Village Knowledge Centers and the Use of GIS-derived Products in Enhancing Micro-level Drought Preparedness: a Case study from South Central India

G. Dileep Kumar, *R. Nagarajan, A.V. R. Kesava Rao and V. Balaji
International Crop Research for Semi-Arid Tropics, Patancheru-502324, A.P, India.
* Center for Studies in Resources Engineering, Indian Institute of Technology, Mumbai-400076, India

Abstract- **Drought affects hundreds of millions of people in the developing world and causes serious disruption of social and economic activities. Preparedness is better than relief and information is the backbone of drought preparedness. In this paper we report the results from a study in the use of GIS-derived products to assess micro-level drought vulnerability, taking a cluster of 17 villages in the South Central India as the study area. An internet-connected rural information center, linked to village knowledge centers, played a key role in testing the utility of this product, and the associated local-level predictions for seasonal rainfall.**

I. INTRODUCTION

One of the significant challenges that South Asia faces is the recurrence of disasters that lead to large-scale disruption of economic and development activities and cause considerable distress. Over a period of time, relief measures have become affordable in many situations but the cumulative losses are staggering. The Disaster Management Authority of India has identified drought and earthquakes as among the phenomena that can cause deep and lasting distress among the victims while generating massive economic losses to the system as a whole. There is a need to identify new systems that combine early warning arrangements with access to appropriate support services. The science and technology panel of the UN Convention to Combat Desertification and Drought (UNCCD) has recommended the adoption of a communication system that combined top-down approaches with bottom-up approaches and community mobilization. The UN Sudano-Sahelian Organization, now the UN Center for Drylands, observed that information was the backbone of drought preparedness [1].

Over the last three years, ICRISAT has developed a pilot project to study the possible use of the ICT-based rural knowledge centers in enhancing drought preparedness at the micro-regional level among the rural families under the umbrella of the Virtual Academy for the Semi-Arid Tropics (VASAT). The pilot is premised on the assumption that a country such as India has reasonable arrangements for early warning communication in a top-down manner. International experience shows that such top-down flow of important information must combine with a bottom-up process for its rapid and effective use by the intended recipients, namely the rural families. The rural knowledge centers, operating in an interactive hub-and-spokes model for local value-addition and dissemination and capture, could provide the right interfaces to generate such blended communication [2].

As an activity in this pilot, we made an effort to develop a GIS-derived micro-level drought vulnerability assessment framework for use by the rural families. This was developed and tested in Addakal Mandal, Mahbubnagar district, AP State in India.

The principal local partner is a community-based NGO called the Adarsha Mahila Samaikhya (AMS), which is a federation of village-level micro-credit groups in the Mandal. The coverage extends to all the villages while the federation has a membership of about 6000 individuals, all women (as of September 2006). The AMS has provided good quality space and furniture and electricity for the rural knowledge centers in three villages while its own premises act as the local hub that has access to the Internet. The village access centers act as channels for two-way communication between the hub and the rural families. The AMS Governing Body has identified and deputed village women to operate the three village centers as volunteers and they have been trained extensively in essentials of IT and in general information management. The active participation of the AMS volunteers and the rural families encouraged us to develop a drought vulnerability assessment framework in the Addakal area, to cover a cluster of 17 villages.

II. THE STUDY AREA

Addakal is one of the most drought prone regions in South Central India. It has a cluster of 17 villages, spread over an area of 19,397 ha; 15% of this area is covered by irrigated land, 60% by rain-fed lands, and remaining 25% is considered as 'wasteland.' The district comes under Southern Telengana agro-climatic zone. Annual rainfall varies from 391 to 542.6 mm. This region has significant number of unemployed people and most families here are classified as living below the poverty line. This area experiences high levels of seasonal outmigration caused by drought, and is characterized by extreme seasonal fluctuations in markets and income. There are pockets here that experiences consistent and severe scarcity of water which causes distress among the rural families and animals (Fig 1).

Figure 1: Addakal region in AP State, South Central India

According to the Censes of India 2001, the population of this area is 46,380 (Male: 50.57%, Female: 49.43%) and the literacy rate is 35% (Male: 66%, Female : 34%), respectively. Over 75% workers are engaged in agriculture, dairy farming and allied activities. High risk associated with low investment capacity of farmers often results in higher rate of out migration, food insecurity and poverty. The main agriculture crops are castor, groundnut, maize, chickpea, pigeonpea, sorghum, pearl millet, paddy and orchard crops. This area consists of 8639 houses, 10 post offices, 998 telephone connections, 1 government hospital, 8 veterinary hospitals (one doctor is available for all the hospitals), 1 government junior college, 9 government high schools, 21 government elementary schools, 1 Anganvaadi Kendras (government baby care center), 10 dairies led by women, 1 library, and 3 banks including Aadarsha Mahila Bank.

III. DEVELOPING A DROUGHT VULNERABILITY ASSESSMENT FRAMEWORK

We adapted an approach developed at the Indian Institute of Technology, Bombay (http://www.iitb.ac.in) for developing a drought vulnerability assessment framework, which was tested in Nanded district in Maharashtra. The color coded maps which were outcome of this method could be easily understood by a rural person. The steps in developing this framework described briefly:

First Step: We selected 17 contiguous villages and in the process of *ground truth verification,* assessed the individual surface water storages or tanks that are connected to a group, their degradation status, and feasibility of restoration and benefits of restoration.
Second Step: Status of degradation was assessed in terms of surface area, silt thickness, encroachments on the reservoir bed and blockage / impediments along the inward channels.
Third Step: Thematic maps (Survey of India [1]) were prepared and Indian Remote Sensing satellite data was used for collecting the data.
Fourth Step: Status of outward channels and the probable areas for rainfed agriculture were estimated in calculating the restoration benefits.
Fifth Step: Annual (40 years), monthly (10years) and daily (5 years) rainfall records were used in understanding the rainfall intensity and time series pattern. We further estimated the run-off from the tank catchments for a range of rainfall.[2]
Sixth Step: Scenarios were calculated in meeting the human, animal and crop-irrigational requirements of villages that are located in the vicinity. Deficiency of water availability from the tanks towards the winter and summer crops and ground water extraction requirements were estimated. [3] Based on this information the color-coded maps were generated to indicate the drought vulnerable areas. (Fig 2)

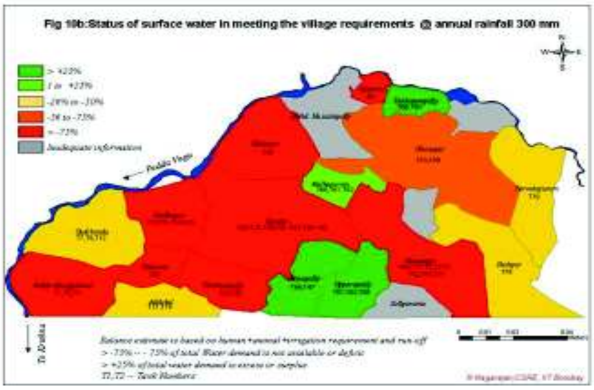
[1] Survey of India Topographic sheet surveyed in the scale 1:50,000 during 1959-60 (sheet no. 56 H/14), 1966-67 (56 L/2) and 1:25,000 scale during 1986-87 were used as the thematic maps.

[2] The rainfall data i.e., annual (1960-2004); monthly rainfall (1996-2000); daily rainfall (1996-2000) collected from District Collector Office, Mandal Revenue Office, and from village access center with the help of a rainguage established by the IIT Bombay,

[3] Human and animal population data collected from 1991 and 2001 census. Drinking water requirements (human 120 lts/person & 80 lts/animal) estimated. Data on crop type and the pattern of crops of the individual villages collected and their water requirements estimated. Crop irrigation water and drinking water requirements of the villages were calculated. The assumptions made for calculating the agriculture water requirement. Based on this data the status of surface water in meeting the villages requirements at various annual rainfall situation of 200, 300, 400, 500, 600, 700, 800, 900 mm were estimated and the color coded maps generated.

Annual rain fall 200 mm

Annual rain fall 600 mm

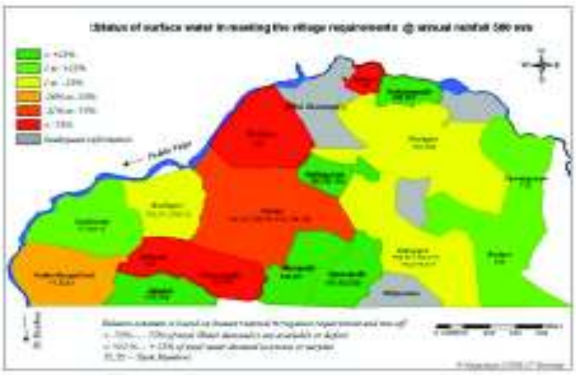


Annual rain fall 300 mm

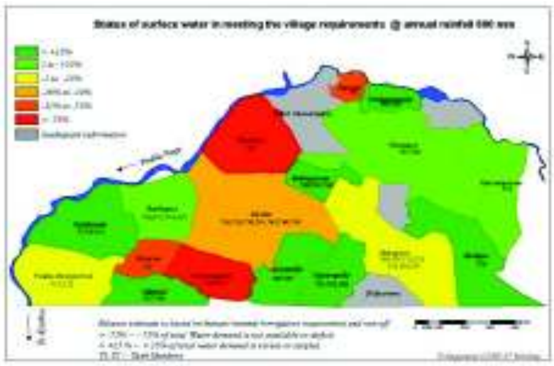
Annual rain fall 700 mm

Annual rain fall 400 mm

Annual rain fall 800 mm



Annual rain fall 500 mm



Annual rain fall 900 mm

Figure 2: Drought vulnerable villages under different rainfall scenarios in Addakal (2006)

IV. INTERPRETATION OF COLOR-CODED MAPS

The red color indicates the villages, which are most vulnerable to drought under various rainfall conditions. Based on this information, decisions could be made at two levels for avoiding the adverse impact of drought. These are:

(1) *At district administration level:* If the district authorities would be aware of those villages, which are more prone to the drought, then they could take up the coping measures well in time.

(2) *At community level:* If the rural families would be aware their village will be get affected by the drought in a season, they could take up the measures to mitigate the effects of drought. For instance the rural families could change their cropping pattern (or) they could go for non-agricultural options.

To render these maps useful, it is important to predict the rainfall in an upcoming season. This was also carried out such that only a cluster of villages rather than the district was covered. To effect suitable corrections in the predicted rainfall, ground level data was regularly gathered.

V. EVALUATING DROUGHT VULNERABILITY ASSESSMENT FRAMEWORK

IIT-Bombay, ICRISAT and the AMS verified the efficacy of this framework by (A) using rainfall predictions developed at ICRISAT (B) A wiki-based system for uploading the rainfall data collected by AMS volunteers daily (C) ground truth verification by taking the interviews from residents of covered villages.

The experiment conducted between June – December 2006 indicated that drought alarms generated from the use of this framework was more than 95%. The details of the experiment are discussed in detail in the following sections:

A. Rainfall predictions at Addakal during 2006

The southwest monsoon normally sets over Addakal area by the first week of June and withdraws by the end of October. Normal annual rainfall for Addakal *Mandal* is about 600 mm received in 41 rainy days. Normal seasonal (Jun-Oct) rainfall is about 535 mm received in 36 rainy days. About 89% of the annual rainfall is received in this season. Year-to-year variations in onset, amount and distribution of monsoon rainfall have major impacts on water resources and rainfed crop production in the area. Advance information on the possible rainfall quantity and distribution in the season equip the farmers for better decision-making with respect to crop planning and choosing management options.

Analogue Method is one of the several methods that can be used to prepare a seasonal forecast. The Analogue Method involves critically examining the past several years' data to identify the weather scenario, which looked very similar to the existing conditions and try to forecast the weather for the future period with assumption that the weather in this forecast will behave the same as it did in the past. The limitation is that it is virtually impossible to find a perfect analog. Also, even if the match is perfect, the weather that follows could be significantly different during the forecast period. An attempt was made to experimentally predict the seasonal rainfall and its monthly distribution at Addakal for the year 2006 and the same was disseminated to the farmers in the first week of June 2006.

Based on the daily rainfall data for the past 34 years of Addakal area, various statistics like average, standard deviation, coefficient of variation for weekly, monthly, seasonal and annual rainfall were computed. Rainfall that can be expected at different probability levels was also estimated.

The India Meteorological Department's (IMD) operational Long Range Forecast for the 2006 Southwest Monsoon season (Jun-Sep) was that "The rainfall for the country as a whole is likely to be 93% of the Long Period Average with a model error of ± 5 %". The IMD issued this long-range forecast on 24 April 2006.

It was observed that Addakal was receiving below normal rainfall for the previous 8 years (except for the year 2005). Depending on the rainfall distribution for the first five months (Jan-May 2006) and rainfall of the previous years, good match analogues were identified. After repeated analysis and observation, most optimum analogues were filtered out. Based on the analogues, statistical values, long-range forecast of the IMD and to some extent on intuition, two scenarios were developed with the predicted seasonal rainfall of 450 and 500 mm each with different monthly distribution. The prediction error assumed was ±50 mm. for both the scenarios. Raingauge was installed at Addakal and the data was regularly monitored. Rainfall as measured at the Addakal *Mandal* office was also collected for comparison and for correcting the data as measured by the farmers in the initial period. The scenarios of rainfall predictions are shown in the graphs (Fig 3).

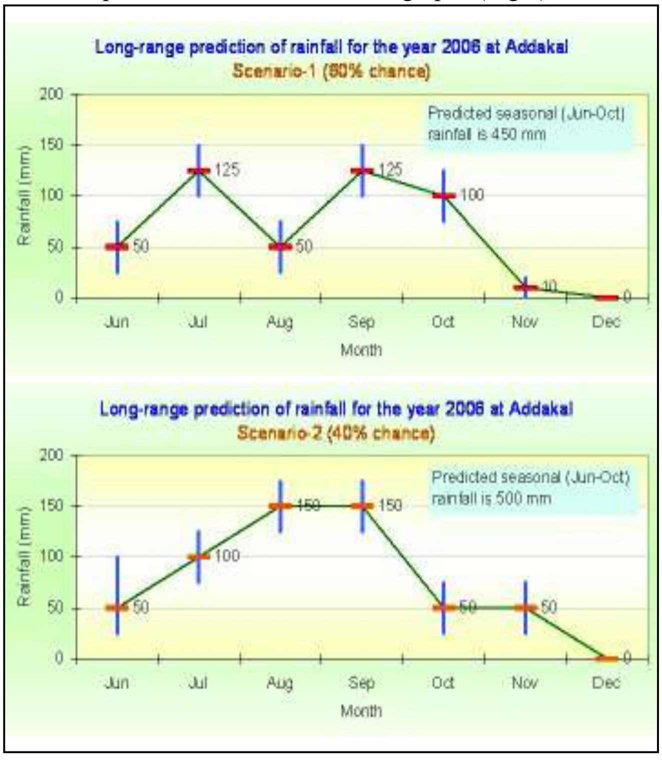


Figure 3: Seasonal Rainfall prediction for the Addakal region (2006)

B. Daily updation of the rainfall data collected by the rural volunteers

In June 2006, a rain gauge was installed in the AMS information hub. Four volunteers were trained in the measurement techniques and in maintaining the rain guage (Fig 4). They were also trained in uploading the measured data to a wiki-site, which would retain date and time stamp whenever an update took place (Fig 5).

Figure 4: Rural volunteers trained in rainfall measurement

Addakal

rainfall data of 2007 kharif season

Date	Rain Fall (mm)	Description
24/06/06	22.5	Rain in the morning
25/06/06	70.0	Rain in the morning
26/06/06	00.0	Normal
27/06/06	205.0	Rain in the evening
28/06/06	50.0	Mostly cloudy,rain in the morning
29/06/06	15.0	Mostly cloudy
30/06/06	00.0	Normal
01/07/06	00.0	Normal
02/07/06	35.5	Rain in the night
03/07/06	00.0	Normal
04/07/06	00.0	Morning with clouds and rain in the night
05/07/06	00.0	Rain in the night
06/07/06	00.0	Normal
07/07/06	00.0	Normal
08/07/06	00.0	Normal

Figure 5: Rainfall data uploaded by rural volunteers on VASAT wiki @ http://vasatwiki.icrisat.org/index.php/Addakal

The data uploaded by the rural women volunteers was used to assess the usefulness of the rainfall prediction for the Addakal area. The results are presented in table 1.

TABLE 1:
Usefulness of Predicted Rainfall in Comparison with uploaded Bv Rural Volunteers

Category	Month	Normal	Predicted	Observed	Comment
Scenario -1	June	68	50	107	Usable
	July	145	125	39	Fail
	August	122	50	80	Usable
	September	103	125	180	Usable
	October	97	100	15	Fail
	Season	**535**	**450**	**421**	**Successful**
Scenario -2	June	68	50	107	Usable
	July	145	100	39	Fail
	August	122	150	80	Fail
	September	103	150	180	Usable
	October	97	50	15	Usable
	Season	**535**	**500**	**421**	**Usable**

VI. VERIFYING THE ACCURACY OF PREDICTED VULNERABILITY

In June 2006 when we discussed with the village volunteers about the use of the color coded maps in identifying the drought vulnerable villages, they expressed their happiness and willingness to participate in this experiment. For instance Mrs Vimalamma, 35 years, resident of Janampeta village expressed "If we know about drought well in advance we can avoid its occurrence by taking up drought tolerant crops, saving the water resources, finding the alternative livelihood opportunities other than agriculture." And Mrs Narmadamma, 38 years, resident of Vemula said "even we prepare to migrate to the other areas well in advance to avoid the ill effects of drought.

Further we discussed about the usefulness of rainfall predictions in this process. Since the rainfall predictions lies in between 400mm and 500 mm, the villagers suggested 400mm scenario was suitable in predicting the vulnerable villages.

Based on the 400 mm color-coded map, village volunteers identified Thimmayipalli, Kataram, Peda Mangalched, Shakhapur, Kandur, Manajipet, Nijalapur, Agaram and Ghanpur were most vulnerable to the drought.

During the ground truth verification study, which was conducted in the month of December 2006, the same village volunteers and ICRISAT research scholars participated. They followed an ethnographic methodology to collect the data on the severity of drought and comparisons were made with the predicted scenarios. Ethnographic methodology is a research methodology and not a specific technique to collect data (unlike participant observations, or interviews). In fact, it is a multiple technique approach; an ethnographer uses a mixture of techniques appropriate to her/his situation; and adapts each technique to her/his situation. Ethnography tries to integrate the different methods into one holistic study [3].

The village volunteers and scholars stayed in the villages for understanding the dynamics and actual scenario of the village. They recorded 170 respondent interviews (10 in each village). During the assessment process we observed that Thimmayapalli, Kataram, Kandur, Nijalapur, and Agaram had been severely affected by the drought and the others Peda Mangalached, Shakhapur, Manjipet and Ganpur had been affected to a lesser extent.

Our observations were made on the village conditions, the agricultural production scenarios, rural families experiences, and availability of water for various purposes. We observed that red color-coded villages were indeed affected by drought.

For instance, Ms Narayanamma, 38 years, a farm labourer from Nijalapur village said that she had to travel 3-4 kms daily for getting drinking water." It is observed no farmer in this village had taken up agriculture and most of the men migrated to Hyderabad or Bombay in search of livelihood opportunities. The predicted scenario for this village was severe scarcity of water, which was reflecting from the findings. Similar situation was also observed in the other severely affected villages.

Mr Raghuvardhana Reddy, 43 years, a farmer and resident of Kandur village said "this time I cultivated paddy and the crop failed because of non-availability of water. I am afraid to take up a crop in the next season and want to go to Hyderabad to look for construction job."

Mr Sailu, 46years, a milk vendor and resident of Agaram said "I am not getting sufficient feed for my animals in the villages. I am buying feed and fodder from Koththakota and Jadcherla at high cost and I find it difficult to manage my dairy cattle."

Unlike this the residents of the villages, which were predicted, to be relatively free from drought, expressed that they did not have any drinking water problem; they even had sufficient agriculture produce.

Ms Premalatha, resident of Addakal village said "This year we did not have drinking water; even the yield of our paddy crop good though we didn't get much profit."

Mr Rajeshwar Reddy a carpenter from Venkatampally village said "this season our two villages bore wells were providing sufficient water to all the residents. I didn't have to fight for water."

Even we could physically note the difference between the villages which were affected by drought and which were not affected by the drought. Based on the observations and residents experiences, we are of the view that the maps were useful.

VII. INFERENCES

The results of this pilot experiment showed how best we could use the ICT enabled early warning systems for disaster management with a combination of top-down and bottom approaches and community mobilization. The pilot experiment revealed that the village volunteers, (intelligent intermediaries or an interface between the communities and natural resource management agencies) could effectively use the ICT-enabled tools like VASAT-wiki with continuous capacity building exercises/training programmes.

Through continuous ICTD experiments of VASAT-AMS at Addakal hub (http://www.icrisat.org/vasat/pilothub/sa-hub-index.htm) in the last three years, we noted the changing roles of village volunteers from learners to trainers. In this particular experiment they actively participated in the data collection and impact assessment surveys.

The methodology used in this experiment is the first of its kind; it showed a way to develop a micro-level drought vulnerability assessment by combining various ICTD tools with the help of an intermediary entity, the Village Knowledge Centers, owned and operated by the communities, to improve local responses to drought.

VII. NEXT STEPS

The pilot study also continues to the South West monsoon season of 2007. Three more rain gauges have been added. Studies on cropping pattern and animal rearing practices are going on, while new learning modules on coping with drought[4] have been designed for use in the village knowledge centers. We hope to expand the coverage to more clusters in India during the year 2008.

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REFERENCES

[1] UNSO, 2000. Report on the status of drought preparedness and mitigation in Sub Saharan Africa. [Online]. Available: http://www.undp.org/seed/unso/concepts&programs/pub-htm/dpm-1.pdf

[2] V. Balaji, K. G. Rajamohan, R. Rajasekara Pandy, and S. Senthilkumaran. (2000). Towards a Knowledge System for Sustainable Food Security: The information village experiment in Pondicherry. On the Internet, Fall/Winter. [Online]. pp.32-37.Available: http://www.isoc.org/oti/articles/0401/balaji.html

[3] P. Balaji, A. Punathambekar, G. R. Kiran, G. Dileep Kumar, J. Srinivasan, R. Kumar. (2005). Information and Communications Technologies for Development: A Comparative Analysis of Impacts and Costs from India,. Available: http://www.iiitb.ac.in/Complete_report.pdf

[4] The learning modules explains (1) the best methodologies to cope with drought (2) the suitable crops under various water stresses (3) Methodologies to recharge the wells and tanks (4) Management of water sources from various villages (villagers expressed sharing of water resources from excess water available villages to drought prone villages).