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Agriculture has been a part of human life since the beginning of the human race and the need for agricultural information is probably almost as old as agriculture itself. Babylonian clay tablets have been found that contain agricultural information. Blanchard (1997) hypothesized that, "the great library at Alexandria undoubtedly had many treatises on agriculture inscribed on papyrus". Throughout history, in many civilizations, there have been libraries that have included agricultural information, and separate agricultural libraries were established in Europe in the mid-eighteenth century.

In India, special attention was paid to development of an agricultural research infrastructure immediately after Independence. The Indian Council of Agricultural Research (ICAR) acts as a repository of information and provides consultancy on agriculture, horticulture, resource management, animal sciences, agricultural engineering, fisheries, agricultural extension, agricultural education, home science, and agricultural communication. It has the mandate to coordinate agricultural research and development programmes and develop linkages at national and international levels with related organisations to enhance the quality of life of the farming community. ICAR has established various research centres in order to meet the agricultural research and education needs of the country. It is actively pursuing human resource development in the field of agricultural sciences by setting up numerous agricultural universities spanning the entire country. The Technology Intervention Programmes also form an integral part of ICAR's agenda which establishes Krishi Vigyan Kendras (KVKs) responsible for training, research, and demonstration of improved technologies. Agriculture universities were set up in various states and national level agriculture labs were established under the ICAR. Presently there are 38 state agricultural universities, 37 research institutes, five research bureaus, 17 national research centres, seven project directorates and other allied departments. These universities and laboratories have helped in bringing the Green Revolution, White Revolution, and Blue Revolution , and have helped the country to come out of the situation of food scarcity and achieve food self sufficiency and food surplus.

The Indian agricultural sector provides employment to about 65% of the labour force, accounts for 27% of the GDP, contributes 21% of total exports, and provides raw materials to several industries. The livestock sector contributes an estimated 8.4 % to the country's GDP and

35.85 % of the agricultural output. India is the seventh largest producer of fish in the world and ranks second in the production of inland fish. Fish production has increased from 0.75 million tons in 1950-51 to 5.14 million tons in 1996-97, a cumulative growth rate of 4.2% per annum, which has been the fastest of any item in the food sector, except potatoes, eggs, and poultry. The future growth in agriculture must come from new technologies which are not only "cost effective" but also "in conformity" with natural climatic regime of the country (Singh, 2004); technologies relevant to rain-fed areas specifically; continued genetic improvements for better seeds and yields; data improvements for better research, better results, and sustainable planning; bridging the gap between knowledge and practice; and judicious land use resource surveys, efficient management practices, and sustainable use of natural resources.

Recommendations of the United Nations Conference on Environment and Development - Agenda 21 (United Nations 1992) on "Information for decision-making" are the development of indicators for sustainable development; promotion of global use of indicators for sustainable development; improvement of data collection and use and methods of data assessment and analysis; establishment of comprehensive information framework; strengthening of capacity for traditional information; production of information usable for decision making; development of documentation about information; establishment of standards and methods for handling information; establishment and strengthening of electronics networking capabilities, and making use of commercial information sources. The Agenda-21 recommends major adjustments in agricultural, environmental and macro-economic policy to create the conditions for the Sustainable Agriculture and Rural Development.

Digital Technologies and Agricultural Information

Contemporary challenges facing agricultural information parallel those facing agricultural research and practice. Agriculture today must feed a growing population in a world of static or shrinking natural resources and increasing social and environmental constraints. Agricultural information professionals similarly must support agriculture by managing and improving access to a proliferating and increasingly complex array of information resources in a climate of shrinking resources and expanding constraints. Yet both fields have access to powerful resources and technologies. Informatics for agricultural development requires coordinated inter-sectoral approach and application of appropriate information technology (IT) tools. For increasing production at micro level, an inventory of those currently used and potentially available, and an evaluation of the quantity and quality of these resources is required. This requires design and development of agricultural resources information system using state-of-the-art IT tools, as given below, to facilitate effective agricultural planning and development:

- Data warehousing (Data Bases & Model Bases)
- Expert Systems & Knowledge Bases
- Networking (Internet, Intranet and Extranet)
- Geographical Information System (GIS)
- Application of Remote Sensing Data
- Multi-media Information System
- Decision Technology System

- E-Commerce & E-Governance, and
- Digital Library / Virtual Library

Digital preservation, processing, and managing of agricultural information involves a number of issues and problems. The process initially starts with preservation of information in archives or by conversion to other digital formats. The second issue facing agricultural research and information is the rapid growth of technology, whether biotechnology or information technology, which also influence agricultural information management. Technological advances create new challenges and often require new skills and infrastructure. The third issue is diversity. Agriculture practice and research are becoming increasingly interdisciplinary while serving widely diverse populations. Agricultural information experiences a high level of diversity, too, in content, format, technology, audiences, and services. Understanding the central models and metaphors of a profession helps information professionals in two ways. First, it provides insight into the thought processes of users, which leads to better understanding of their information needs. Second, thinking metaphorically and abstractly offers fresh perspectives on the profession and sparks new insights and practices.

Multimedia Channels and Case Studies

Agriculture is a mainstay of the state economy, and it is the role of government to motivate and instruct the farmers about new developments in agriculture. As a result, the government has set up various institutions, agricultural universities, centers, and agencies such as T&V (Training and Visit), other extension agencies such as Krishi Vigyan Kendra (Reddy, 1987; Bihari et. at, 2001).

Agricultural extension is aimed at promoting agricultural development by providing information on improved production technologies and their adoption. The Directorate of Extension (DOE) is a national agency that implements specific programmes and activities. Though agricultural extension is primarily the responsibility of state departments of agriculture (SDAs), the Directorate of Extension works in collaboration with SAUs andICAR Institutes. The programmes and activities of the Directorate are in areas like extension management, extension training, farm information and farm women's development.

The Extension Management Unit of the Directorate operates the Central Sector Scheme "Strengthening of Agricultural Extension Services," which includes NGOs in the extension network. The Unit also monitors and implements the "Innovations in Technology Dissemination" component of the World Bank-aided National Agricultural Technology Project (NATP). This scheme strengthens the training infrastructure, including the National Institute of Agricultural Extension Management (MANAGE), four regional Extension Education Institutes (EEIs) and 15 Centres of Excellence (CETs) established at ICAR/SAUs and other Central Institutes to provide training in various areas. The Farm Information Unit of DOE extends information support through the Central Sector Scheme on "Information Support/Management Information System," which organizes exhibitions, shows, and fairs.

Extension workers are the most important source in transmitting technology to users (Sharma 2003). Radio, television, publications, demonstrations, tele-conferencing and Internet technology have all been used to accomplish this (Singh et. al. 2003). The Internet plays a major role in the transfer of high-tech agriculture technologies from global pocket to farmers' field (Kumar et. al., 2002). For developing countries, the use of the Internet in farm decision-making is much less. Only 12% of farmers use this technology, and the majority of them use traditional technologies like radio (77.3%) and newspapers (11.3%) (Cecchini, 2002). Agricultural extension agencies must make farmers aware of the use of the Internet in

technology transfer. This can help farmers keep pace with rapidly changing agricultural technologies (Vashistha, 1987).

The Union Agriculture Ministry is considering a proposal to revamp the ICAR along the lines of the Council of Scientific & Industrial Research, to bridge the gap between technology generation and technology dissemination, since 60 percent of farmers have no access technology as revealed by the latest National Sample Survey Organization report (Suryamurthy, 2005).

Sharma (2003) states that,

> "Quick dissemination of technological information from the Agricultural Research System to the farmers in the field and reporting of farmers' feedback to the research system is one of the critical inputs in transfer of agricultural technology. The information and communication support during last 55 years has mainly been conventional. The extension personnel of the Department of Agriculture disseminated the technological messages to the farmers manually. Through this approach information has not been able to reach majority of the farmers who are spread across the whole country. This gap remains a challenge for the Extension system even today. ... Farmers' needs are much more diversified and the knowledge required to address them is beyond the capacity of the grass root level extension functionaries".

It is possible to find a solution to this situation using information technology to meet the location specific information needs of farmers. Information and communication networks are expanding quickly. The number of Internet connections in India has crossed the two million mark and the number of telephone connections is over 22 million. The weak linkages among extension, research, marketing networks, and farmers limits the ability of research and extension to contribute to agricultural development. The government of India is addressing this problem through national programmes. The use of the vernacular press, radio, and television for reaching farmers is being augmented with state-of-the-art communication technologies such as Internet and satellite communication. Under the NATP initiative, adequate attention is being paid to ICT connectivity. This connectivity will facilitate two-way communication among all the stakeholders in the Research-Extension-Marketing-Farmers loop. Apart from core Information and connectivity, other forms of audio and visual communication like Satellite Communication (SATCOM) are also being promoted. Cyber Extension includes effective use of information and communication technology, national and international information networks, Internet, Expert Systems, Multimedia Learning Systems, and Computer based training systems to improve information access to the Farmers, Extension Workers, Research Scientists, and Extension Managers.

A report from the Food and Agriculture Organization of the United Nations (FAO) states that,

> "Most developing countries are rushing to join the Internet age. India, in particular, invested heavily in telecommunications infrastructure over the last decade, and now has Internet connectivity down to District level throughout the country. Policies to improve information and information communication technologies policies are fragmented in many countries and the capacity to implement them is weak. It is wrong though to assume that that without access to the internet, communities do not have existing information systems of any substance. This can lead an overly optimistic technologically deterministic approach to the conclusion that the problem will only be solved if the existing information networks are replaced with modern systems. Furthermore, this

> runs the risk of losing farmers rich, vital, experiential knowledge of agriculture, much of which circulates in local informal networks, and of undermining trust and social systems. Many organizations are incorporating this information within the new information systems. The CAB International manages a wide range of information resources of existing agricultural information, through publications, CD ROMs and research studies. A recent CD-ROM and Internet-based database contains farmer-based information on 200 crops and 150 countries including images and descriptions of over 1800 pests, diseases and weeds. This is also happening in developing countries. The National Innovations Foundation (NIF) in India has been established to build linkages between excellence in formal scientific systems and informal knowledge systems." (FAO 1996)

The major medium of communication among the research and extension agencies in India is still face-to-face communication. The DAC (Department of Agriculture and Co-operation)-ICAR interface at the highest level provides the interaction platform for the policy makers in the Department of Agriculture and Cooperation and the Senior Scientists of ICAR.

The report adds that,

> "Agricultural research and extension has undoubtedly contributed profoundly to development as demonstrated by the Green Revolution, but the combination of a reduction in public research budgets, a globalizing market and the information explosion has created a more complex knowledge landscape. Information on demand and markets is becoming increasingly important to minimize price fluctuations due to over or under-production, and help farmers get the best price for their products (see for example Foodnet in Uganda). The role of international development institutions is increasingly to transfer knowledge to intermediaries, and to manage knowledge as an international or global public good. This role is particularly important to ensure that good information is available to poor rural farmers and developing countries with limited public sector information management capabilities. New organizations are emerging in many countries to provide a wider range of practical and information services to rural communities, for example The National Institute of Agricultural Extension Management (MANAGE) in India, and the National Agricultural Advisory Services (NAADS) in Uganda. Information systems will need to combine the benefits of new information and new information technologies with the advantages of traditional knowledge and traditional communication networks to do this." (FAO 1996)

Government and NGOs have made efforts to educate farmers about agricultural technology, but successful cannot be ensured unless farmers put the technology into practice in the right way. It has been found that farmers are reluctant to adopt new technology. Hence, the first requirement is the development of human capital, which is the main problem of any developing country. This could be done through collaborative efforts of libraries, extension people and farmers.

Agricultural Libraries

Francis Crick, Nobel laureate and one of the discoverers of the molecular structure of DNA, has observed that "communication is the essence of science" (Crick, 1979). The first part of his article has examined one part of the communication process: the creation of agricultural information from its many sources and in its many forms. Another critical part of this large scale communication process is storing and making available what has been created so that the

link between one mind and another will be complete. The largest and best agricultural libraries are generally affiliated with the largest and best agricultural research programs. In the US, for example, the older and larger land-grant institutions have generally excellent agricultural collections, most with special strengths important for regional research interests. The US National Agricultural Library (NAL) houses perhaps the largest and richest collection of agricultural and forestry-related materials in the world, and is especially strong in Americana but replete with materials from around the world. In the United Kingdom, the CAB International libraries, located at the various Commonwealth research bureaus and institutes, collectively represent very strong European materials as well as literature from developing countries. Agricultural holdings in the British Library are truly impressive, with special strengths in twentieth-century journals and conference proceedings from around the world. In addition to strong national library collections, most countries also have specialized libraries associated with major agricultural research organizations. The FAO library in Rome contains an impressive collection which is especially strong in materials from Africa, South America, and Asia (Jones, 1998).

Kranich (2004) outlined progress toward using new technologies and suggests strategies for helping universities and their research libraries reap the benefits of adopting these new models of access and participation over the coming years.

> "New methods for creating and disseminating scholarly information provide extraordinary opportunities to transform research libraries into 21 st century institutions for collective action. Actually, this transition began as far back as the mid 20th century. Clifford Lynch has cogently summarized the four stages of this transition, beginning in the 1950s with the automation of day-to-day library operations, followed by reference use of computerized databases in the late 1970s, then direct patron access to the Internet in the 1990's, and finally purchase of commercial databases and digitization of collections to digital formats. By automating and then networking their operations, librarians built bridges that connected collections and reference services directly to faculty and students needing context, connectivity, content, and capability to navigate the bewildering sea of information flooding their desktops. As a result, libraries are now available to anyone, anytime, anywhere, although many of their collections are restricted for use by specified communities."
>
> Further the article says,
>
> "[R]esearch libraries began transcending from automated information providers to digital information collaborators. Today, many librarians are expanding their information organizational role into knowledge management and electronic publishing, greatly increasing the availability of resources for teaching and research.. Rather than simply supporting the work of the academy, librarians are now becoming partners in a common enterprise that relies on their leadership and vision. 21 st century librarians are working together with information/learning communities to enhance the production, availability, and preservation of knowledge; collaborating beyond their facilities to create active, resource-based learning models that encourage critical thinking; and fostering the creation of information communities, both within and outside the library."

Trends in Seeking Knowledge from Multiple Channels

Agriculture extension workers do not reach every farmer and every farmer cannot attend agricultural fairs. Hence there is limited flow of information about the latest agri-

technologies. However, there are multiple channels available for the transfer of knowledge from the laboratory to farmers. With the availability of multi-disciplinary information for integrated agricultural development and availability of technology-based multi-media information systems, opportunities are available for easy transfer of knowledge from the information generators to the information users. A majority of farmers in developing countries are not information literate and do not have access to the Internet. Some farmers visit rural public libraries to spend their leisure, but in the majority of public libraries, information that can be of use to them is not available. Libraries must play a role in transferring information.

Libraries have a crucial role to play in bridging the technology gap between available information and information in the hands of farmers. Digital library technologies have immense importance in doing this. Libraries can also work with the National Information Centre Network (NICNET) of India to disseminate knowledge that can link to the wider farmer community.

In India, various attempts have been made to improve the flow of agricultural information, but no serious efforts have been made for the integration of library services into any such scheme. Stressing the importance of libraries and information in national development, Iraset Paex-Urdaneta (1989) wrote:

> "The governments of several developing countries undertook the organization of national development but without promoting decisive actions to foster, at the same time an adequate level of awareness about the use and value of information."

Today some extension agents are operating without adequate information, and it is evident that the extension departments have no effective links with universities and other research institutions from which research findings flow. The library can provide useful support here. A lot of agricultural information is available in written form, but a majority of Indian farmers cannot understand it because of the low literacy level. Libraries can be involved in the introduction of a functional literacy program in designated Farmer Training Institutes.

Published materials in the developing world are few. Low publication rates and the high illiteracy rate should not be used as an excuse for poor information services to the farmers in the rural areas. The library should identify itself with developmental efforts by producing abstracts and summaries of its latest arrivals and drawing the attention of extension workers and farmers to them. The rural librarian should not see himself as a white-collar worker manning an elitist organization. Rather he should see himself as a sort of "barefoot librarian" who is able to relate well with his rural community and come to be relied upon as a reliable source of information on rural life. More than anything else, this will demonstrate the usefulness of his library to the community and help to cultivate the idea of the library as a permanent extension agency, always there to be consulted in the absence of the any other readily available source.

There is a need to document the ancient traditional farming practices in order to protect the farmers against patents and to ensure that these historic and highly efficient methods are preserved and not lost. Ultimately, this documentation will not only be useful for local people, but will assume importance on an international level. The library should involve other stakeholders such as NGOs, farmers' bodies, local administration, research institutions, etc., in protecting and upholding farmers' rights. Such collaborative efforts would also be instrumental in establishing much-needed communication channels with policy makers and for documenting the traditional knowledge of local farming communities.

The concept of "Village Information Shops" is being discussed, debated, and experimented with in various places in India. Experiments include M.S. Swaminathan Research

Foundation (MSSRF), Chennai, "Information-Villages" of MANAGE in Ranga Reddy District in A.P., Gyandoot.net initiative of District Administration Dhar, Madhya Pradesh, EID-Parry's Wireless in Local Loop-based Village Kiosks in the Cuddalore District of Tamilnadu and "Warna Wired Villages" of National Informatics Centre (NIC) in Kolhapur-Sangli Districts of Maharashtra. These will provide insight into farmers' and farm-families' information needs and paying capacity. Preliminary results indicate that agricultural extension alone is not sufficient to sustain an "Information Shop" at the village or even at Block level. The information supply domain has to be much larger and dynamic so as to offer value-added information like market prices, local topical information like bus and railway timetables, weather forecasts, etc. The experiences of Gyandoot indicate that the "Village Information Kiosk" can be a self-sustainable enterprise (with a potential to provide jobs for two young rural people at each kiosk), if 'e-governance" services are integrated with the information network. The rural people are willing to pay for the information services, provided the services are a little more exhaustive and improve their livelihoods (Sharma).

The packaging of extension Information for the Information Kiosk must be more visual, more complete, and should also indicate the source of information and further references for crosschecking and clarifications. This will create more direct communication between the farmers and researchers and will also improve the quality and language of research-extension packaging and feedback. The lessons from Pondicherry indicate that farmers seek information on seeds and fertilizers and also on pests and diseases in groups, and then they discuss the information at the Information Kiosks. This implies that the information dissemination in the connected villages is likely to happen through the farmers' organisations, farmer interest groups, and other informal groups. Another such experiment that has been running for more than three years is the "Warna Wired Villages," connected by National Informatics Centre. In Tamilnadu, the Nellikuppam Project of n-Logue and EID Parry, the basic framework of farmers groups is provided by a sugar factory catchment area. Another technology that is gaining farmers' confidence is satellite-enabled mobile videoconferencing. MANAGE has had more than 100 videoconferencing sessions with farmers and farm families. They send the Mobile VSAT Van to remote locations and a crew sets up the videoconferencing within one hour. They then connect to MANAGE using satellite Connectivity. MANAGE invites university scientists and employees working for the crops/agro-climatic offices of that area to answer farmers' queries. All the interactions are in the local language. The impact of this connectivity has been beyond expectations. They are also pilot-testing the efficacy of WLL technology to provide last mile connectivity in Amravati District of Maharashtra (Sharma).

ITC, one of India's largest exporters of agricultural commodities, launched "e-Choupal", in June 2000. It serves more than 3.1 million farmers growing a range of crops in over 31,000 villages through 5,050 kiosks across six states. And it enables the agricultural community access information in their local language on the weather and market prices, disseminate knowledge on scientific farm practices and risk management, facilitate the sale of farm inputs (now with embedded knowledge), and purchase farm produce from the farmers' doorsteps. Decision making is now information-based.

Agricultural universities and training institutes have also re-engineered their approach to education and are now offering a variety of job-oriented courses for agriculture graduates. Among these new offerings are a post-graduate course in rural reporting, which leads to opportunities not only in extension work but also in mass media, and a specialised MBA in agricultural management. Another new training is aimed at turning graduates in agriculture and allied disciplines into entrepreneurs, giving them the know-how to start their own "agriclinics" and "agribusinesses". The Ministry of Agriculture, Government of India, in association with National Bank for Agriculture and Rural Development (NABARD) has launched a unique programme to take better methods of farming to farmers across the country. The objective is to provide the farming sector with state-of-the-art knowledge and technology inputs through

these self-employed agricultural consultants, and to strengthen the government extension system, which has been stretched beyond capacity in the past few decades.

In India, we have more than 20 initiatives where information on agriculture, and, more importantly, on agricultural prices and extension, have been successfully tried and tested. These projects have been isolated attempts, and the time is now ripe to consolidate the lessons learned and launch state-wide connectivity or information access projects and a nation-wide project which may integrate the state level projects and participate with international-level initiatives and efforts.

Information Integration and Access through Digital Libraries

To understand the future of agricultural information integration and access, one must understand present-day information networks in the proper context, i.e., how information networks evolved as a result of new digital technologies; how end users have affected the design of information networks; and how the increased demand for technology transfer and evolving role of information systems in this knowledge transfer process have influenced the structure of national, regional, and international information networks.

The prerequisites for a successful universal agricultural digital library include: a knowledge transfer problem that is clearly defined with a realistic agenda for action; a bottom-up approach to defining issues; a strong self-interest that drives productive collaboration; willingness to commit resources, e.g., personnel, funding, facilities; the availability of trained and qualified people.

A viable digital library network is an association of research organizations with sufficient common objectives to share current research programs and invest resources in digital library network activities. It is a systematic organization of separate units, with the purpose of achieving a goal that is more than any one of the units can achieve individually. The following links are important for a digital library gateway: resources, communication, bibliographic resources, library, and extension.

In the past, agricultural extension has not been closely allied to agricultural education. Today there is a recognition of the need to link the extension centres and the sources of agricultural information which exists in the universities and research organizations. Attention will now be paid to how knowledge is sought, used, and transferred into action and to how the characteristics of new ideas and technologies influence the acceptance rate by the farmer. The integration of the end user into the design and structure of the universal agricultural digital library network is essential. The obstacles to application of IT in India include training of extension and agriculture research personnel, lack of familiarity with computers, lack of infrastructure, lack of information to create a database, lack of legal framework, and financial constraints.

The problem of access to digital information by developing countries is not unique to the field of agriculture, but there are several aspects of agricultural information that set it somewhat apart from other disciplines and thus account for some of the difficulties of creating an adequate information networks for its dissemination. First, the information exists in many different databases. Secondly, a great deal of the output of agricultural research and extension activities exist in a grey or unpublished literature form, and are thus not widely available. Thirdly, the agricultural information must exist on many levels to serve many target audiences, from researchers through policy makers and extension workers to farmers. Finally, agricultural information is being generated throughout the world, and research is being undertaken, data collected, and techniques developed, modified, and transferred in all geographical regions and in many languages.

Other problems include the fact that electronic information sources, such as satellite programming and online bibliographic databases, were used infrequently, and by relatively few advisers. Problems of accessibility and user friendliness were major hindrances. Another problem was that literature included in major databases often was not easily translated into localized, field-level applications. These problems suggest directions for future efforts by the extension service.

The design and strategic planning of a universal digital library must consider the following: a clear definition of use and ultimate users' needs, better agricultural knowledge capture and resource coordination, and designing metadata and domain specific markup language for description of information resources. An integrated agricultural digital library system will be helpful not only to extension officers but also to users of agricultural information, including farmers, cooperative societies, governmental organizations, researchers, students, and policy makers. Progressive farmers who are willing to use this digital library will, no doubt, benefit from such a system. They will have access to the appropriate information at the right time, allowing the right decisions to be made, which will consequently lead to an increase in agricultural productivity.

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