ICT-enabled knowledge sharing in support of extension: addressing the agrarian challenges of the developing world threatened by climate change, with a case study from India

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The need for improved agricultural extension throughout the developing world has never been greater. Agricultural and rural development and hence rural extension continue to be in a phase of transition in this part of the world. The vulnerability of farming in the developing world to climate change, to changes in natural resources quality (including desertification over large tracts),and lack of coping and adaptation strategies at micro and macro levels of decision making are all well documented, while globalization of commodity trade offers a mix of opportunities as well as challenges. The role of extension and support systems in this background is undergoing profound changes while no unified alternative framework has emerged (Eicher, 2007). In this paper, we offer some suggestions on building new and more effective linkages between research and extension sub systems in agricultural knowledge systems, with a range of information and communication technologies offering platforms and mediation services. The focus is on assessing the effect of improved information access and development of human capacity in supporting extension processes at the micro-level.

ICTs in the Context of Extension:

Information and Communication Technology (ICT) is an umbrella term that includes computer hardware and software, digital broadcast and telecommunications technologies as well as digital information repositories online or offline (Selwyn, 2002), and includes contemporary social networking aspects, read/write interfaces on the web besides file sharing systems online. It represents a broad and continually evolving range of elements that further includes the television (TV), radio, mobile phones and the policies and laws that govern the widespread use of these media and devices. The term is often used here in its plural sense (ICTs) to mean a range of technologies instead of a single technology.

From the perspective of agricultural knowledge and information systems (AKIs), ICTs can be seen as useful in improving linkages between the research and the extension sub systems. The experience of rural telecenters in the developing world shows that ICT can help in enabling rural development workers to gather, store, retrieve, adapt, localise and disseminate a broad range of information needed by rural families (Davison *et al* 2005). The ICTs in extension can lead to the emergence of knowledge workers that will result in the realisation of a bottom-up, demand-driven paradigm for technology generation, assessment, refinement and transfer (Meera, 2003; Meera *et al* 2004).

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ICTs and Extension in the Context of Climate Change:

The linkages between agriculture and climate are pronounced and often complex. Crops and livestock are sensitive to climate change in both positive and negative ways. Agricultural systems are most sensitive to extreme climatic events such as droughts, floods and hailstorms, and to seasonal variability and changing rainfall patterns. Against this backdrop, farmer adaptations are influenced by many factors, including agricultural policy, prices, technology research and development, and agricultural extension services (Kajfez-Bogataj, 2005). The poor often bear a disproportionate burden of direct damage from catastrophes and climate change as concluded by most studies in developing countries (IPCC, 2001).

The role of inadequate institutional support is frequently cited in the literature as a hindrance to adaptation. For example, Adger and Kelly (1999) and Huq *et al* (1999) show how institutional constraints and deficiencies affected managerial capacities to cope with anticipated natural events.

Many observers of rural development in recent times have commented on the frequent manifestations of unsatisfactory extension performance (e.g., Rivera *et al* 2001). Feder *et al* (2001) have suggested interrelated characteristics of extension systems in the developing world that jointly result in deficient performance, namely low staff morale, reduced efficiency and financial stress etc. One more such key factor is the number of clients and the vast spectrum of information/services needed to be covered by extension systems. Policy makers in the developing world have reacted to this with the deployment of more extension personnel which has continued the emphasis on a more centralized, hierarchical and top-down management systems. The requirement for combining a bottom up approach with the conventional extension process is yet to be fulfilled and the limitations on the extension process to influence issues such as credit availability, input supplies, market linkages and logistics facilitation continue without change. In effect, there has been no visible impact due to such changes within the extension system in many parts of the developing world.

Sulaiman and Hall (2006) have described a range of extension initiatives from the public and private sectors that explain the way extension agenda is expanding as embodied in the concept of "extension plus" and have pleaded for new experiments in extension. Pluralistic institutional arrangements are emerging and are finding wider acceptance and this is mainly because developing countries have realized the need for extension to engage in a wider range of issues beyond merely disseminating production-oriented technologies. Extension pluralism is at the core of farmer adaptation strategies and ICT's can offer new advantages in enabling reliable and rapid access to expert information support which is much needed in the realization of adaptation strategies on a large scale.

ICT-infused extension projects: what do we learn from them?

Leaders in extension research have pointed out the importance of learning from the deployment of contemporary ICT's in extension (Van den Ban and Samanta, 2006). A number of pilot projects in applying ICT in rural development are in progress in many parts of the world (Davison *et al* 2005). Only a small number of these have a bearing on agricultural information sharing and extension. Some of the projects that have relevance in agricultural extension have been analysed a group of scholars facilitated by Keniston *et al* (http://www.iiitb.ac.in/research_egovernance.htm). For the purposes of this paper, we summarize below our inferences from the published studies:

- There is prevalence of top-down approaches with few attempts to reflect the end users' preferences and needs;
- Production advisory services and market information access do not go together in all such efforts;
- In almost all the projects, the participation of agricultural education and research institutions appears to be marginal;
- Localization and customizability of content are still not practiced on a significant scale.

We shall now present the results from an ongoing project of ICRISAT that combines the ICT aspect of extension communication with the instructional paradigm based on the practices of open and distance learning. What emerges is a collection of inferences that can help integrate the requirements of extension pluralism with the advantages that contemporary ICT can bring, namely, improved access to information in the right place and in the right time and enhanced capacity to make use of it in a local context.

The Virtual Academy for the Semi Arid Tropics: a new platform for extension communication

Studies on drought relief and preparedness, carried out in different parts of the world, especially in North America and sub Saharan Africa, were considered by the Committee on Science and Technology (CST) of the UNCCD in formulating a strategy for drought-proofing of vulnerable rural communities. In a series of documents presented at the CST meetings, members made the following suggestions (http://www.iisd.ca/download/pdf/enb04153e.pdf, 2001, visited in June 2001 and in October 2007):

- Preparedness is better than relief and information is the backbone of drought preparedness (UNDP/UNSO, 2000; also Wilhite, 2002)
- An immediate need is to establish an experimental communication system for drought preparedness that combines both the top-down and the bottom-up approaches in information management (CST, 2001 - Canada submission).

ICRISAT proposed a program of community-level drought-preparedness that would combine the suggestions above and would include practices derived from the paradigm of open and distance learning and ICTs applied to rural development. Given that mass learning would be at the core of this effort, the project has been called the Virtual Academy for the Semi Arid Tropics (VASAT). It is a coalition of organizations that have the common goal of improving drought preparedness among vulnerable rural families through improving their coping capacities. The VASAT is positioned as a technology-mediated extension and knowledge-sharing program partnering global as well as national and local organizations (Navarro and Balaji, 2003). More background information on the VASAT is available at http://vasat.icrisat.org. In the CGIAR, ILRI and IWMI have partnered with ICRISAT in this effort.

As part of the activities of the VASAT, two field projects involving the participation of rural organizations were launched in 2004. They are located in India and Niger. In both the sites, an established community-based organization serves (CBO) as a partner while ICRISAT and coalition partners provide information and learning inputs to the CBO members in various aspects of enhancing drought preparedness at micro-level. Towards fulfilling this purpose, experts in ICRISAT and partner organizations have developed a number of learning modules (Table 1) all of which are placed in the public domain. Our work in the Addakal region (South Central India) will be described in some detail as a case study in this paper.

1. AMS-The Community-based Partner Organization:

Addakal is a block of 37 villages in the Mahabubnagar district of Andhra Pradesh State in India (Map 1). It is officially a development block of the State and the block has a population of 45,688 with a sex ratio of 0.966 (Census of India, 2001). Addakal's economy revolves around semi-arid agriculture and livestock. Out of 14616.40 ha of cultivated land, around 11440 ha are cultivated under rainfed conditions. More than 70% of the farmers are small and marginal farmers. Addakal is in a low rainfall region and its average rainfall was 512 mm during 2003 and 425 mm during 2004, more than 90 percent of it occurring during the period June to October. Without any major irrigation system, agriculture depends on the scanty rainfall. Castor, pulses, groundnut and rice are the major crops in the block. Cropping intensity is also low. Similar to other SAT regions Addakal also depends on livestock. Nearly 70000 sheep, 9000 cattle and 8000 goats are helping the people of Addakal to survive the vagaries of the local climate. However, there has been noticeable lack of drought-coping and support systems in the locality, and, large scale out-migration has become the principal drought-coping mechanism of the people in this area while suicides among the farm families have started to occur since 2004 (Gaharwar, 2005).

The principal community-based organization here is the Adarsha Mahila Samaikhya (AMS- the Adarsha Women's Welfare Organization in English) which is a federation of all-women micro-credit groups that functions in the Addakal Block. It has a membership of 5200 women, covering all the 37 villages in the locality.

The AMS has been operating in this area since 1994 to address various development issues of rural families resident in the area. It has a campus of its own on land made available by the local government with the finances contributed by the elected Member of Parliament. It houses the credit federation offices, a restaurant for travelers on the highway, a market for local produce and a training center to impart income generating skills to rural women. The AMS, with the support of the State Government, 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.

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. The AMS also set up village access centers in three villages each with its own set of PC's and low cost internet access.. They also provided for local level managerial support and pay for principal operational costs such as electricity and communication. The ICT-based hub in their premises as well as the village access centers are operated by AMS rural women volunteers. The population covered is approximately 12300 and the cultivated area in the June-October season in all the three villages is about 1940 ha. ICRISAT and VASAT partners provide capacity strengthening support and technical advice. The AMS volunteers maintain hard copy registers of all user queries and the responses on a daily basis.

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 Addakal block. This study yielded interesting results, which showed, from the points of view of rural families resident in the area, that macro and meso level Knowledge-based development organizations had limited reach with the village community. Mass media, rural development offices of the local government, agricultural input companies etc. appeared to have strong linkages while natural resource management based education and research institutions and local banks had weaker linkages. The 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. Input suppliers and other agricultural traders were about the most important source of information. The linkages with the agricultural extension processes were assessed by the rural residents to be generally weak. Market, climate, employment and wages emerged as some the important information needs of the community. 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. Since the start in 2004, ICRISAT has helped the AMS, whose members manage the information hub, in designing a simple and daily information service covering local weather, wages and market information besides providing occasional other services such as rapid delivery of 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. A number of joint experiments have been carried out in the last two years to assess the impact of improved information access and enhanced capacity of women intermediaries in facilitating the extension support processes.

Experiment 1 :Does Addition of Learning Make a Difference in Improving Agriculture-related Query-Answer Processes?

This was a research objective in one of the studies carried out by ICRISAT and AMS. A number of ICT-for-development projects in India and elsewhere consider fulfilling farmer-queries as a key service. The *Kisan Call Centers* program in India was set up in 2004 to support farm production through provision of expert answers, and used landline telephones and call-center-style arrangements to answer farmer queries. This program is an evolving one and there is no reported study on its impact yet. A number of projects such as the e-sagu (http://esagu.org), also operating in India, have developed new approaches to Q&A between farmers and experts using computer-based interfaces. Our hypothesis was that adding an element of learning among the credible "info-mediaries" might lead to more effective and satisfactory (from the farmer's point of view) responses than design of interfaces on telephone or PC-based platforms.

Besides providing standard information services, the research team developed a blend of approaches that allows for flexible learning using ICT mediation. The AMS volunteers acquired proficiency in the basics of IT and in the essentials of natural resource management. ICRISAT, with advice from the Commonwealth of Learning, (www.col.org) organized the generation of learning modules on drought for the village women. In a series of field-based studies, we found that the practice of closely-packaged modules, standard in class room learning, did not suit the requirements, capacity and pace of learning of the rural women learners (Balaji and Navarro, 2004). The content needed to be presented as granules that support short-duration learning by people who have been outside the class room milieu for at least several years. Ingraining this practice, ICRISAT experts re-designed the modules. The state Open University and India's Central Research Institute for Dryland Agriculture (CRIDA) (a NARES partner, www.crida.ernet.in) joined in the conversion of learning materials into Telugu, the local language. The AMS volunteers took up the modules in a mostly self-study mode and completed about 100 hours of learning in three months.

During and after this training, the volunteers of the AMS went around their own villages gathering queries from the farmers, especially those that were known to be small or marginal farmers. he queries were transmitted using email (as PDF attachments to preserve the Telugu language fonts). They were posted to an online content management system (the ATutor (www.atutor.ca), which is an open source learning management system that is widely used in many universities). ICRISAT scientists on a voluntary basis answered these queries and the AMS volunteers assessed the satisfaction level directly from the farmers.

In the experiment, three volunteers trained in info-mediation were given additional support in learning about the basics of pest management in crops. A module prepared by ICRISAT experts was rendered into Telugu and the info-mediaries or volunteers were administered the granules over a period of three days at different times and intervals. The purpose was to help the volunteers "refine" farmers' queries before passing them on to the experts. In a span of one month after the learning, it was found that the time-to-satisfactory response declined from about 6 days to less than 24 hours, going down to as low as 8 hours (Dileepkumar *et al* 2005; also see Table 2 below).

Similar topics were discussed with the volunteers on crop rotation and on the use of micro-nutrients in farming. The farmers pointed out that because of prevalent wild boar attacks in the area, crop rotation was not practical, while the interest in soil testing and micro-nutrients use has developed to a considerable level. Absence of local services and suppliers is the only factor preventing the wider adoption of these practices now.

Experiment 2: Video-conferencing and Online Forums in Support of Agriculture-related Q&A Processes:

Since March 2007, we have used a two-way video-conferencing facility (donated by the Indian Space Research Organization in association with the M S Swaminathan Research Foundation) to assess changes in the effectiveness of query-responses when a new digital medium is used. The video-conferencing process required certain adjustments in communication habits because of the high latency in connection (resulting in delay in voice reaching the destination). During the seven months since the conferencing began, a weekly meeting of two hours is organized with a junior expert at ICRISAT receiving the queries. The Addakal side invites farmers with queries to join the sessions. The young expert does not attempt to answer the queries unless they are of a routine nature. The questions are first clarified and refined with adequate details by the AMS-based volunteer who conducts the session. The questions are noted and are uploaded to an online forum (www.aaqua.org) which has features to enable any registered expert to view the queries and answers. ICRISAT or ICAR experts have generally provided answers (in English) and now answers have started to come in from India's principal network of farmers' training centers called the Krishi Vigyan Kendra (farm Science Centers) or the KVK's. In terms of numbers, so far, 22 sessions have been held, 172 unique queries were received and answered; the KVK-based subject matter experts in a different state of India have provided responses to 37 of these over the last 9 sessions and the number of queries fielded by them is on the increase.

A detailed study of the communication patterns and the emergence of links with distant KVK-based experts has just commenced. The farmers in general expressed the view that the video-conferencing could be more effective if the voice-latency issue is addressed by the service providers but appreciated the quality and relevance of the answers or responses received from the experts. The effort involved in intermediation and facilitation for an effective video session with farmers is rather intensive, especially if one includes the effort involved in processing expert responses. This is where prior capacity development of the rural info-mediary is found most useful. While investments in human and other resource terms are high, when effectiveness is considered, video-conferencing with opportunities to receive responses in the immediate aftermath is a highly appropriate channel to work with. Since India has announced a program to set up 7000 village resource centers serving about 70000 villages, carefully planned research on the use of this tool as an extension support will be useful and can contribute to wider use of video-conferencing in other parts of the developing world.

Experiment 3: Improving Micro-level Drought-preparedness Using GIS-derived Tools:

As part of our studies on the use of ICT-based techniques to enhance drought preparedness among rural families, we adapted a technique for micro-level drought vulnerability assessment developed by Nagarajan and co-workers in India (http://www.icrisat.org/vasat/research/gis.htm). The technique involves the use of satellite-imagery for a given area, a cluster of villages, and overlaying it with verified use of surface and ground water usage in the area. This helps in estimating the demand on local water resources in a particular season and the quantum of rainfall necessary to fill the deficit. Degrees of drought vulnerability based on different rainfall scenarios are then prepared and overlaid on the map, and color codes to indicate various degrees of severity are assigned (red indicates higher severity while green indicates a business-as-usual scenario). A set of such maps were prepared for twelve contiguous villages in Addakal cluster for the June-October season in 2006 while the ICRISAT agro-meteorology expert predicted the quantum and distribution of rainfall in the area chosen. Scenarios of drought vulnerability from a base line of 300 mm rainfall to 900 mm were computed. Two most likely scenarios based on the seasonal prediction for the local area were identified (maps 2 and 3). These were then shared with the AMS volunteers who held village meetings in places considered highly vulnerable. The task was to verify the correctness of the projections as perceived by the rural families. The AMS volunteers also trained themselves in rainfall measurements using a simple rain gauge (certified by the India Meteorological Department) and uploaded the data on a daily basis to a site maintained by ICRISAT with irrevocable date/time stamps of the upload (Figure 2). At the end of the season in November 2006, we conducted an appraisal with 180 individuals in the villages covered to record their perceptions about the degree of severity of drought felt. More than two-thirds of the respondents felt that the projections derived from the color-coded maps were useful, and more than half of those interviewed felt that this tool would be useful in making decisions on continuing or abandoning cultivation. The study has continued into the same season in 2007 (Dileepkumar *et al* 2007). Clearly, approaches such as these will have implications in planning micro-level adaptation strategies in the context of climate change. Potentially vulnerable families now have the means to estimate their own vulnerability and can use this information to make more informed decisions, which offers a sounder basis for designing adaptation strategies.

VASAT: Implications for Extension

The experiments on VASAT in field locations in India offer some clues for the development of new linkages between the research and extension sub systems. It is clear that new intermediaries in rural locations to support ongoing, conventional extension processes are needed in view of the near-impossibility of tackling the scale and demands for services required of extension personnel. The challenges of climate uncertainty require even faster response times than originally envisioned. The results emerging from the VASAT field studies show that when creatively deployed, ICT-based support systems can provide more in terms of quality information services that are accurate as well as timely. It is also possible to formulate newer linkages with different components of the extension system (as happened with distant extension workers responding to queries on the aAQUA site) provided the extension workers have access to online information systems however limited is the connectivity. The challenges addressed in the VASAT activities that have implications for extension practices are:

- Agricultural information support services offered with ICT infusion should be part of a wider range of general information services.
- Involvement of credible individuals from the locality as facilitators or intermediaries is essential to the sustenance of the information service as whole.
- Such facilitators need to have their capacities newly developed in the essentials of practical agriculture so that they are in a position to relate to extension personnel online or offline. The approach should be based on building science literacy.
- Methods derived from the open learning paradigm, especially those that ingrain the practices of teaching those with very limited class room exposure should be adapted in designing the capacity strengthening activities.
- Content needs to be aggregated by experts from different sources but it needs to be stored in granular format for rapid adaptation for local use
- Vulnerability analysis with contemporary tools needs to be scaled sufficiently to a micro-level so that potentially affected people can apprise them and make use of them
- Services availability in terms of input supply and testing need to be integrated with information and advisory services for greater impact
- Strong linkages with national and local organizations responsible for extension and research are necessary for rural organizations to sustain their information services. Conversely, national and

local extension organizations need to develop their capacity for online services management in order to make effective use of ICT-based channels that are increasingly becoming available with local and community-based organizations.

It is clear that further experiments on a much larger scale are necessary to assess the usefulness of ICT-mediated information services in supporting extension in general and in improving the coping strategies for coping with drought. It is also clear that expert-based and expert-derived information services can be easily aggregated into a digital knowledge organization that can combine different types of sources (Figure 5). For more effective extension support, new information delivery and exchange services covering both digital and non-digital channels need to be developed for reach as well as impact (Figure 6). ICRISAT has recently formed a consortium of state agricultural universities and India-based institutions of higher learning in ICT for developing such a knowledge organization in agriculture which proposes to build new linkages in the education-research-extension continuum. The activities of this consortium are expected involve at least 30000 farmers in three different regions of dryland India over a period of two years. The aim is to generate results on a scale that can be useful in building a model for the effective infusion of ICT-mediated services in support of extension that is oriented towards farmer adaptation. Capacity development and learning opportunities on a mass scale are viewed as the glue that will bind the new linkages over a long term.

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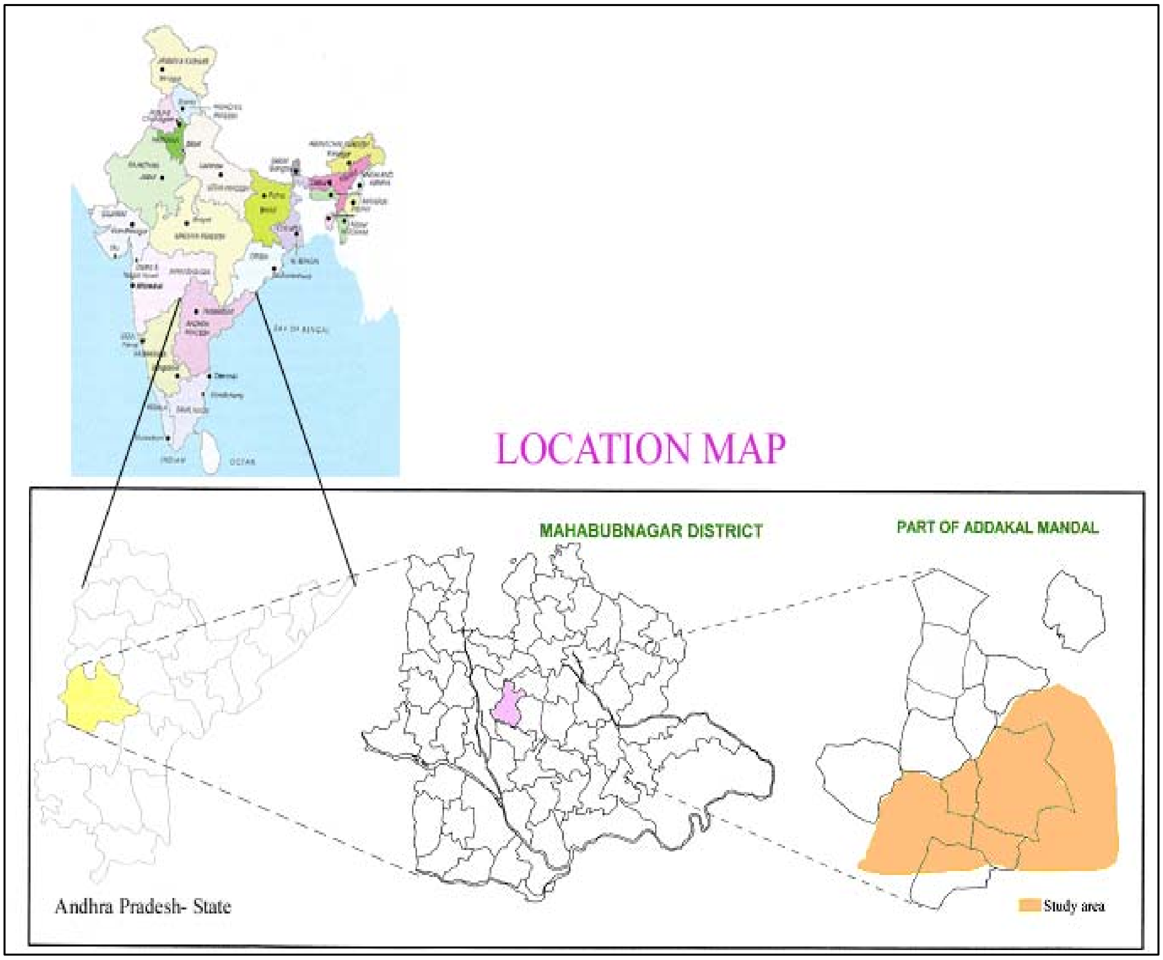
Table 1: Learning resources available on VASAT Website

Coping with Drought	Pearl Millet Diseases
Groundnut Production Practices	Pigeonpea Course
Groundnut Insect Pests	Chickpea Course
Groundnut Diseases	Crop-Weather Relationships
Sorghum Production Practices	FAQs on Organic Manures and Fertilizers
Sorghum Insect Pests	Micronutrients
Sorghum Diseases	Vermicomposting
Pearl Millet Production Practices	Soil and Soil Health

Table 2: Analysis of data on queries and response times collected during ICT- mediated agro-advisory process (Dileepkumar *et al* 2005)

Date	No. of questions	Repeated questions	New questions	Un-answered	Date answers provided	Process duration
1st October	8	3	-	0	7th October	6 days
2nd October	6	4	-	0	7th October	6 days
14th	17	14	3	0	18th October	4 days
After training						
24th	2	0	2	0	24th October	8 hours
4th	17	12	5	0	5th November	31 hours
14th	24	16	8	0	15th	26 hours



Map 1 : Location Map of Addakal Mandal, Mahabubnagar District, India

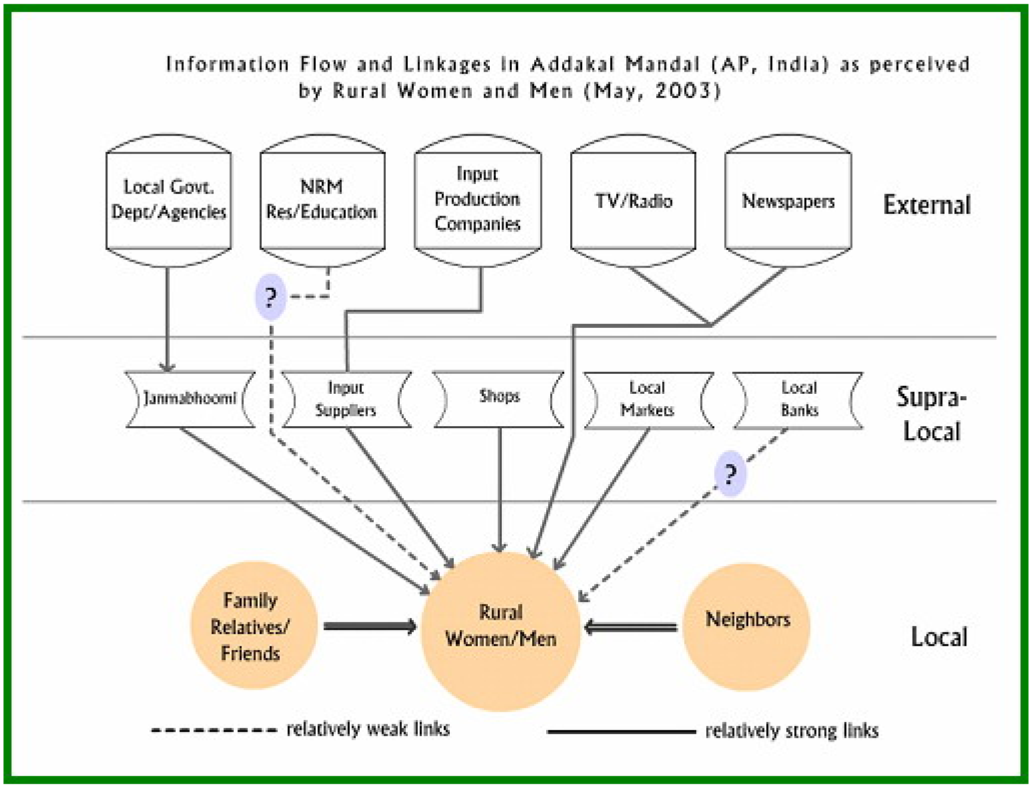
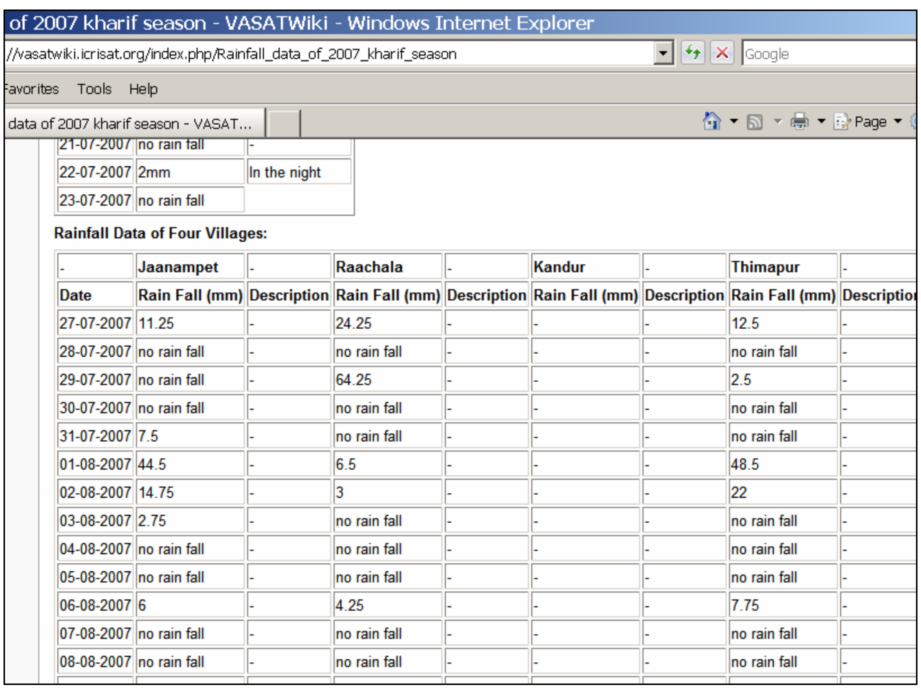


Figure 1: Information Flow and Linkages in Addakal Mandal



21-07-2007	no rain fall	-
22-07-2007	2mm	In the night
23-07-2007	no rain fall	

Rainfall Data of Four Villages:

-	Jaanampet	-	Raachala	-	Kandur	-	Thimapur	-
Date	Rain Fall (mm)	Description	Rain Fall (mm)	Description	Rain Fall (mm)	Description	Rain Fall (mm)	Descriptio
27-07-2007	11.25	-	24.25	-	-	-	12.5	-
28-07-2007	no rain fall	-	no rain fall	-	-	-	no rain fall	-
29-07-2007	no rain fall	-	64.25	-	-	-	2.5	-
30-07-2007	no rain fall	-	no rain fall	-	-	-	no rain fall	-
31-07-2007	7.5	-	no rain fall	-	-	-	no rain fall	-
01-08-2007	44.5	-	6.5	-	-	-	48.5	-
02-08-2007	14.75	-	3	-	-	-	22	-
03-08-2007	2.75	-	no rain fall	-	-	-	no rain fall	-
04-08-2007	no rain fall	-	no rain fall	-	-	-	no rain fall	-
05-08-2007	no rain fall	-	no rain fall	-	-	-	no rain fall	-
06-08-2007	6	-	4.25	-	-	-	7.75	-
07-08-2007	no rain fall	-	no rain fall	-	-	-	no rain fall	-
08-08-2007	no rain fall	-	no rain fall	-	-	-	no rain fall	-

Figure 2: Rainfall data uploaded from participating villages

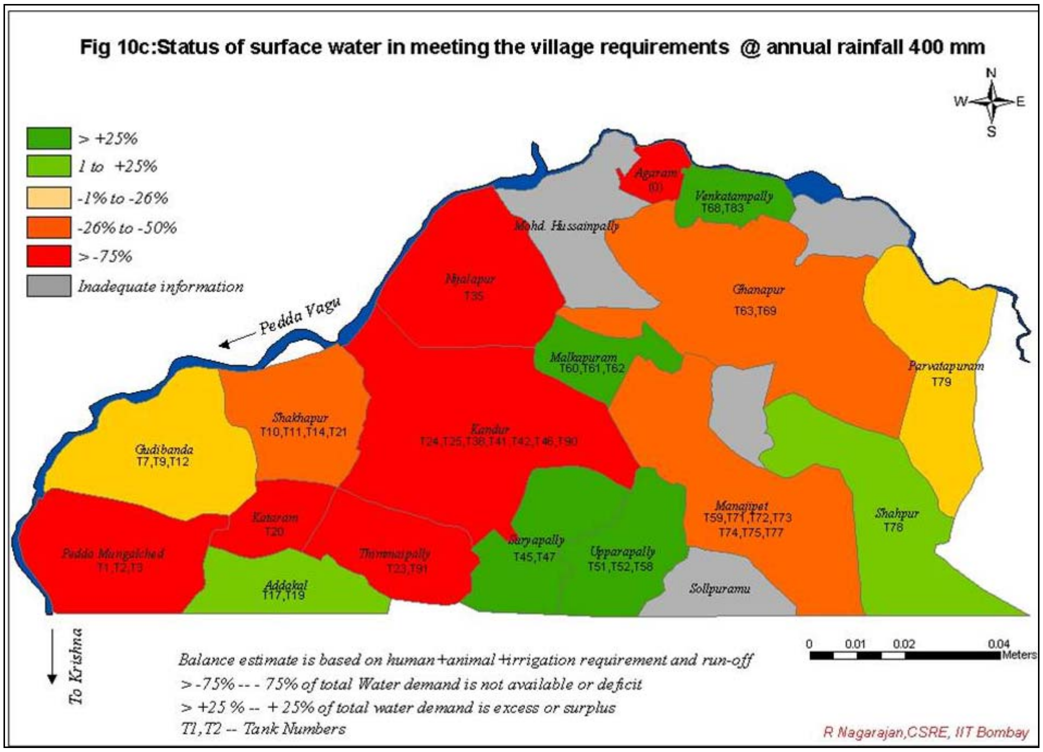


Figure 3 : Drought vulnerable villages in Addakal block at an annual rainfall of 400mm

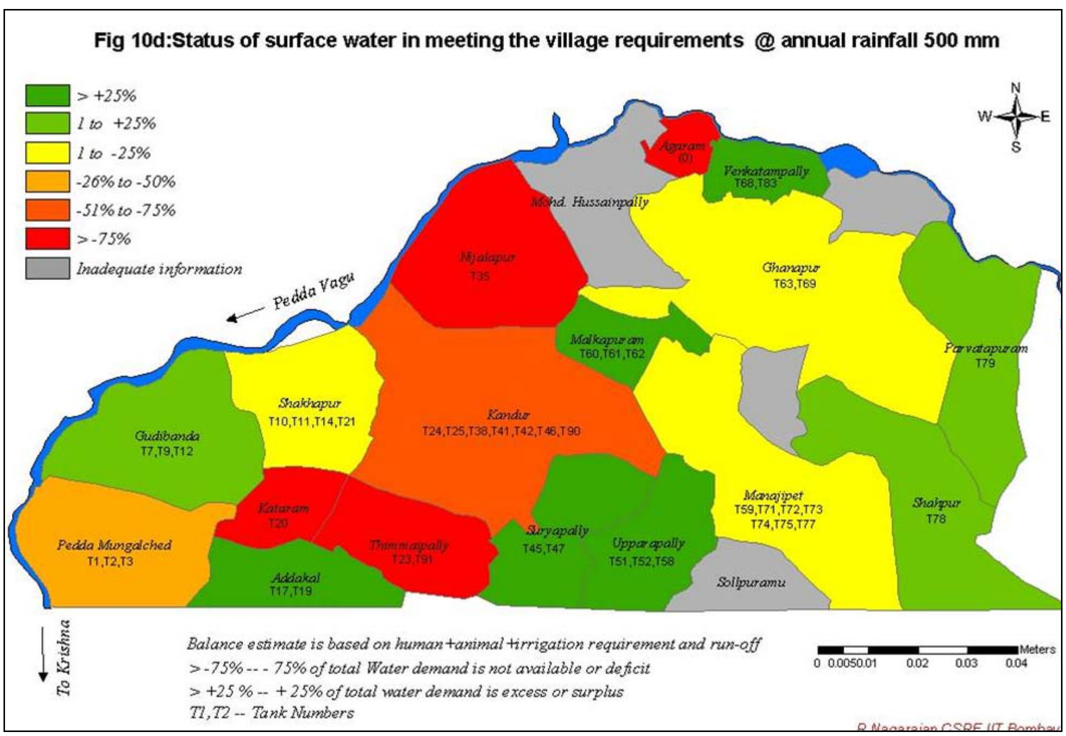


Figure 4: Drought vulnerable villages in Addakal block at an annual rainfall of 500mm

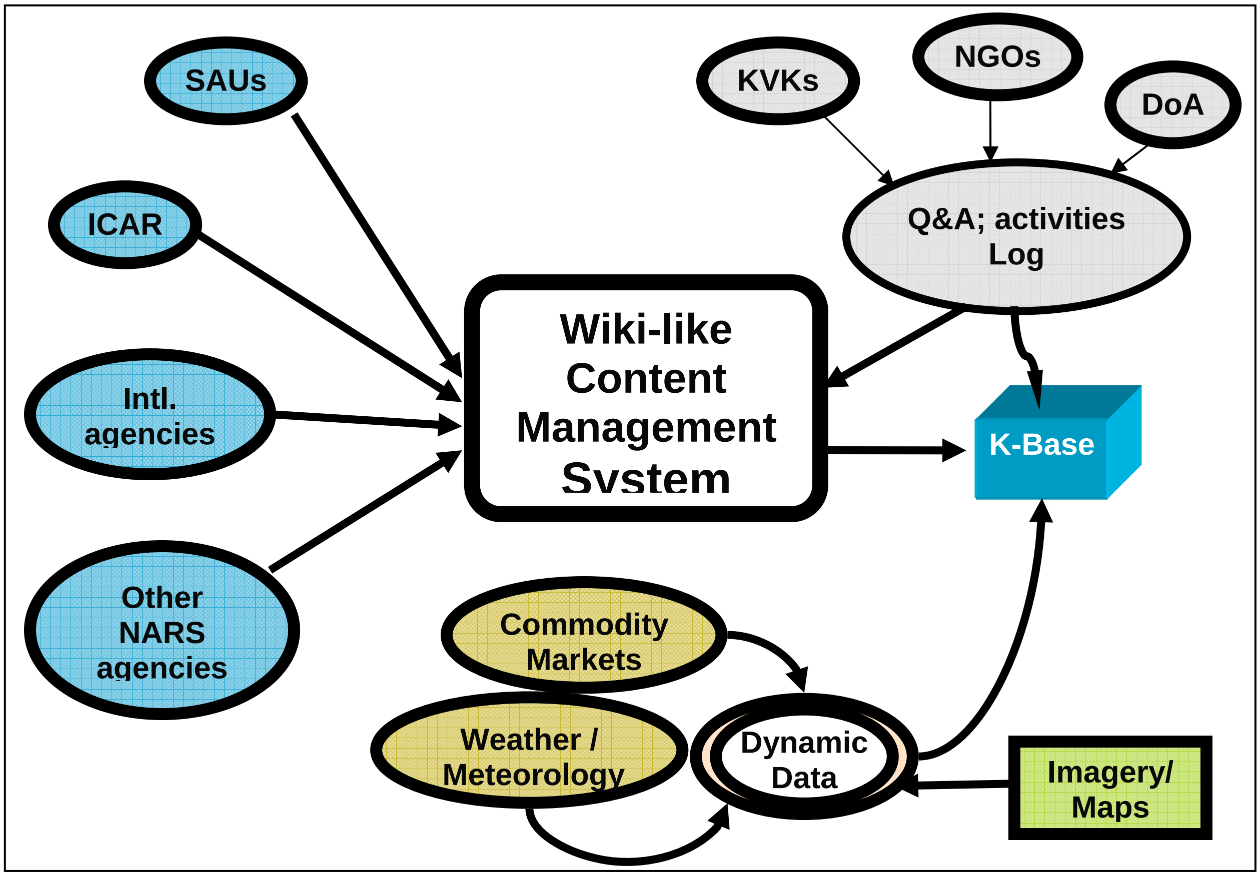


Figure 5: Proposed Digital Knowledge Organization in support of Agriculture (India as a case)

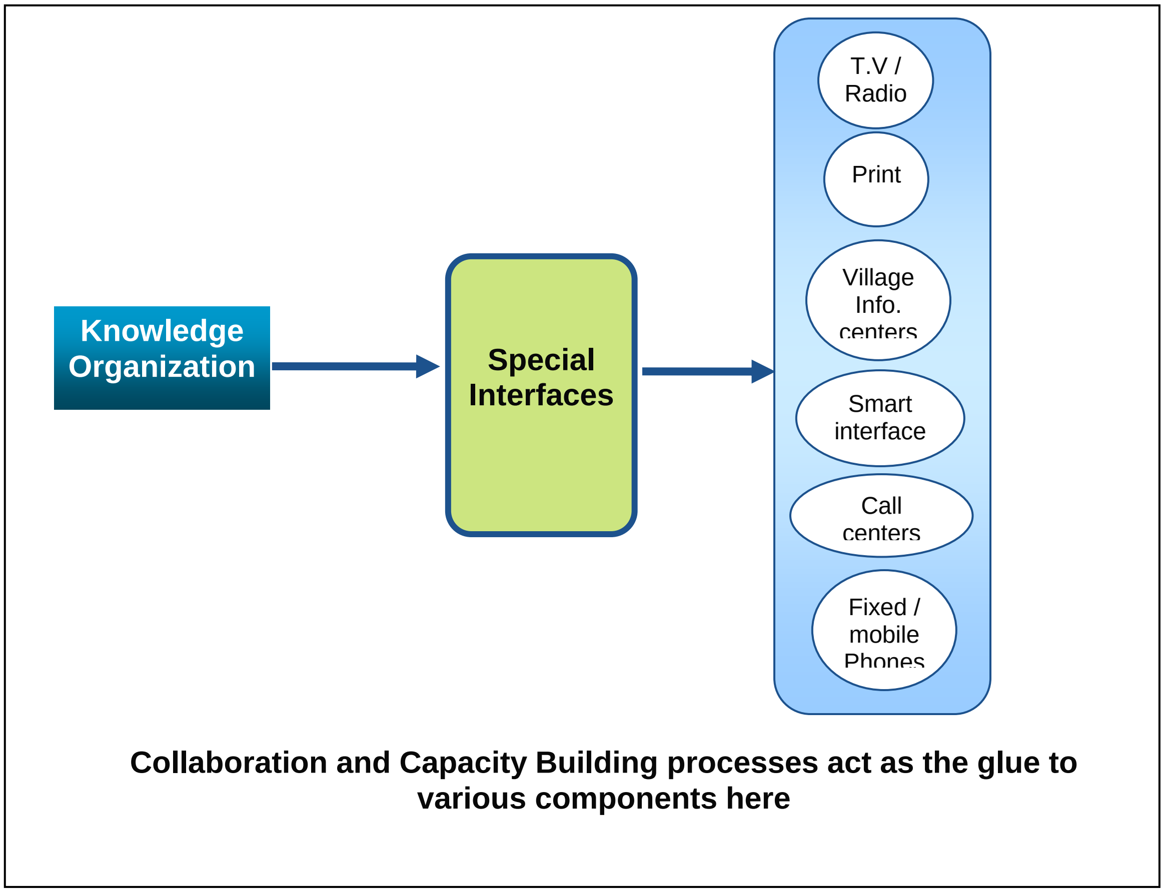


Figure 6: Proposed Content Delivery and Exchange services in support of Agricultural Extension