IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 10, December 2014.
www.ijiset.com
ISSN 2348 – 7968

# A Comprehensive Agriculture Ontology: Modular Approach

**Dineshkumar P[1], Manoj G[2], Punyashree PB[3], Shruthi N[4] and Rajendra Akerkar[5]**

[1]CSE, Saranathan College of Engineering, Trichy, Tamil Nadu, India
[2]Data Science Analyst, Compegence, Bangalore, Karnataka, India
[3]Decision Analyst, Compegence, Bangalore, Karnataka, India
[4]Web Developer, Institex International Trading Company, Bangalore, Karnataka, India
[5]Techno Mathematics Research Foundation, Vestlandsforsking, Sogndal, Norway

**Abstract**

India, being second largest producer in agriculture in the whole world, it suffers serious back-logs because of no proper information flow and knowledge deficit. This paper presents a new attempt to create an agriculture ontology with splitting agriculture domain into 4 subdomains namely crops, crop diseases, soil & climate, constructing ontologies for each sub-domain and merging it together as a single comprehensive ontology. This proposed work will help to model vast and diverse agricultural domain well so that the domain knowledge is utilized well and knowledge sharing is efficient. It will help in providing proper information flow and reducing knowledge deficit.

***KEYWORDS***

*Ontology, Agriculture, Knowledge-base, Protégé, domain model*

## 1. Introduction

The greatest challenge faced by Indian planners is how to reach rural people effectively to make them take the advantages of the benefits of planned development program. The greatest problem faced by the Indian rural population is that they are not getting any proper support and timely help from the government and other helping organizations. “Like any other business enterprise, agriculture is subjected to high risks because of volatile nature and high risk factors. For an instance, weather is often a problem. We have drought in one year and heavy rain in next. In both the cases, farmers lose out; hence they have to look for a normal period to make money. Government, therefore, has to play a major role in providing support to farmers” [1]. Lot of helping organizations which are out there should have a proper understanding with the farmers, government and within themselves, which is lacking. Another important issue in recent years is drying up of population in rural areas and unwillingness of many people to work in rural areas.

India is a country which is mainly depends on agriculture and it is considered as the back-bone of Indian economy. India is second largest in the whole world and lot of improvements happened in agriculture after Independence, but crop yield per hectare is among the poorest in the world. Lot of problems are faced by Indian farmers and agriculture is inefficient. The Indian farmers have suffered over the years partly due to lack of timely, comprehensive information. It is required to provide them timely reliable information at a reasonable cost to the farmers in particular and rural people in general.

Then media started to share information to farmers, “Radio and television to some extent helped in disseminating the technologies but it has the in-born limitation that it is one way audio/visual media, with no immediate feedback. The farmers in particular and rural India in general need to be provided with the latest technologies at a shortest span of time effectively to run the farming on a profitable venture in present competitive world”[2]. Then the idea of using Information Communication Technology (ICT) came up, as it is capable of sorting out the above problem.

Indian Space and Research Organization (ISRO) started village Resource Centers (VRCs) all over India which is a place to render variety of services from a single window to remote rural people in a given geographical location through modern information and satellite technologies [3]. Increasing penetration of the mobile phone usage over rural India led to the development of support system through mobile. Many government organizations, NGOs and private organizations including Tata Consultancy Services (TCS) started SMS services for the farmers. These services were started for providing information to the farmers. They sent daily SMSes providing information about soil, crop, weather, prices of crops, etc., according to particular geographical location and in their local language. Even though such supporting systems using ICT came up using lot of latest technologies, its success rate is very low and not up to the mark.

This critical issue in Agriculture is because of knowledge deficit and infrastructure deficit. This brings up the need for a good Agricultural Knowledge Base or an Information System. It is capable of reducing a knowledge deficit and infrastructure deficit too. We here propose a solution for this problem using semantic technologies. A Comprehensive agriculture ontology will be a model base for achieving this task.

## 2. Literature Review

This research topic focuses on building a comprehensive ontology for agriculture. So the reviewed literature will be divided in to following parts:

### 2.1. Ontology

There are numerous definitions for ontology which shows various aspects and in various levels. The definition of Ontology was originally proposed in 1992 by Tom Grubar. He defines Ontology as, “An Ontology is the specification of conceptualization” and it is given in his article which was published in 1993. He used this definition in the context of knowledge sharing and ontology is explained as the description of concepts and relationships that can exist in an agent or a domain [4].

An ontology defines a common vocabulary for researchers who need to share information in a domain. It includes machine interpretable definition of basic concepts in the domain and relations among them. Here are some reasons for need of ontology:

- To share common understanding of the structure of information among people or software agents.
- To enable reuse of domain knowledge.
- To make domain assumptions explicit.
- To separate domain knowledge from operational knowledge.
- To analyze domain knowledge.[5]

From various definitions, it implies that ontology for a particular domain is taxonomy of that domain combined with properties and rules. Taxonomy of a domain is vocabulary or concepts with particular arrangement and properties are relationships which exist among those concepts. Technically, in a simple way, ontology consists of Concepts, Relations, Axioms and Instances. It is used to model a domain formally so that it can be used for information integration and knowledge sharing. Ontologies are basically modeled and represented as graphs. Popular language which is used for formal specification is OWL (Web Ontology Language), which is a semantic markup language [6].

### 2.2 Modular Ontology

Since there are various kinds of views on Modular ontology. Simple definition for Modular ontology is “An ontology that is composed of smaller (Semantically) connected component ontology”. Modular ontological approach is mainly used for [16]

1. Creating Distributed Ontology Network.
2. Effective knowledge utilization.
3. Partial Ontology Reuse.
4. Localized Semantics.

Since agriculture domain has various sub domains such as crops, crops disease, soil, and climate. Integrating crops, crops disease, climate and soil ontologies enable localized ontology network. Building such kind of modular ontology will create efficient information integration and knowledge based system.

### 2.3 Agriculture Ontology

There are numerous ontologies available online in agricultural domain which includes ontologies for individual crops, types of corps, fisheries, animal husbandry, etc., The number is increasing still, but their range of application in real world project is comparatively limited. Only very few ontologies applies to real world applications. Following are such examples:

### 2.3.1 Crop Ontology (CO)

Crop Ontology project is the creation of the Generation Challenge Program (GCP). Agricultural crop databases maintained in gene banks of the Consultative Group on International Agricultural Research (CGIAR) are valuable sources of information for breeders. To facilitate data sharing within and between these databases and the retrieval of information, the crop ontology (CO) database was designed to provide controlled vocabulary sets for several economically important plant species. Existing public ontologies and equivalent catalogues of concepts covering the range of crop science information and descriptors for crops and crop-related traits were collected from various sources including CGIAR consortium. Using all these information, Ontologies for each crop are constructed. All terms within an ontology were assigned a globally unique term identifier.

Two web-based online resources were built to make these COs available to the scientific community: the 'CO Lookup Service' for browsing the CO; and the 'Crops Terminizer', an ontology text mark-up tool. The Crop Ontology web site is a participatory tool that enables the users to browse the Crop Ontology, search for specific terms and access the definition, as well as additional information These ontologies are available to everyone and researcher can also submit their ontology to this. [7], [8] & [9].

### 2.3.2 OntoCrop Ontology

This is the ontology constructed for horticulture domain of agriculture and the author examines the usage in particular domain. This ontology is used,

- As a refining and classification tool facilitating indexing and searching process in a repository environment.
- As a domain model for rule knowledge-base construction [10].

## 2.4 Related Works in India

India is a country which depends largely on agriculture and it is considered as the back-bone of country's economy. Even though agriculture in India is second largest in the world, the yield per hectare is among the poorest in the world. This implies that there should be a serious improvement in the field of agriculture. The most serious disadvantage in agriculture is process of information flow and knowledge deficit. Various organizations and institutions are working on to improve these back-logs in agriculture through the use of ICT.

**Agropedia** platform is an agricultural Wikipedia for wide range of application in agriculture in India and it is developed by Indian Institute of India-Kanpur (IITK). It consists of an online knowledge repository, a social networking platform and content distribution services. This knowledge repository consists of universal meta-model and localized content for a variety of users with appropriate interfaces that supports information access in multiple languages [11].

They have developed the foundational agricultural ontology contains information common to every type of crops. This information include,

- Production practices (production and protection technologies).
- Post production practices (related to harvesting, threshing, post harvesting technologies, marketing, etc.,)
- Environmental information(climate, soil)
- Varieties in cropping system.
- Botanical description.
- Origin (geographical views).

Crop specific ontologies for rice crop were also built in IITK. Whereas researches are going on in Indian Institute of Technology-Bombay (IITB) in crop specific ontology for cotton crop and building ontology form text document.

## 2.5 Motivation for our work

India is a big country with diverse environment and people. The agriculture patterns are also very diverse. Firstly, climate has a great impact on agriculture and its productivity. It may happen that in a year crop yield will be affected by more rain and next year by low rain. India has two monsoon seasons in which some parts will get rain from any one and some parts will get from both. The amount of rainfall, temperature, wind, patterns, etc.., changes from place to place. Secondly, we will have a look at soil. There are almost 200 types of soil in India. Each type varies with different ingredients and components with different pH values. Types of soil also play a great role in the yield of crops, as each crop need different type o soil and components. Lastly it's about crop diseases. We are blessed with different types of soil, crop and crop diseases.

From the above, it is clear that soil and climate have a great impact in agricultural practices. So it is important to add climate and soil as a part of the agricultural domain itself. And it is important to give more importance to crop diseases. Adding these will make the agricultural domain bigger. It is important to model agricultural domain formally including all the diversities so that it will match the diversity of our country, it will be utilized to the maximum in wide range of application and will be a starting point to solve the existing problems. These implications motivated us to propose this system.

## 3. Proposed System

### 3.1 Methodology

We are considering climate and soil as a part of agricultural domain. So it can be considered as subdomain of agriculture. Here we present a new attempt to create a comprehensive ontology as follows:

- Splitting agricultural domain into four sub-domains: Crop, Crop diseases, Soil, Climate.
- Studying sub-domains individually.
- Constructing ontologies for sub-domains separately.
- Merging/Integrating four ontologies into a single comprehensive ontology.

### 3.2 Crop Ontology

The crop ontology we proposed will have following things,

- Taxonomies of crops growing in India
- Geo location
- Sowing season for each crops
- Types of soil preferable for the crops
- Information about pests and fertilizer
- Details on cultivation method
- Details on irrigation system
- Harvesting season

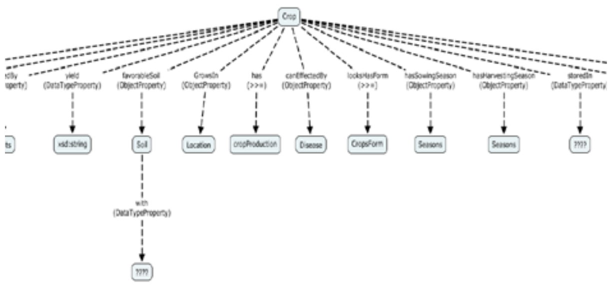

Fig.1 A Part of Crop Ontology – 1 by Cmap tools

### 3.3 Crop Disease Ontology

The proposed crop ontology will have the following things,

- Classification of micro-organisms
- Taxonomy of crop diseases based on micro-organisms and causes for the disease.
- Crop disease caused by season and climate change
- Prevention mechanism
- Curing mechanism

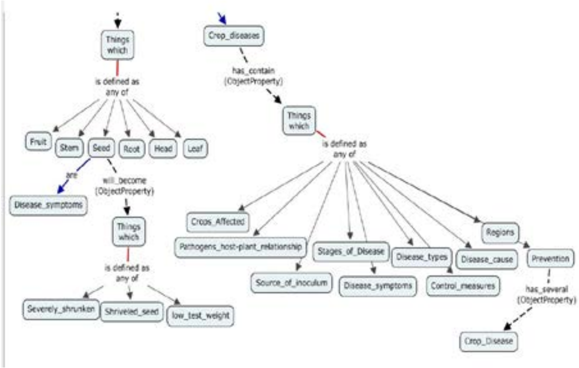


Fig.2 A Part of Crop Disease Ontology by Cmap tools

### 3.4 Soil Ontology

The proposed Soil Ontology will have the following things,

- Types and taxonomies of soil
- Soil acidity
- Soil Salinity and alkalinity
- Soil regions
- Soil moisture regimes
- Soil physical and chemical properties
- Soil genetic system classification
- Soil formations
- Diagnostic horizon of soils

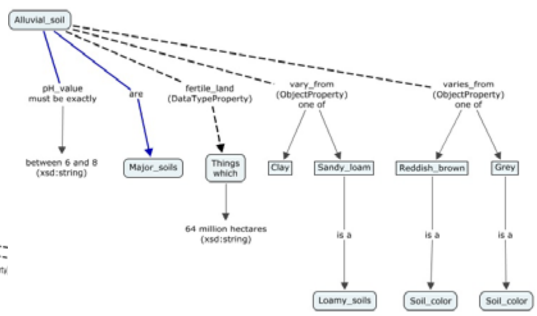


Fig 3. A Part of Soil Ontology by Cmap tools

## 3.5 Climate Ontology

The proposed climate ontology will have the following things,

- Atmospheric phenomena
- Weather which includes temperature, humidity, precipitation and wind
- Meteorology and types
- Monsoon and cyclones
- Seismology
- Global warming, climate change and greenhouse effect.
- Classification of areas based on rainfall, temperature and wind flow

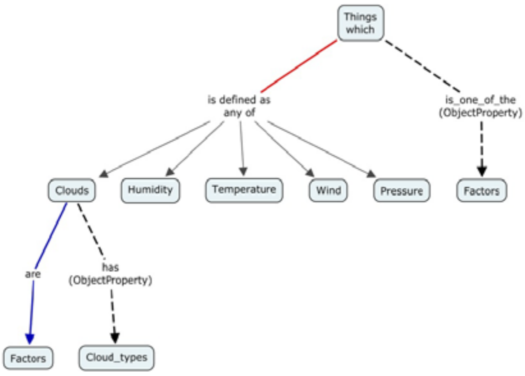


Fig 4. A Part of Climate Ontology by CMap Tools

## 3.6 Ontology Construction

We used Protégé ontology editor for ontology construction. The following are the steps to create ontology.

### 3.6.1. Creating classes and sub-classes:

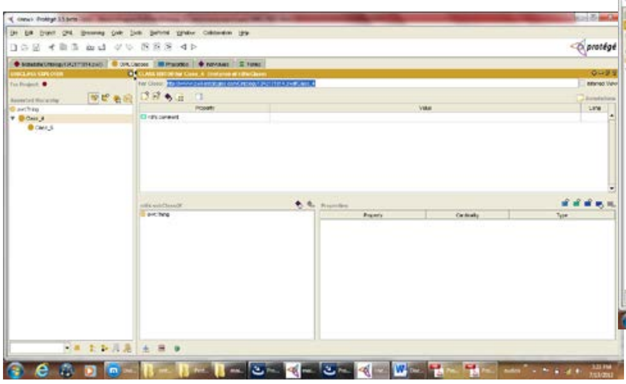

Fig 5. Creating classes and sub-classes in Protégé ontology editor

### 3.6.2 Creating properties/Relations:

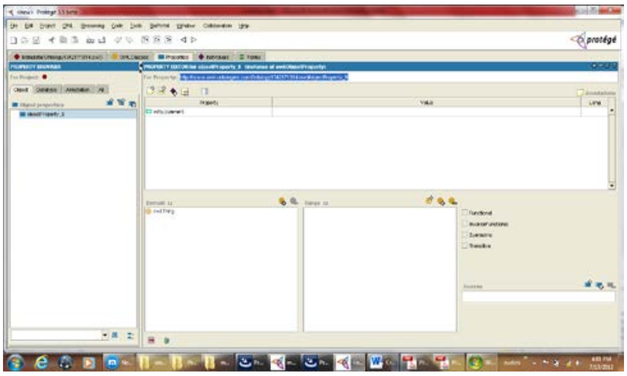

Fig 6. Creating object properties in Protégé ontology editor

### 3.6.3 Creating Individuals:

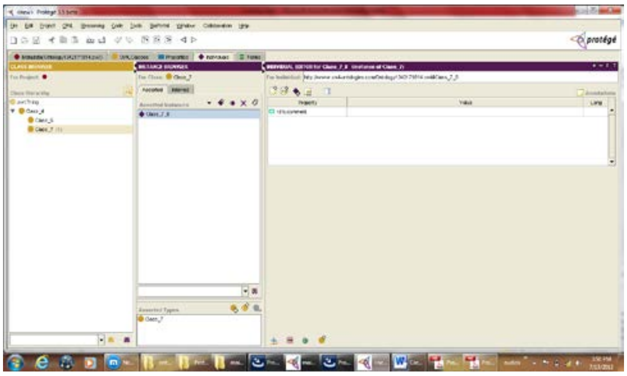

Fig 7. Creating Individuals in Protégé ontology editor

### 3.6.4 Creating Restrictions:

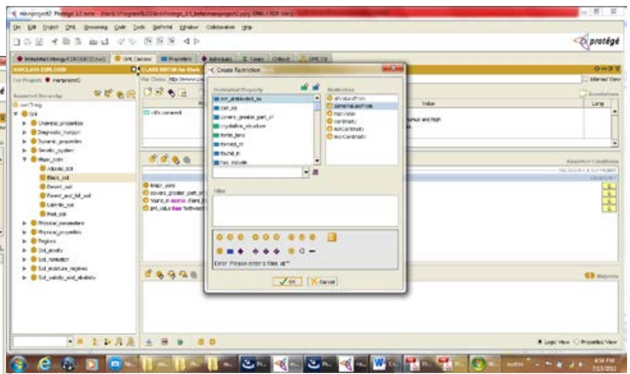

Fig 8. Creating restrictions in Protégé ontology editor

### 3.6.5 Adding Descriptions:

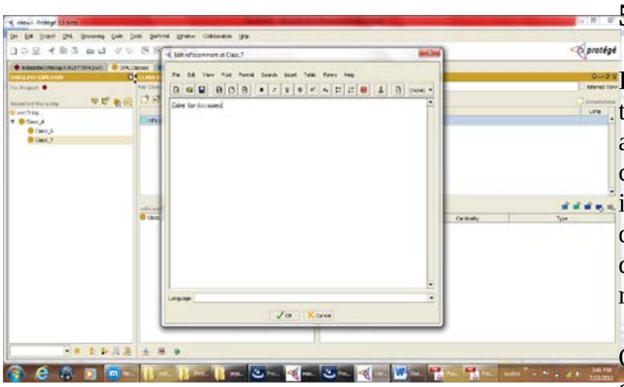

Fig 9. Adding descriptions in Protégé ontology editor

### 3.6.6 Adding Domain/Range values:

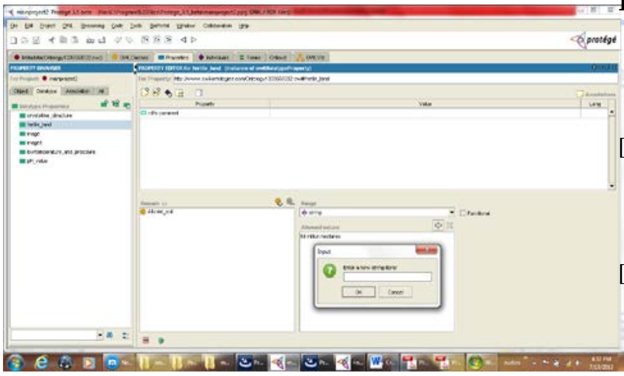

Fig 10. Adding Domain/Range values in Protégé ontology editor

## 4. Discussion

We put forward our findings and implicaitons in this section. They are as follows,

- Climate and soil should be part of agricultural domain as it has a greate impact.
- We have proposed new approach of modelling agricultural domain from which an Information Management System or knowledge base can be constructed. Such system will reduce the knowledge deficit in India.
- We can use split and conquer approach; Splitting agricultureal domain in to 4 sub-domains, creating ontologies for the sub-domains and integrating it. The domain can be best modelled in this way to use it for wide range of applications.
- Images and videos can be added as a part of domain ontology.

## 5. Conclusion

In this paper, we have presented a new method to create agricultural ontology by splitting the agricultural domain into sub-domains, constructing ontologies for sub-domains and integrating it together. We conclude that the domain can be modelled well and so that the domain knowledge can be utilized for the wide range of application.

Our future work includes reusing some of the existing ontologies with this proposed work to make it still more efficient and to build an information system or a knowledge base using this ontology.

## References

[1] Indian Agriculture – Issues and Reforms with Prof. Gopal Naik [online]. Available: http://tejas-iimb.org/interviews/12.php.

[2] Dr. K. Narayana Gowda and Shamna A, “How to Enhance the Effectiveness of VRCs”, Lecture to KVK SMS incharge of VRCs, 2008.

[3] “Space Technology Enabled Village Resource Center (VRC)” [Online]. Available: http://www.isro.org/publications/pdf/VRC Brochure.pdf.

[4] “What is an Ontology?” [Online]. Available:http:/wwwkal.stanford.edu/kst.what-is-an-ontology.htm

[5] Natalaya F. Noy and Deborah L. McGuiness, “Ontology Development 101: A Guide to Create your First Ontology, 2001, [Online]. Available: http://protege.stanford.edu/publicaitons/ontology_development/ontology101-noy-magunniess.html.

[6] Kelly Moran and Kajal Claypool, “Building the NNEW Weather Ontology” MIT Lincoln Laboratory, 2010.

[7] “Crop Ontology”, [Online]. Available: http://www.cropontology.org.

[8] Rosemary Shrestha, Elizabeth Amaud, Ramil Mauleon, Guy F. Davenport, David Hancock, Norman Morrison, Richard Bruskiewich and Graham McLaren, “Multifunctional Crop Trait Ontology for Breeders’ Data: Field book. Annotation, Data discovery and Semantic environment of Literature”, AoB PLANTS (2010) Vol, May 27, 2010.

[9] Crop Ontology curation and annotation tool – 2011 Generation Challenge Programme, Biodiversity International as project implementing agency.

[10] Malppis, M.T (2009), "Applying an Agricultural Ontology to Web-based Applications", Int. J. Metadata, Semantics and Ontologies, Vol.4, Nos. ½, PP. 133-140.

[11] Agropedia, [Online]. Available: http://www.agropedia.iitk.ac.in.

[12] "Agropedia: The Knowledge and Interaction hub for Indian Agriculture", ICRISAT, [online]. Available: http://vasat.icirisat.org/images/New%20Folder/Agropedia.pdf.

[13] "Fundamentals of Soil Science", 2nd Edition, Indian Society of Soil Science

[14] G. Rangaswamy, "Disease of crop plants in India", 4th Edition, Prentice-Hall of India.

[15] Nyle C. Brady, Ray R. Well, "The Nature and Properties of Soils", 13th Edition, Pearson Education

[16] Jie Bao, "Modular Ontologies: Package-based Description Logics Approach"[online], Artificial Intelligence Laboratory, Computer Science Department, lowa State University, July 26, 2006." http://www.slideshare.net/baojie_iowa/modular-ontologies-packagebased-description-logics-approach"