using the symbology tool of ArcGIS software. All the above variables are entered into the GIS-tool to developing colour-coded maps indicating drought vulnerability of villages at different rainfall scenarios from 200 to 900 mm per season (Figure 4 and 5).

These maps were developed in such a way that a rural resident with basic training could easily understand the meaning of the colour code in the map. Red colour indicates the villages that are highly prone to drought, orange and yellow colours also indicate vulnerability of villages to drought but less intensity than the red colour. Green colour indicates that the villages can just sustain in drought situation. These maps could help in decision making at two levels for avoiding the impact of drought. At an administrative level, planners can make informed decisions in adopting proper strategies to reduce the impact of drought. At the village level, these maps can help communities in knowing the drought condition and thus can reduce the impact of drought by choosing alternative cropping patterns or by taking up other employment opportunities.

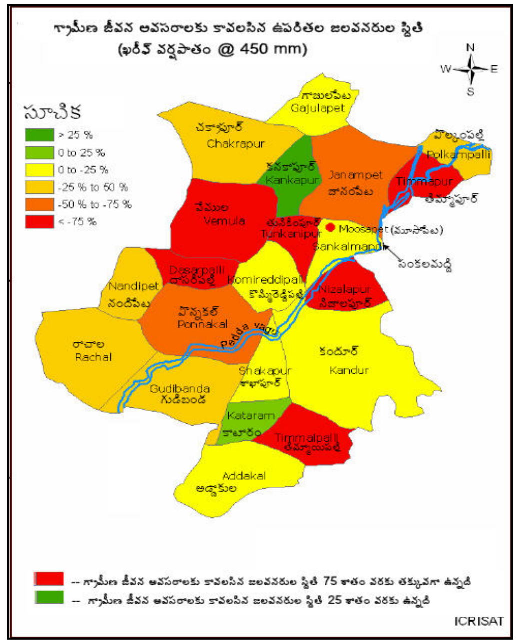


Fig 5 Seasonal rainfall 450mm

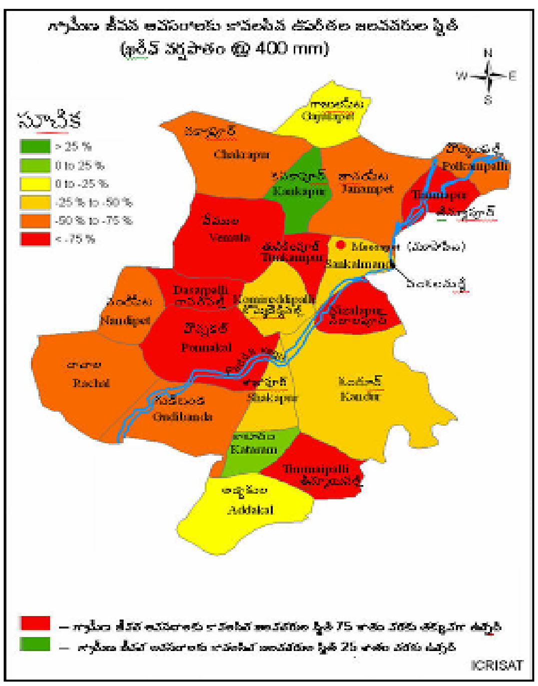


Fig 4 Seasonal rainfall 400mm

VI. DISSEMINATING THE VULNERABILITY MAPS AND FOSTERING DROUGHT PREPAREDNESS:

With the help of Adarsha Mahila Samaikha, ICRISAT actors initially disseminate the vulnerability maps through face-to-face interactions; through this ICRISAT was able to bring across the severity of the drought situation to the knowledge of farm communities in that *Mandal.* These maps were also made available in all the village knowledge centres for further consultations. The videoconferencing facility is used to follow-up on recommendations and to foster drought preparedness by giving advisory on cropping, water and soil management.

VII. VALIDATION OF DROUGHT VULNERABILITY MAPS

Preliminary studies undertaken on micro-level drought vulnerability have shown that drought vulnerability maps have been useful in enhancing drought awareness. Field surveys and comparison of predicted and observed rainfall have also shown consistent results in previous seasons (Dileepkumar *et al*, 2007, Sreedhar *et al*, 2008). For the validation and refinement of the drought vulnerability maps, four raingauges were established in Adakkal *Mandal* at Rachal, Timmapur, Janampet and Kandur villages. The rural women were trained in measuring the rainfall (Figure 7) and in uploading the rainfall data onto a Wiki-based website (http://vasatwiki.icrisat.org/index.php/Rainfall_2009_*kharif*) (Figure 8). The predicted rainfall is compared with the actual rainfall of the villages to continually refine the micro-level drought vulnerability maps in the rural context.

A. Rainfall predictions for Addakal during 2009

The southwest monsoon normally arrives over Addakal by the first week of June and retreats by the end of October. The normal rainfall for the Addakal is around 600 mm per annum and 550 mm seasonal (June-Oct). However, this region has been continuously receiving below normal rainfall for the last 10 years. Because of lack of available groundwater, surface water stored in the irrigation tanks form the main source for livestock and for the irrigation of crops. The variation in the onset, amount and distribution of rainfall severely impacts the surface water availability and agricultural production. Therefore it is essential to provide farmers with advance information on rainfall quantity and distribution for better agricultural decisions.

An analog statistical method is one of the several methods that can be used in predicting seasonal forecast. The method is based on critical examination of past several years of rainfall data to identify the weather scenario and assign values very similar to the existing conditions (Piani et al, 2005). The forecast is made on the assumption that the rainfall pattern will be similar to the past few years. The limitation with the weather forecast is that it is virtually impossible to find a perfect analog and even if the match is perfect, the weather that follows could be significantly different during the forecast period.

According to India Meteorological Department's (IMD) press release issued on 17th April 2009 the operational Long Range Forecast for the year 2009 Southwest Monsoon season (June-Sep) the country as a whole would receive 93% of the Long Period Average with a model error of + 5% and the South Peninsula would receive 93% of long period average of 725mm (http://www.imd.gov.in/section/nhac/dynamic/lrf.htm). IMD predicted a normal rainfall for the India as whole whereas International Research Institute for Climate and Society, Columbia University had predicted a below normal rainfall for South India (http://portal.iri.columbia.edu/portal/server.pt).

Considering IRI's prediction, an attempt was made to experimentally predict the seasonal rainfall and its distribution for the year 2009 based on the monthly rainfall data for the past 18 years of Addakal. Various statistics like average, standard deviation, and coefficient of variation for monthly, seasonal and annual rainfall were computed. Rainfall that can be expected at different probability levels was also estimated. The analog statistical assessment of 18 years of monthly rainfall data of Addakal has shown that there is 90 % and 75% probability of getting 441 mm and 524 mm annual rainfall respectively. Keeping in view the above statistics and conditions of previous years two scenarios of 400 mm and 450 mm rainfall were predicted for year 2009 with prediction error of +50 mm. The monthly distribution of rainfall was predicted based on the long period average of each month obtained from statistical analysis.

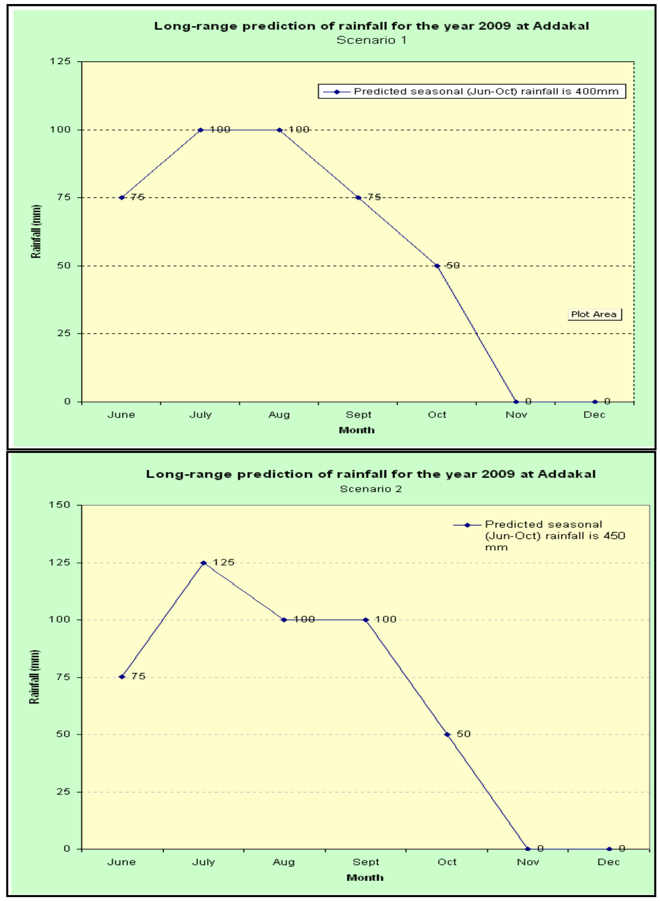
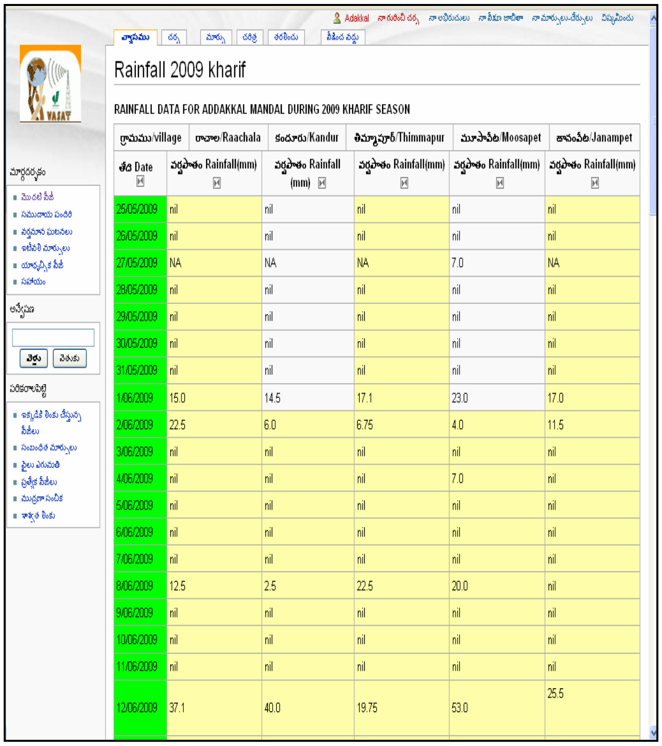


Figure 6 Seasonal Rainfall predictions for the Addakal region (2009)

Figure 7 Rural women measuring rainfall



Rainfall 2009 kharif

RAINFALL DATA FOR ADDAKKAL MANDAL DURING 2009 KHARIF SEASON

గ్రామము/village	రాచాల/Raachala	కందూరు/Kandur	తిమ్మాపూర్/Thimmapur	మూసాపేట/Moosapet	జానంపేట/Janampet
తేది Date	వర్షపాతం Rainfall(mm)	వర్షపాతం Rainfall (mm)	వర్షపాతం Rainfall(mm)	వర్షపాతం Rainfall(mm)	వర్షపాతం Rainfall(mm)
25/05/2009	nil	nil	nil	nil	nil
26/05/2009	nil	nil	nil	nil	nil
27/05/2009	NA	NA	NA	7.0	NA
28/05/2009	nil	nil	nil	nil	nil
29/05/2009	nil	nil	nil	nil	nil
30/05/2009	nil	nil	nil	nil	nil
31/05/2009	nil	nil	nil	nil	nil
1/06/2009	15.0	14.5	17.1	23.0	17.0
2/06/2009	22.5	6.0	6.75	4.0	11.5
3/06/2009	nil	nil	nil	nil	nil
4/06/2009	nil	nil	nil	7.0	nil
5/06/2009	nil	nil	nil	nil	nil
6/06/2009	nil	nil	nil	nil	nil
7/06/2009	nil	nil	nil	nil	nil
8/06/2009	12.5	2.5	22.5	20.0	nil
9/06/2009	nil	nil	nil	nil	nil
10/06/2009	nil	nil	nil	nil	nil
11/06/2009	nil	nil	nil	nil	nil
12/06/2009	37.1	40.0	19.75	53.0	25.5

Figure 8 Rainfall data uploaded by rural volunteers on VASAT wiki @ http://vasatwiki.icrisat.org/index.php/Rainfall 2009 kharif

Category	**Month**	**Normal (mm)**	**Predicted (mm)**	**Observed (mm)**
Secrario 1 (400 mm)	June	68	75	83
	July	145	100	11.65
	August	122	100	2.0
Secrario 2 (450 mm)	June	68	75	83
	July	145	125	11.65
	August	68	100	2.0

Table 1: Predicted Rainfall in Comparison with the uploaded data

It was observed that only in the month of June, predicted rainfall was in agreement with the observed rainfall condition of the Addakal (see Table 1), whereas the other two months (July and August) have received much lower rainfall than the predicted value. This clearly shows that the medium-term climatic aberrations at this scale are quite unpredictable.

VIII RELEVANCE OF THIS STUDY WITH REFERENCE TO THE 2009 DROUGHT IN INDIA

India Meteorology Department declared on 13th August 2009 that there was a deficiency of 29 percent in the Southwest Monsoon. This prolonged failure of rainfall accounted for the drought situation in almost half of India with 246 districts in 10 states having been declared as drought affected[5,6].

The Prime Minister of India, Dr. Manmohan Singh also noted the "difficult situation" following delayed and deficient rainfall that the country was facing. Eminent agricultural scientist Dr. M.S.Swaminathan has also emphasized the need for a science-based contingency plan[7].

This study gains significance in the fact that it succeeded in predicting a near drought-like situation in the study area much before the monsoons and much before IMD's drought predictions were released. We believe that the framework and the method presented in this paper will be useful in integrating scientific inputs for local-level contingency plans. Alternate crop based strategies to mitigate drought such as land planning, soil management, crop management, integrated watershed management and other water management techniques can be integrated into this framework.

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