

# **DIGITAL INITIATIVES FOR AGRICULTURAL RESEARCH AND EDUCATION UNDER ICAR IN INDIA**

**Amrender Kumar<sup>1</sup> and K. Veeranjanyulu<sup>2</sup>**

<sup>1</sup>AKMU, ICAR-Indian Agricultural Research Institute, New Delhi

<sup>2</sup>Professor Jayashankar Telangana State Agricultural University, Hyderabad

## **INTRODUCTION**

Timely access to information is becoming more and more crucial for survival in every sphere of life and agriculture sector is no exception. In the present competitive world, moving towards what we perceive as knowledge society, the access to right information at anytime, anywhere, about anything has gained high significance. This off course does not mean that the earlier societies were not aware of importance of information or were not knowledgeable. The information played very important role even in ancient time when hunters & gather of the sub-continent evolved into agri-pastoral society, domesticated plants, animals and learned farming using draft animals, inventing tillage, seeding, intercultural operations, harvesting, and primary processing and prospered as interregional/international traders. They were knowledgeable enough to evolve into present day society. The crucial difference now is the speed with which you can access information, the magnitude of available information and removal of geographical boundaries to access information. The developments in computer technology itself revolutionized the world and the sudden growth in telecommunication methodologies provided the necessary synergy to create a catastrophic change breaking every boundary and connecting the planet into one giant network of information and knowledge.

Today, the information has become absolutely important input in agriculture along with seed, fertilizers, pesticides, land, water and environment. The contribution of public extension system in disseminating information and attaining self-reliance in food production is very well recognized. But in this changing time, traditional public extension system is not sufficient to address multi faceted problems faced by farmers. The existing public extension system is also constrained by limited resources, wide ratio between farmers and extension workers and also by added responsibility of handling emerging issues like marketing

extension, agri-business, quality conscious consumers and WTO. The need of the hour is to evolve a comprehensive agriculture extension system shared by all the stakeholders. These stakeholders could be farmers co-operatives, progressive farmers, agricultural consultants, consultancy firms, farmers organizations, unemployed agricultural graduates, non-governmental organizations, Krishi Vigyan Kendras (KVKs –Farm Science Centers), agri-business companies, input dealers, newspapers, agricultural magazines, private television channels, private sector banks, market information systems, weather forecasting agencies, agro-advisory services etc.

The convergence of computers and communication technologies has open up vast arena of Internet and Intranet. One cannot ignore the silent revolution taking place in the communication systems in Rural India, thus, paving way for "Cyber Extension" initiatives. Concept of Village Information Kiosks is fast spreading to blocks/mandals and villages empowering Indian farmers to digitized access of vital information available through the Internet. There are dozens of cyber-experiments going on in rural India, which have unequivocally demonstrated the power of Internet and Information Technology. The overwhelming response and eagerness of farmers to use such systems is now paving the way for replicating cyber extension initiatives in large numbers. In such a scenario, the demand for authentic and credible digital information sources has risen in agriculture sector especially in research, education or extension. End to end value chain development requires quick access to diverse type of information.

In the present era of knowledge revolution the organization, capturing, preserving and reusing of knowledge has become absolutely essential for any organization to keep itself competitive and efficient. Digital repository with open access policy may cater the needs of National Agricultural Research and Education System (NARES) with centralized hosting of content but decentralized management. The basic idea of open access (OA) policy is to limit the permission barriers for the user and making the content available online without any permission and price barriers. Thus, OA is free, immediate and a permanent online access to research articles for anyone in the world to improve upon the existing research findings. The ICAR adopted the open access policy (<http://icar.org.in/en/node/6609>) for easy access of information to the community of research, faculty and extension workers. The main points of ICAR, OA policy are:

- Each ICAR institute to setup an Open Access Institutional Repository.
- ICAR shall setup a central harvester to harvest the metadata and full-text of all the records from all the OA repositories of the ICAR institutes for one stop access to all the agricultural knowledge generated in ICAR.
- All the meta-data and other information of the institutional repositories are copyrighted with the ICAR. These are licensed for use, re-use and sharing for academic and research purposes. Commercial and other reuse requires written permission.
- All publications viz., research articles, popular articles, monographs, catalogues, conference proceedings, success stories, case studies, annual reports, newsletters, pamphlets, brochures, bulletins, summary of the completed projects, speeches, and other grey literatures available with the institutes to be placed under Open Access.
- The institutes are free to place their unpublished reports in their open access repository. They are encouraged to share their works in public repositories like YouTube and social networking sites like Facebook ®, Google+, etc. along with appropriate disclaimer.
- The authors of the scholarly articles produced from the research conducted at the ICAR institutes have to deposit immediately the final authors version manuscripts of papers accepted for publication (pre-prints and post-prints) in the institute's Open Access repository.
- Scientists and other research personnel of the ICAR working in all ICAR institutes or elsewhere are encouraged to publish their research work with publishers which allow self- archiving in Open Access Institutional Repositories.
- The authors of the scholarly literature produced from the research funded in whole or part by the ICAR or by other Public Funds at ICAR establishments are required to deposit the final version of the author's peer-reviewed manuscript in the ICAR institute's Open Access Institutional Repository.
- Scientists are advised to mention the ICAR's Open Access policy while signing the copyright agreements with the publishers and the embargo, if any, should not be later than 12 months.
- M.Sc. and Ph.D. thesis/dissertations (full contents) and summary of completed research projects to be deposited in the institutes open

access repository after completion of the work. The metadata (e.g., title, abstract, authors, publisher, etc.) be freely accessible from the time of deposition of the content and their free unrestricted use through Open Access can be made after an embargo period not more than 12 months.

- All the journals published by the ICAR have been made Open Access. Journals, conference proceedings and other scholarly literature published with the financial support from ICAR to the professional societies and others, to be made Open.
- The documents having material to be patented or commercialised, or where the promulgations would infringe a legal commitment by the institute and/or the author, may not be included in institute's Open Access repository. However, the ICAR scientists and staff as authors of the commercial books may negotiate with the publishers to share the same via institutional repositories after a suitable embargo period.

OA is a process and expects full compliance over a period of time. Therefore, the OA policy is a first step in the journey towards formal declaration of openness in the system.

#### **WHY OPEN ACCESS INSTITUTIONAL REPOSITORY NEEDED?**

Institutional repository is a “Digital Collection that captures, preserves, archives and provides policy based access to the intellectual output of an institution”. It can be perceived as an organization based set of services which the organization offers to the members of its community for the management and dissemination of digital materials created by the institution and its community members. Researchers, faculty and authors in quest for greater impact of their intellectual work share their hard work in the form of research papers, technical bulletins, books etc., with commercial publishers and they don't have to look for the commercial income from it. Their interest is wide dissemination and further follow-up of their research output. On the other hand publishers owing to commercial interest put high subscription cost, thus, restricting the circulation. This creates an impact barrier. On the other hand, researchers, faculty and scientific workers look for easy access to relevant scientific and other literature but do not have easy access to most of the literature for want of monetary cost required to be paid to publishers. This leads to creation of an access barrier. These structural problems with scholarly

publishing can be addressed to great extent by creating Open Access Digital Repositories.

For an institutions, an open access digital repository can go long way in raising the profile and prestige of the institution, provide efficient management of institutional information assets, accreditation and performance management. In long-term such digitally accessible organizational knowledge repository results in cost savings. For the research community it provides an alternative route to free research communication process and helps avoids time lag and unnecessary duplication. However, there are some concerns with respect to quality control - particularly peer review, IPR and copyright issues, etc. In fact, if institutional repository is seen as complementary to the commercial publishing not intended to totally replace it, it can help and advice on IPR issues as outputs are easily available in digitally searchable form. The open access institutional repository can help and advice on formulation of further research strategy for acquisition of relevant knowledge to meet the goals of an organization.

### **IMPORTANCE OF DIGITIZATION AND PRESERVATION**

As we are aware,the digital world is a binary world where all the information is represented as bits, 0s and 1s as against conventional analog representation where infinitely variable nature of information is preserved. Contents in every format and medium held by library, manuscripts to maps, moving images to musical recordings can be converted to suitable digital format. In addition to hardware, software needed for conversion and creation of digital content, the required practices for describing the digital content and their retrieval are also developing fast. The advantages of digital content normally outweigh the loss of fidelity in converting the information from continuous to discrete form due to following advantages:

- Wider and easy policy based access,
- Easy presentation and maneuvering of data,
- Compression of large storage space,
- Fast, multi-dimensional and semantic retrieval,
- Reproducibility and repackaging in different forms,
- Simultaneous & endless reusability,

- Digital resources are best for facilitating access to information but questionable when it comes to traditional library role of authentic preservation.
- Digital content is machine-legible only whereas conventional content is eye-legible.
- Digitized information needs computer hardware and software which are often proprietary and become obsolete very fast, requiring conversion to newer formats and technologies.
- Transition from one file format to other may not produce exactly same file, although, there may not be any loss of intellectual content.
- Assuring integrity of digital file and keeping track of versions is another challenge.
- Active human intervention for refreshing and migration of data is required for maintaining it in the fast changing digital technology environment.
- The life expectancy of digital media, the quality of its manufacturing, the number of times the media is accessed over its lifetime, the quality of the device used to write to or read from the media are matter of concern and need careful media handling, storage temperature, humidity and cleanliness of the storage environment.
- DNA-storage: The researchers of the Chinese University of Hong Kong used encoded *E. Coli* plasmid DNA (a molecule of DNA usually present in bacteria that replicate independently of chromosomal DNA) to encrypt the data and store it in the bacteria. Then, by using a *novel information processing system* they were able to reconstruct and recover the data with error checking. Based on the procedures tested, they estimate the ability to store about 900 terabytes (TB) in one gram of bacteria cells. That is the equivalent of 450 hard drives, each with the capacity of 2 terabytes (2000 GB). Another advantage of the system is that the bacteria cells abundantly replicate the data storage units thereby ensuring the integrity and permanence of the data by redundancy. Genetic codes have been preserved using similar strategy by nature. ([http://2010.igem.org/Team:Hong\\_Kong-CUHK/Project](http://2010.igem.org/Team:Hong_Kong-CUHK/Project))

### **NEED OF INSTITUTIONAL REPOSITORY (IR)**

Institutional repository is a Digital Collection of information which captures, preserves, archives and provides policy based access to the intellectual output of an institution. It can be perceived as an organization based set of services which the organization offers to the members of its community for the management and dissemination of digital materials created by the institution and its community members. IR helps in increased control by scholars and the academy over the system of scholarly publishing. IR provides scholarly information free of cost or at fair and reasonable price. However, IR should be seen as complementary channel, not intended to replace commercial publishing. The IR increases the visibility and citation impact of an institution's intellectual output and provides unified access to an institution's output. The IR act as digital platform to preserve institution's intellectual assets and help in providing and managing open access to institution's intellectual assets.

Taking the clue from this, strategy of 'replication and evolution' can help manage data preservation, even on magnetic media of today for very long time. Indian National Agricultural Research & Education System (NARES) has a very large collection of conventional knowledge base in agriculture and allied sciences, spread over the country in Institutes and State Agricultural Universities. Digitization of these valuable archives would allow online access to researchers, teachers and students to which they would not otherwise have an easy access. Therefore, Indian Council of Agricultural Research (ICAR) took several digital initiatives to capture and manage knowledge in NARES, one of the largest agricultural research & education system in world. These initiatives came in the form of several subprojects under the World Bank supported National Agricultural Technology Project (NATP) and National Agricultural Innovation Project (NAIP), a major initiatives to reform the way research and development is done in our traditional system. CeRA, E-Granth, Rice Knowledge Management Portal (RKMP), Agroweb, Agripedia, MIS/FMS, ICAR journal portal, supercomputing for Bioinformatics, Computing facilities, etc. are the few impacts making initiatives on digital access has been started by ICAR[NAIP, 2014].

- (i) **KrishiKosh a Digital Repository of NARES:** Indian National Agricultural Research & Education System (NARES) is a huge repository of knowledge and information on crop sciences, horticulture, resource management, animal sciences, agricultural engineering, fisheries, agricultural extension and agricultural education. Digital technologies and online access to information

resources have brought increased expectation from library and information services. For researchers, fast access to existing scientific outputs and archived scholarly information on the topic of interest is as crucial as current scientific knowledge. The modes of services that librarians and information professionals provide has thus become very important and have undergone fundamental changes over past few decades. Digital resources, digital services and access technologies continue to create new opportunities, new challenges and new expectations. Union catalogue, digital repository and digital libraries are the new paradigms which have been taken up to facilitate researchers, teachers, students, extension professionals. ICAR also has declared adoption of open access policy for proper utilization of Intuitional knowledge. It has been observed that in the recent years subscription to journals by libraries of ICAR Institutes / State Agricultural Universities (SAUs) has been on the decline mainly because of the increase in the cost of reputed relevant journals and books coupled with reducing fund availability for the purpose. At the same time, the research/educational activities must always keep pace with the international competition for which all important journals and books should be made available to researchers/teachers in the NARES. Maintaining a traditional form of library with hardcopies is becoming labour-intensive and adds to the cost. Each and every library cannot be sustained without adequate funds. NARES must take advantages of sweeping changes taking place globally. Considering these facts the importance of digital repository and digital library under e-Granth becomes more relevant. The institutional repository can hold all the intellectual outputs of the NARES system in the form of digitized institutional publications, technical reports, annual reports, lectures, authors collection in the form of preprints, reprints etc. These contents to which one can easily have open access, essentially captures all the intellectual work being done under NARES. The same intellectual output when gets published in the form of research papers in the commercial journals become inaccessible due to high cost. Thus institutional repository provides alternative source of scientific information to support our quality research and teaching. KrishiKosh is available at <http://krishikosh.egranth.ac.in> and provides open access to most of its content.

KrishiKosh is a versatile open access digital repository catering to the needs of NARES and has architecture of centralized hosting of



content but decentralized management. The KrishiKosh is hosted at the data center of Indian Agricultural Research Institute (IARI), the premier research institute and deemed university under NARES. Each institute or university can manage and administer its own repository which is integral part of KrishiKosh. The KrishiKosh has been designed by using open source software DSpace which has been suitably configured to meet the requirements of NARES. Each institution in NARES has been configured as community in DSpace having its own collections and logo. Each community and collection can be given independent rights to registered users for uploading and managing the contents. Thus, KrishiKosh is a collectively managed, centrally aggregated repository with integrated search facility. The major objectives of KrishiKosh are to create a digital Institutional Repository of important institutional publications including rare books and old journals and make them open access under NARES. The need for improving accessibility coupled with preservation is necessity for implementation of KrishiKosh under E-Granth. To create dependable digital storage and an efficient Integrated Content Management System (ICMS), an open source software DSpace has been customized to meet the requirements. It provides following functionalities:

**Improve Accessibility:** The ICMS makes the holdings more accessible to scholars, teachers, academics and the general public, both within the premises as well as to those who cannot personally visit the NARES libraries but want to access the contents through the internet, under open access policy.

**Enhanced Search ability:** All holdings are grouped communities and collections based on institutions, subjects, themes or other criteria making large amount of information easily available on any subject matter for teaching, research and development. Any researcher looking for content on any subject or themes can have a unified access to content on all media types (manuscripts, photographs, audio-video, etc.) thereby making the searching much easier and faster.

**Preservation:** Preservation of all the rare documents in electronic form is an important objective. Also, once the documents are scanned and digitized, preservation of the originals can be ensured for a much longer period as the need to handle the physical documents is eliminated or minimized to a great extent since documents are made available through the ICMS.

**Content Selection:** High power committees of subject matter experts have identified the content of intellectual and academic value to be included in the repository. Other institutions have identified the content in consultation with subject matter experts approved by the Directors/ Vice-Chancellors. The identified content was then harmonized centrally to avoid duplication.

Various types of archival material at NARES comprises of rare books, old journals, reports, newsletters, annual reports, success stories, special bulletins, convocation addresses, endowment lectures, author's collections, preprints, reprints, patents, manuscripts, periodicals, grey literature, photographs, existing digital content, audio-video recordings.

It is NARES's intention to make the Metadata for all records (and categories) freely available to all, however the actual records would be accessible based upon its access category.

All of NARES's holdings are classified under the following three access categories:

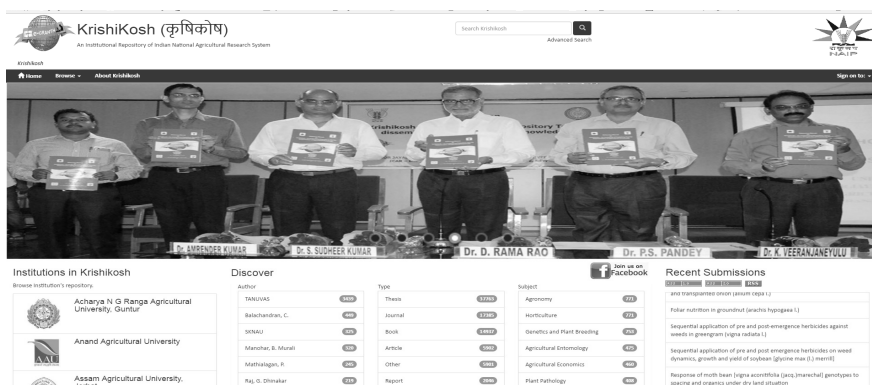
**Public Access :** Any record that can be made available to public at large shall fall under this category

**Privileged Access:** Records classified under this category shall be accessible to only to those individuals or organizations that have a privileged status with NARES (such as other national / state archives / research and academic institutes / eminent researchers etc.). Others (the world at large) would have to seek prior permission / approval from IARI to access any Record classified as Privileged Access.

**Prohibited Access:** Records which are accessible ONLY to NARES authorized officials, due to their confidential and sensitive nature as defined by statutory rules and regulation.

Thus, KrishiKosh is a digital repository which captures, preserves, archives and provides policy based access to the intellectual output of Indian NARES. It is a unique repository of knowledge in agriculture and allied sciences, having collection of old and valuable books, institutional publications, technical bulletins, project reports, lectures, preprints, reprints, thesis, records and various documents spread all over the country in different libraries of Research Institutions and State Agricultural Universities (SAUs). The home page of this repository is given below and can be visited through the link (<http://krishikosh.egranth.ac.in/>). At present KrishiKosh has more than 16 million digitized pages in

more than 71,000 digital items (volumes) like old books, old Journals, reports, proceedings, reprint, research highlights, training manuals, historical records. More than 26,000 thesis are submitted at Krishikosh by various SAUs / Institutions and value addition has been done by making these full Text searchable.



Krishikosh platform is an Institutional Repository for collecting, preserving, and disseminating information in digital form for the intellectual output of an institution. In this repository, some important terminology such as Community, Sub Community, Collection, Item and Bitstream needs to be understood. The explanations of these terminologies are given below.

**Community:** Community is the top level reference term which describes the University/ICAR Institute group. Generally the right to create a Community is with the Administrator of the Krishikosh.

**Sub Community:** This is second level of hierarchy. It may describe departments/ division under the University/ICAR Institute.

**Collection:** Collection is a part of Community or Sub-community in which we can add different categories like books, thesis, journals, newsletters etc. Creating collection is necessary to post the document under Krishikosh.

**Item:** The record/document which is uploaded in collections is termed as item.

**Bitstream:** It is the file which will be uploaded in the Krishikosh preferably a searchable pdf/a or pdf file.

(ii) **Integrated Digital Ensemble of Agricultural Libraries (IDEAL):** To strengthen the digital library initiatives, more

advanced Library Management Software, compliant to open international standards is necessary for easy data portability and data sharing. Koha is open source software which has been identified for implementation in the NARES libraries with expert support, intensive trainings. In-house capacity building has been part of the strategy. All further advanced library automation system like RFID for automated library services can be built only on robust Library Management System compliant to international standards for data compatibility and portability. Koha has been implemented in the 38 libraries under NARES. Koha is a full featured Integrated Library System (ILS), downloadable free under GNU General Public License, maintained by a dedicated team of software providers and library technology Koha OPAC page at IARI, New Delhi professionals from around the globe. Authorized user may modify the codes to adapt it to local needs and redistribute it. Koha has robust Cataloging, Circulation, Patrons, Search, Serials control, Acquisition, Reports and Administration modules along with utility Tools and OPAC. By adopting it, the customer becomes 'joint stake holder' in the product. Koha is well tried and tested software and has demonstrated both stability and scalability, is being used in hundreds of libraries worldwide. It is an example of Collaboration and Resource Sharing. Software solutions are freely available to all libraries worldwide. Libraries benefits from the contributions of other participating library systems. Being an open source software it has benefit of being free from vendor lock-in whereas, in proprietary software, source code is 'closed' and support and future development of the product solely rely on the success and resources of a the single vendor. If the vendor goes down or does not cooperate, your product support is gone. Open source solutions rely on stable code bases developed and supported by many providers worldwide. Koha is compatible with existing technologies viz. RFID, and being open source developing software, compatibility with any new Library Technology will be available in future also. The IDEAL platform has been developed on Software as Service (SaaS) architecture with independently configured instance for each library having OPAC and staff clients running on centralized servers along with option to run local mirror for individual library. It can be accessed at <http://ideal.egranth.ac.in>. All the libraries of NARES can join IDEAL platform to get themselves integrated to Virtual Digital Library of NARES and get freedom from

maintaining hardware and software locally for day to day functioning of their own library. This enables them to focus more on their core competency of managing their library more efficiently [Jain *et. al.*, 2014; Jain *et. al.*, 2016].

**(iii) Integrated National Agricultural Resources Information System:** INARIS was taken up as a sub-project under National Agricultural Technology Project (NATP). The goal for this project was to design and develop a flexible Central Data Warehouse (CDW) of agricultural resources and databases on different subjects. The target users of information systems and decision support system developed under this project are

- (i) Research Managers
- (ii) Research Scientists
- (iii) General Users.

In this project a state of art Central Data Warehouse (CDW) of agricultural resources of the country has been developed at ICAR-IASRI, New Delhi. This provides systematic and periodic information to research scientists, planners, decision makers and developmental agencies in the form of On-line Analytical Processing (OLAP) decision support system. It has been implemented with active collaboration and support from 13 other ICAR institutions, namely NBSSLUP Nagpur (for soil resources), CRIDA Hyderabad (for agro-meteorology), PDCSR Modipuram (for crops and cropping systems), NBAGR Karnal (for livestock resources), NBFGR Lucknow (for fish resources), NBPGR New Delhi (for plant genetic resources), NCAP New Delhi (for socio-economic resources), CIAE Bhopal (for agricultural implements and machinery), CPCRI Kasargod (for plantation crops), IISR Calicut (for spices crops), ICAR Research Complex for Eastern Region Patna (for water resources), NRC-AF Jhansi (for agro forestry) and IIHR Bangalore (for horticultural crops). In all 59 databases on agricultural technologies generated by council, research projects in operation and related agricultural statistics from published official sources at least from the year 1990 onwards at the district level were integrated into this information system. Subject-wise data marts were created; multi-dimensional data cubes have been developed and published on Internet/Intranet. The validation checks have been implemented wherever possible. The information of this data warehouse are available to user in the form of decision support system in which the all the flexibility of the

presentation of the information, it's on line analysis including graphic is inbuilt in to the system. The system also provides facility of spatial analysis of the data through web using functionalities of Geographic Information System (GIS). Apart from this, subject wise information system has been developed for the general users. The user of this system has the access of subject wise dynamic reports through web. The facilities of data mining and generation of ad-hoc querying were also extended to limited users. Therefore, the dissemination of information from this data warehouse for different categories of users is through web browser with proper authentication of the users. The web site of the project is already launched ([www.inaris.gen.in](http://www.inaris.gen.in)) and the multidimensional cubes, dynamic reports, GIS maps and information systems are already available to the users. This project is viewed to strengthen the information system conceptualized by ICAR. Other agencies, in particular, the planning portfolio, are eagerly waiting for such a decision support system. Based on the interaction among the basic resources like soil, water, climate, animal and vegetation that form the prime components of the production system this data warehouse will help in determining the carrying capacity of the region. The project aims at giving suitable opportunity on multi-disciplinary mode through enhanced linkages among research institutes and other development agencies by providing first hand information on problems and potential in production systems. This data warehouse may be intensively used with an ultimate aim of enhancing better quality of life of the farming community and society at large

- (iv) **Establishment of an Online System for NET/ARS - Prelim Examination:** A state-of-the-art infrastructure facility for conducting examination of ARS/NET of ASRB was created under the subproject with the major objective to develop the capability to change over from on-site to on-line Examination for NET/ARS Prelim. The on-line examination network consisting of one Data Center (DC) at the ASRB, One Disaster Recovery (DR) site near its premises, and 23 Examination Centers (or Nodal Centers) across the country was set up. These Examination Centers were created at 21 ICAR Institutes and two SAUs considering that the management control would be better at these locations being part of the NARES family. These centers were equipped with necessary hardware and software that was developed and customized as per the requirements of the ASRB.

- (v) **Establishment of Supercomputing Hub for Indian Agriculture:** During the last decade, genomics has witnessed an information explosion. Genomic databases contain huge amounts of information that are not amenable to traditional analytical approaches. The analysis of genomic sequences for drawing valid conclusion is highly computer intensive and needs different tools and technique. Apart from this, there is need to design and develop databases and data warehouse of genomic data of local species and commodities to facilitate researchers. Software and web browser based systems need to be developed for visualization, mapping and interpretation of these genomic sequences. Also, there is hardly any consolidated efforts are made for collection, compilation, storage and knowledge mining of indigenous agricultural genomic resources. In order to keep pace with the research and developments in agricultural bioinformatics at global level, country needs expertise and exposure in this area of research. Therefore, there is an urgent need to establish this National Agricultural Bioinformatics Grid (NABG) which will help in developing databases, data warehouse, software and tools, algorithms, genome browsers and high-end computational facilities through systematic and integrated approach in the field of agricultural bioinformatics. The first supercomputing hub for Indian Agriculture in bioinformatics called ASHOKA (Advanced Super-computing Hub for OMICS Knowledge in Agriculture) was established at the IASRI in New Delhi under the National Agricultural Bioinformatics Grid (NABG) sub-project of NAIP (<http://www.nabg.iasri.res.in>). The hub consisting of supercomputing systems at the NBAGR, NBPGR, NBFGR, NBAIM and NBAIR constitutes the National Agricultural Bioinformatics Grid in the country.
- (vi) **Development and Maintenance of Rice Knowledge Management Portal (RKMP):** RKMP (<http://www.rkmp.co.in>) is a technical highway for sharing the knowledge of Rice by using new Information and Mobile Technology. It helps the departments which are working in agricultural activities to reach the farmers through extension advisory services, in the best possible way. This platform are built on Microsoft Web 2.0 technology, it caters to location specific information needs of farmers and research officials through IP based customization on 24X7 bases. RKMP is operating by providing content in local language. RKMP operates in multiple domains e.g. Extension and Farmers that provides

production know how, practices, FAQs etc., in local languages and English. In research domain, various services are provided such as AICRIP Intranet, archives of AICRIP data (27000 datasets), communities of practice (CoP), bio-informatics suite, approach papers, India Rice Research Repository (i3R), status papers on rice for different states etc.

The portal works on two e-learning platforms which provide learning opportunity to scientists and extension workers simultaneously. This portal also caters to information needs of exporters and farmers through the trade information system. It also provides indexing of mandi prices of paddy from regulated market yards (from Agmarknet). Policy makers can directly access area, production, productivity trends of last four decades up to district level. In a first kind of an attempt, the users can upload the content as a registered user, irrespective of institutional affiliation. RKMP Nodal officers (AICRIP Scientists from State Agricultural Universities) will validate and approve your content before it is displayed online with due credit to the contributors.

- (vii) **Agroweb-Digital Dissemination System for Indian Agricultural Research (ADDSIAR):** An attempt was made to create a common gateway to ICAR Institutes to act as a one stop window for getting access to all the information about National Agricultural Research and Education System in India. Accordingly, the ADDSIAR was conceived with the broad objective to improve the web presence of ICAR and its Institutes through their websites by making the websites more dynamic and developing a brand image of ICAR. Website Uniformity Guidelines for the ICAR was developed and disseminated which outlined the Standards and Content Management Strategies (CMS) to be employed by all the ICAR Institutes. The ADDSIAR established at the Directorate of Knowledge Management in Agriculture (DKMA) is committed to promote ICT driven technology and information dissemination system for quick, effectual and cost-effective delivery of messages to all the stakeholders in agriculture. Keeping pace with the current knowledge diffusion trends, the Directorate is delivering and showcasing ICAR technologies, policies and other activities through print, electronic and web mode [Tyagi *et. al.*, 2014].
- (viii) **Engaging Farmers; Enriching Knowledge, Agropedia:** Agropedia is a comprehensive and integrated model of digital content organization in the agricultural domain. It aims to bring together a community of practice through an ICT mediated



knowledge creating a common platform with an effort to leverage the existing agricultural extension system. There are three groups of agencies/institutions on this project with different roles & responsibilities (<http://agropedia.iitk.ac.in/>)

*ICT Resource Institutions:* IIT Kanpur (agropedia platform); IIT Bombay; IIITM Kerala (multi-modal delivery); NAARM

*Agricultural Information and Learning Resources:* G B Pant University for Agriculture and Technology, Uttarakhand; University of Agricultural Sciences, Dharwad with two KVK's in Maharashtra through the IIT Bombay network.

**ICT4D Interface Partners:** ICRISAT, with its VASAT project in India and the NAARM will provide the facilitation support for agricultural research scientists and educators and the ICT4D actors. ICRISAT is the consortium leader, which has overall responsibilities for the outputs and deliverables. ICRISAT is uniquely positioned because of its long- standing formal and working relationship with nearly all the partners. Its strength in IT innovations for human development has been described in the IEEE Spectrum (Feb 2004). Its long standing partnership with the FAO (especially in AGROVOC work), and its position as the hosting centre of many CGIAR activities in India, add further strength in implementing this project in a consortium mode. Agropedia has been developed as a common platform for all kinds of information related to Indian agriculture. In one of the first attempts worldwide, the practice of crop knowledge models has been defined and developed to create architecture for accumulating known codified and approved information about crops. This was accomplished with the support of Food and Agriculture Organization (FAO), Rome. Knowledge models (KMs) are the structural representation of knowledge by using symbols to represent pieces of knowledge and relationships between them, which can be used to connect to the knowledge base in agropedia using semantic tools. KMs have been represented using Concept Map (C-Map) tools. KMs have been designed with the intention of using them for indexing and browsing the content that we gather in the repository. A template for objects and relationships within the KMs as well as guidelines to develop KMs were formulated by the NAIP- KM team of IITK with the assistance and support of FAO. Agropedia an agricultural knowledge management portal (<http://www.agropedia.iitk.ac.in>) was developed as an open platform to facilitate exchange and delivery of information

between the agricultural community through a web portal and mobile phone networks.

- (ix) **E-Publishing of Scientific Journals for Indian NARES:** The E-Publishing and Knowledge System in Agricultural Research (EPKSAR) portal developed in the Project has made significant impact on the publishing process and manuscript management of research journals through the implementation of ICT in research journal publishing. Implementation of e-publishing (<http://epubs.icar.org.in/ejournal/>) has resulted in making the entire publishing process quick, transparent and paperless resulting in the improvement of overall efficiency are being published using the developed ICT enabled platform and are available on-line now. Open Access policy in ICAR for enhanced dissemination and sharing of Indian agricultural research is the outcome of the sub-project.
- (x) **Consortium for E-Resources in Agriculture (CeRA):** The Consortium for e-Resources in Agriculture, popularly known as CeRA, facilitates online access to about more than 3400 journals in agriculture and allied sciences to all researchers comprising; scientists, teachers, faculty, research fellows and students in the National Agricultural Research System (NARES) through IP authentication. This is the first of its kind for facilitating 24 x 7 on-line accesses of select journals in agricultural and allied sciences to all researchers. At present, there are 147 members (along with regional stations, KVKs and colleges) in CeRA comprising ICAR Institutes, SAUs, NRCs, PDs, etc. in the NARES. About 3,490 journals are now accessible in CeRA [(<http://cera.iari.res.in> & <http://www.jgateplus.com>), which is now the most sought after on-line platform by scientists/teachers in the NARES for literature searchthrough IP authentication. The website (<http://cera.iari.res.in>)has been developed in Joomla platform using PHP, HTML languages in frontend and MySQL database in the backend. Contents in the site comprises general information on CeRA, committees, feedback, available journal lists, information on workshops and important news, important publications, manual, etc. – accessible to general public and information on financial details, agreements with publishers, invoice, unprocessed data, SOEs, etc. – under secured access. In this way, all information of the Consortium is available in one platform. The second website (<http://www.jgateplus.com>) is the updated version of (<http://cera.jccc.in>)developed at the time of launch workshop. This

site contains metadata of all journals available in CeRA and accessible through IP authentication. Besides, the contact details of each member and the nodal officer of CeRA have to access to generate reports on hits/downloads and DDRS. This is the online platform for access to CeRA journals. Some of the important options facilities available in this platform are: advance search, my favorite journals and live chat with the service provider for online solution to a given problem. The impact of CeRA in research publications is revealed through Web of Science, which indicate qualitative and quantitative increase in the number of published papers during post CeRA (2008-12) than Pre-CeRA (2003-07). CeRA acts like a catalyst to enhance agricultural research, education and extension activities of NARES institutions. This would not have happened but for the constant help and co-operation of all CeRA members all along. The subscription at one place, instead of subscribing individually, provides an efficient way of subscription of research journal under the NARES in terms of time, space and budget [Chandrasekharan et. al., 2012; NAIP (2014)]

- (xi) **Development of E-Courses for degree level programmes in agriculture and its allied areas:** As the traditional methods of educating the new generation of tech-savvy students are found wanting, the need for use of new technologies in agricultural education is gaining momentum. Hence, 425 user-friendly and multimedia-based e-courses for the under-graduate students were developed in seven disciplines viz., agriculture, dairy science, veterinary science and animal husbandry, fisheries science, horticulture, home science, and agricultural engineering comprising 15820 lessons. A dedicated portal on e-courses covering all the seven disciplines was made available at <http://ecourses.iasri.res.in>, so that the user community could access the desired e-Course contents anytime and anywhere. Off-line DVDs were also distributed to all the SAUs, DUs and other academic institutions in India on demand.
- (xii) **Implementation of Management Information System (MIS) including Financial Management System (FMS) in ICAR**
- ICAR took an initiative to develop and Enterprise Resources Planning (ERP) solution that will take care of all Institutes and Centers of ICAR as a whole. ICAR-IASRI was identified as a leading center for development and successfully implements MIS (including FMS) System which includes solution for Financial

Management, Project Management, Material Management, and Human Resource Management & Payroll at ICAR. Major Benefits of this approach are:

- Centralized data management system across all institutes.
- Finally, creating an IT environment in ICAR across all disciplines.

ERP system was planned under the sub-project entitled Implementation of Management Information System including Financial Management System in ICAR. An ERP system integrates different parts of the business processes and their activities such as planning, purchasing, inventory, sales, project, finance, human resources, etc. Establishment of a Central Data Centre (CDC) of ICAR was further added under the sub-project and the CDC was established at IASRI to address the requirement of MIS-FMS including web hosting and unified messaging solution. The software of ICAR-ERP was developed in the project using Oracle ERP available at <http://icarerp.iasri.res.in> . The ICAR-ERP solution facilitates efficient and effective planning and management of resources. The system integration processes were carried out in the five major functional areas *viz.* Financial management; Project management; Material management; Human resource and Payroll system. The solution is developed using Java as a driving engine with a backend of Oracle, the system is designed and implemented in centrally and is used by accessing URLs on java enabled Browsers (<http://www.iasri.res.in/misfms/> ).

- (xiii) Strengthening Statistical Computing for NARES:** Under this sub-project, emphasis was given to strengthen the high end statistical computing environment for the scientists in NARES. Availability of a very healthy statistical computing environment for the scientists in NARES containing a very powerful, all inclusive, a modern, efficient and precise general purpose statistical software package for undertaking a probing, in-depth and accurate analysis of data generated from agricultural research. This is expected to bring a revolution in the analysis of agricultural research data. Exploratory data analysis, which previously was avoided because of non availability of the high end statistical package, would become a common feature of all agricultural research. The power of the package to graphically display dynamic, interactive visual research can enrich the knowledge of agricultural scientists and illuminate concepts which

without statistical software package was more difficult to comprehend earlier (<http://www.iasri.res.in/sscnars/>).

## DISCUSSION

The green revolution in India benefits the livelihood of farmers immensely and enhances agricultural productivity as well. However, there is a demonstrable need for a new revolution may be called digital revolution that may bring the farmers, researchers and policy makers together for smart solutions. In the new digital era with booming mobile, wireless, and Internet technologies, ICT has penetrated even in poor smallholder farms and in their daily activities. The ability of ICTs may become a powerful tool for farmers to access and organize the available knowledge through the digital initiatives taken by ICAR. It facilitates the implementation of technologies –both new and traditional– and transforming patterns of learning and interactive strategies among researchers for real time solutions.

The digital initiatives especially that of E-Granth and CeRA have consistently enhance the quality and quantity of research output in terms of research papers, methodologies and patents. This is because of the fact that all publishers/journals in agricultural sciences are available on CeRA platform and all institutional repository especially thesis are available on E-Granth portal. Thus, these initiatives play a key role in the research and developmental activities in NARES. ICT application based sub-projects have resulted in better and economic access to quality publications for researchers and students. This has greatly impacted the overall quality of the research publication from the NARES. The National Agricultural Bioinformatics Grid (NABG) provides the platform for research and development in agricultural bioinformatics for inter-disciplinary research in cross-species genomics along with the capacity building. It is expected that, in due course of time information and knowledge generated through research on bioinformatics from the genomic knowledge base will start flowing downward to researchers to users and experimentations in different sectors of agriculture can be able to evolve internationally superior competitive varieties/breeds and commodities in agriculture. It is also estimated that the total amount of information doubles every four to five years. ICTs are crucial in coping with the explosion of knowledge in agricultural sciences such as genomics huge data were generated. Supercomputing facility available with advanced statistical tools were utilized to convert these knowledge's into an information.

RKMP is strengthening the research, extension, farmers, private sub-systems, partnerships and networks for the better flow of rice knowledge. It is also providing vital scientific information and contributing to overall rice development in the country. The developed portal helped to strengthen communication infrastructure among the stakeholders, improve tools for collecting data and information, nurture scientific communities in the field of rice, provide platform for collaborative action and information sharing, initiate steps for integrating information systems and improve the knowledge sharing culture throughout various key players and stakeholders in the rice sector. The E-Publishing portal has made significant impact on the publishing process and manuscript management of research journals through the implementation of ICT in research journal publishing and Implementation of e-publishing. ERP system was also developed for Management Information System including Financial Management System in ICAR. An ERP system integrates five major functional areas *viz.* Financial management; Project management; Material management; Human resource and Payroll system e-governance system. The ERP system assists the implementation of policy frameworks and to monitor progress for any organization. For strengthen the high end statistical computing environment for the researcher, faculty and students in NARES, statistical computing environment were provided for efficient and precise general purpose statistical systems for undertaking a probing, in-depth and accurate analysis of data generated from agricultural research. This is expected to bring a revolution in the analysis of agricultural research data for knowledge discovery.

The digital portal provides actionable information to community and policy maker on disaster prevention in real time along with advice on risk mitigation technique. This portal made significant impact in the field of risk management. Through regular and systematic surveillance, disastrous situations can be avoided by detecting the events well in advance. Using these technologies advice on the risk mitigation technique can be generated or communicated to the policy makers (RKMP portal can give information in advance on pests disaster in the rice crop. Internet technologies capture pest information from fields and produce – instant and customized pest reports to the plant protection experts to advise the state agriculture agencies who further advise concerned farmers and the same information is available for agricultural policy planners.)

## REFERENCES

1. Chandrasekharan, H., Patle, Sarita, Pandey, P S, Mishra, A K, Jain, A K, Goyal, Shikha, Pandey, Amit, Khemchandani, Usha and Kasrija, Rajkumari (2012). CeRA - the e- journal Consortium for National Agricultural Research System; Current Science, 102 (06): 847-851
2. <http://www.rkmp.co.in/>
3. Jain, A. K., Chandrasekharan, H. and Kumar Rajesh (2014). Final Report of NAIP sub-project 'Digital Library and Information Management under NARES (e-GRANTH)'. Indian Agricultural Research Institute, New Delhi, India
4. Jain, A. K., Kumar, Amrender, Batra, Kamal, Kapur, Sanjiv (2016). Reference Manual on Krishikosh - A Repository for NARES. ICAR– Indian Agriculture Research Institute, New Delhi, pp50
5. <http://wiki.duraspace.org>.
6. NAIP (National Agricultural Innovation Project) (2014). An Initiative Towards Innovative Agriculture. Final Report, National Agricultural Innovation Project, ICAR, New Delhi
7. Tyagi R.K., Agrawal A., Varshney, H., T. Ravisankar, K.V. Rao, H. Chandrasekharan, M.K. Chandra Prakash, G.R.K. Murthy, Jain, D.K., Singh, N., Dhandapani, A. and Agrawal, R.C. (2014) Final Report of NAIP sub-project 'AGROWEB-Digital Dissemination System for Indian Agricultural Research (ADDSIAR)'. National Bureau of Plant Genetic Resources, New Delhi, India