# KeRALA - AN EXPERT SPATIAL-INFORMATION SYSTEM FOR KERALA

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## ABSTRACT

Natural phenomena metamorphose as natural disasters only when human society is incognizant. Information and Communication Technologies (ICT) are inherently capable to enable societies by rapidly sensiblising the public. Community Informatics aspect of ICT is yet to be fully harnessed in application intensive domains such as agriculture, disaster preparedness/ mitigation, etc. For such applications, we need systems that can sense and communicate timely data, and transmute the same, on the fly into actionable information on the uncertain spatial and erratic temporal dimensions of natural phenomenon. It is proposed to build such a system as a web-accessible portal that is supported by computational spatial informatics facility at the backend. Such a portal allows for collection of real-time primary spatio-temporal data from geographically distributed data and information sources with provision for real-time updation. This web-accessible spatial informatics data aggregation and knowledge dissemination portal is called **K**erala **e**- **R**esource-repository **A**nd **L**ocation-specific **A**dvisory (**KeRALA**). The portal system has two distinct but interrelated parts: **KeR** (Kerala e-Resource-repository) and **LA** (Location-specific Advisory) respectively.  The authors present a description of the KeRALA portal design and illustrate its applicability for real-time information aggregation and dissemination.

## 1.0 INTRODUCTION

Importance of multidimensional modeling for scientific planning is well established. The utilities of such modelling can readily be extended to crop husbandry, water management, public health, urban planning, disaster mitigation, etc. Two fundamental prerequisites for modelling natural phenomenon are (a) comprehensive compatible spatial database of the physical, physiographic, biological and social parameters and (b) System to collect real-time weather data from geographically distributed sources.

Physical and physiographic data of Kerala state, India has been generated under various independent projects. However, these are fragmented, scattered and those available are either incompatible or in non-interactive atlas form. Real-time weather data from 56 representative locations in Kerala is generated by 'Antariksh'. *Antariksh: Meteorological Observation Network in Kerala* is a project of the Government of Kerala and Indian Space Research Organisation (ISRO) (Anonymous, 2005). **K**arshaka **I**nformation **S**ystems **S**ervices and **N**etworking [KISSAN] – Agricultural portal of the Government of Kerala is perhaps the only functional agricultural portal of India. At present KISSAN facilitates to provide discrete advice to individuals on all aspects of crop husbandry.

'Antariksh' facilitated real-time weather data per se, has limited utility unless socially relevant scientific applications are woven around real-time weather data and spatial physical and physiographic data. **K**erala **e R**esource repository **A**nd **L**ocation- specific **A**dvisory, [KeRALA] is a web-based expert spatial information system to utilize the 'Antariksh' facilitated real-time weather data to elicit expert knowledge and effectively transmit it to a knowledge-based system, to be meaningfully disseminated.

Organizing knowledge, functionality and content into a structure that people are able to navigate intuitively and interact meaningfully involves Knowledge Analysis, Knowledge Planning, Knowledge Technology and Computer Assisted Work Systems. A portal encompasses all these, and is an ideal means to deliver the *right* information to the *right* person, in the *right* place at *right* time in the *right* form. This paper, describes KeRALA and illustrate its applicability for real-time information aggregation and dissemination in agriculture.
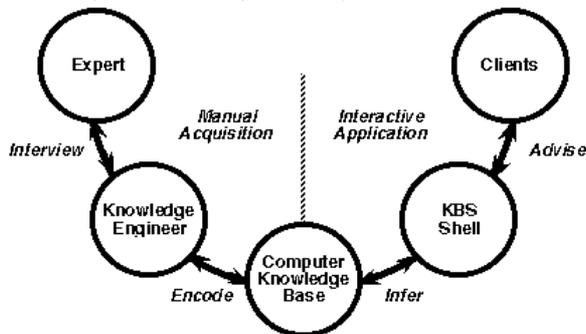
## 2.0 KNOWLEDGE ENGINEERING

An expert system is a computer application that solves complicated problems that would otherwise require extensive human expertise (Keung-Chi Ng and Abramson, 1990). To do so, it simulates the human reasoning process by applying specific knowledge and interfaces. Expert systems represent the expertise knowledge as data or rules within the computer. These rules and data can be called upon when needed.

Knowledge acquisition for expert system development is termed knowledge engineering (Feigenbaum, 1980). The term *knowledge engineer* has come to be used for the person responsible for such system development.

> *"Knowledge acquisition is the major bottleneck in the construction of expert systems. The knowledge engineer's job is to act as a go-between to help an expert build a system. The most difficult aspect of the knowledge engineer's task is helping the expert to structure the domain knowledge, to identify and formalize the domain concepts (Hayes-Roth et. al., 1983)*

Basic model for knowledge engineering has been that the knowledge engineer mediates between the expert and knowledge base, eliciting knowledge from the expert, encoding it for the knowledge base, and refining it in collaboration with the expert to achieve acceptable performance. Figure 1 shows this basic model with manual acquisition of knowledge from an expert followed by interactive application of the knowledge with multiple clients through an expert system shell.

However, the knowledge engineer in the role of an intermediary between the expert and the knowledge-based systems may create as many problems as he or she solves (Gaines, 1987). The computer itself is an excellent tool for helping the expert to structure the knowledge domain. Research on knowledge acquisition has focused on the development of computer-based acquisition tools (Boose & Gaines, 1988; Boose, 1989). Many such tools are designed to be used directly by the expert with the minimum intervention by the knowledge engineer, and emphasize facilities for visualizing the domain concepts. The objective of expert system is to expedite the process of acquiring knowledge and transferring it to knowledge-based systems (Gaines, 1987).



**Figure 1 Basic knowledge engineering**

Knowledge engineers have the responsibility of: (i) advising the experts on the process of interactive knowledge elicitation (ii) managing the interactive knowledge acquisition tools, setting them up appropriately (iii) editing the knowledge base in collaboration with the experts (iv) managing the knowledge encoding tools, setting them up appropriately (v) editing the encoded knowledge base in collaboration with the experts (vi) validating the application of the knowledge base in collaboration with the experts (vii) setting up the user interface in collaboration with the experts and clients; and (ix) training the clients in the effective use of the knowledge base in collaboration with the expert by developing operational and training procedures. Figure 2 depicts the roles of knowledge engineer.
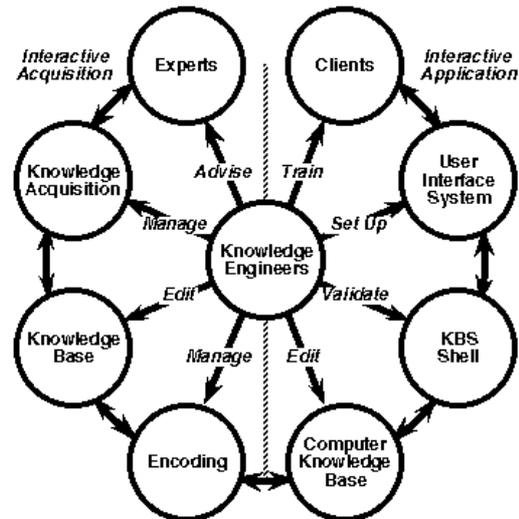


**Figure 2 Knowledge engineering with interactive tools**

Figure 2 specifies multiple knowledge engineers since the tasks may require the effort of more than one person, and some specialization may be appropriate. Multiple experts are also specified since it is rare for one person to have all the knowledge required. Attention to quality control through validating each step of the knowledge acquisition process is key to effective system development.

## 3.0 EXISTING SYSTEMS

### 3.1 Karshaka Information Systems Services And Networking [KISSAN]

**K**arshaka **I**nformation **S**ystems **S**ervices **A**nd **N**etworking is a project of Department of Agriculture, Government of Kerala (www.kissankerala.net). It attempts to tap the potentials of information technology to enhance the efficiency and effectiveness of agriculture extension programme, trade and timely dissemination of best agrarian practices. The project has established a farmer centric integrated distributed information system for agriculture. KISSAN was conceptualized, designed, developed and maintained collectively by experts from Information Technology, Agriculture, Visual Media, etc (Srivathsan, 2004).

KISSAN resides on a dedicated content processing and information dissemination system backed up by high-end servers and other data processing equipments. It involves the collection, analysis, classification and processing multi-source information. KISSAN has already established an agriculture data center. Perhaps KISSAN is the only operational agricultural portal in India. The data traffic within KISSAN is in itself an indicator of its utility.

### 3.2 Meteorological Data Collection

Conventional meteorological data collection, compilation and dissemination as practiced presently, provide selectively represented, discrete data. The state of Kerala has only 30 full-fledged weather stations and 254 rain gauges (Anonymous, 2005). This existing infrastructure fails to measure up to standards prescribed by the World Meteorological

Organization (WMO). An analysis of the spatial distribution of these stations showed that there are several gaps with only a few districts of Kerala covered as required by WMO specifications. Antariksh project was proposed as a solution to overcome the limitation of conventional meteorological data collection (Anonymous, 2005).

### 3.3 Expert Systems

The ability to monitor physical systems in real-time has been demonstrated using expert systems. The Decision Support System for Agrotechnology Transfer (DSSAT) is an expert system used in agriculture (Jones, 2003). DSSAT is a microcomputer software program combining crop, soil and weather database and programs to manage them, with crop models and application programs, to simulate multi-year outcomes of crop management strategies. Since crop growth is primarily driven by weather, and availability of representative meteorological data is often limited, meteorological data becomes the primary limiting factor for widespread adoption of crop simulation models (Laurenson et. al., 2002).

DSSAT also provides for validation of crop model outputs; thus allowing users to compare simulated outcomes with observed results. Crop model validation is accomplished by running the model by inputting the user's minimum data [site weather data for the duration of the growing season, site soil data, and crop management data.] and comparing outputs. By simulating probable outcomes of crop management strategies, DSSAT offers information to rapidly appraise new crops, products, and practices for adoption.

Applications of expert systems have also been demonstrated in meteorology (Nathan and Hofmann, 1997), geology (Starek et. al., 2002), water resource management (Fedra, 2002), health (Kuperman, 1997), education (Weber and Brusilovsky, 2001), and social sciences (Wozniak, 2001).

### 4.0 KeRALA PROPOSITION

Complexity of natural systems is much beyond the comprehension level of conventional information systems and techniques. The unmanaged distribution of available data sets, a lack of documentation, and the lack of easy-to-use access tools and computer codes are major obstacles for scientists and educators alike. These obstacles have hindered scientists and educators in the access and full use of available data and information, and hence have impaired scientific productivity and the quality of education.

Recent technological advances provide practical means to overcome such problems. Advances in computer design, software, disk storage systems as well as the growth of the World Wide Web (WWW) now permit the management of gigabytes to terabytes of data and the uniform distribution of information to scientists, educators, students, and the general public. E- Governance is synonymous with scientific governance/ administration. Scientific disciplines are strongly data driven. Researchers and government agencies develop large data sets. The complexity of the fundamental scientific questions being addressed requires integrative and innovative approaches employing these data sets. The extent, complexity, and heterogeneous form of existing data sets and databases, as well as the need for the optimization of collection of new data, dictate that only a large, cooperative, well coordinated, and sustained effort will allow the community to attain its development goals as well facilitate scientific governance/ administration.

Combining 'Antariksh' facilitated real-rime weather data and Geographic Information System (GIS) with crop simulation models have tremendous potential for improving location-specific agricultural decision support systems. An expert spatial information system will offer much more than a typical 'display'. A GIS provides the capability of combining the weather data with virtually any other geographically based information and then makes it possible to derive socially relevant outputs. Real-time weather data, combined with a GIS, can immediately unlock analytical potential that was hitherto incomprehensible.

Real-time meteorological data collected from 56 representative locations in Kerala will be converted into a spatial real-time weather layer in a web GIS. This, in conjunction with the less dynamic physiographic and pedologic layers constitutes the e Resource Repository. Appropriate Decision Support Systems running in the background constitutes the Advisory System, which generates real-time domain specific advisory. Web GIS systems can make location specific advise the advisory to block or village level. Network of scientists, researchers and field officers spread across Kerala and associated with KISSAN can access real-time spatial advisory maps, available in public domain and interpret the same for the benefit of individuals in his/ her area of responsibility.

GIS and weather are appropriate components that can contribute to increased efficiencies in the emerging field of precision agriculture. The availability of geo-registered weather information within a GIS helps to map and calculate weather parameters for each section of cropland. For example, the mapping of accumulated precipitation can easily be accomplished. Precipitation estimates, converted into GIS formats, affords the agricultural scientist/ officer the ability to easily and quantitatively evaluate the spatial (geographical area) and temporal (time) variations of soil moisture and advise farmers when to schedule irrigation, inter-culture operations, etc.

### 5.0 BENEFITS OF KeRALA

KeRALA mounted on KISSAN has the potential to exponentially increase the quantum as well as the utility of knowledge disseminated. Such an expert system will have the inherent capability to tailor advise to individual farmer. This is achieved by development of identified domain specific applications - especially modelling and forewarning capability. For example: It would be of greater value to a farmer, if sure rain is forecast within next 100 hours than informing him about the quantum of precipitation, received in the last 100 hours; or a tapioca (Manihot esculenta) farmer in Thiruvananthapuram logging on to KeRALA one month before due harvest date can model and determine marketable surplus and execute future trading of produce. Labor scheduling in tea plantations can be optimized based on knowledge of tealeaf flush, which can be generated by the system.

A researcher can access the system to analyze the dynamics of cropping pattern in a region or develop/ improve suitable models for scheduling irrigation, etc. This implies access to data, computation, and visualization - together, sequentially or concurrently - from the same interface. KeRALA can be scripted to automatically generate periodic reports about agricultural situation in Kerala for planners and administrators.

The same system with the same set of basal data can be effectively harnessed to domains like natural disaster preparedness. Geriatric large dams and unforeseen climatic fluctuations resulting in occasional excessive precipitation in Kerala is a potential threat to human life. Technology has matured to enable simulate and model the potential impacts of such unforeseen circumstances. Academicians can access the data in the repository for academic research on climate change analysis; predict weather induced epidemiological outbreaks, coastal algal blooms, etc. These in turn can, spiral out as real world application for health and fisheries industry respectively. The applications of such modelling will find immediate takers in leisure industry such as tourism too.

Multitasking ensures the optimal utilization of the system and will also justify the financial implications associated with development of such systems. Figure3 gives a structural overview of KeRALA.
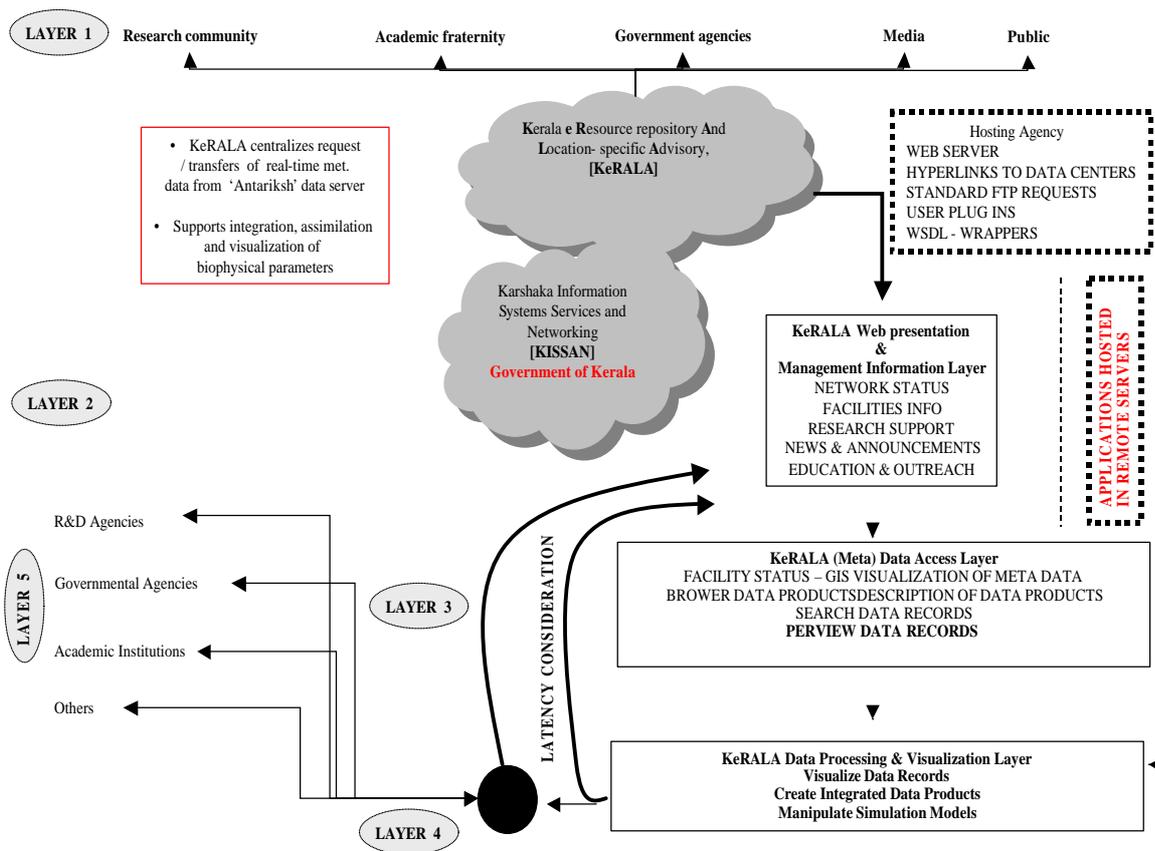


Figure 3. Conceptual Overview of KeRALA

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