Ontology Model for the Knowledge Management in the Agricultural Teaching at the UAE

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Abstract. This work aims to propose a model for the design and construction of a knowledge management model for agricultural education based on ontologies. It proposes, through the business model identification, the business processes, the intellectual capital and the ontologies, to develop a model which can identify intelligent technological tools based on ontologies. The relationship between each part of the model is shown and explained, and the technological elements that support it arise. From the union of the elements such as: knowledge management, the university as capitalizer of knowledge, the ontology as elements to represent the knowledge and the intelligent technologies as support to all the above, develops the ontological model that guides to the innovative university, where the Milagro campus of the Agrarian University of Ecuador (UAE), is the case of study. This model incorporates the "know-how" of knowledge management, agriculture production and collaborative learning articulated with Information Communication and Technology (ICT) applied to educational management in the agricultural sector. The ontology is developed as the main mechanism to represent knowledge, which defines the meaning of the terms and the language used as well as the relationship between them. The application of this model is expected to structure the technological and knowledge bases required for agriculture teaching.

Keywords: Ontology, Agriculture, Teaching, Business Process, Knowledge Management

1 Introduction

The history of agricultural systems modeling shows that major contributions have been made by different disciplines, addressing different production systems from field to farms, landscapes, and beyond. In addition, there are excellent examples in which component models from different disciplines have been combined in different ways to produce more comprehensive system models that consider biophysical, socioeconomic, and environmental responses. For example, there are examples where crop, livestock, and economic models have been combined to study farming systems as well as to analyze national and global impacts of climate change, policies, or alternative technologies for different purposes. The history shows that the development of agricultural system models is still evolving through efforts of an increasing number of research organizations worldwide and through various global efforts demonstrating that researchers in these groups are increasingly interested in contributing to communities of

science. However it is clear that there is a need for a more focused effort to connect these various agricultural systems modeling, database, harmonization and open-access data, and DSS efforts together, so that the scientific resources being invested in these different initiatives will contribute to compatible set of models, data, and platforms to ensure global public goods [24].
The knowledge society has given birth to a new economy based on "know and know-how to do with knowledge" of people and organizations that in the growing challenges of current market behavior require strengthening the construction of that knowledge to be competitive in today's changing world [2]. The knowledge society is considered a new era, leading to changes mainly in educational institutions that must find ways to incorporate technologies into learning processes, to achieve new knowledge [3].
From the union of the elements such as: knowledge management, the university as a capitalizer of knowledge [7], the ontologies as elements to represent the knowledge [5] and the intelligent technologies as support to all the above, the agricultural knowledge model that guides towards the innovative university it developed, where the Milagro campus of the Agrarian University of Ecuador (UAE) is the case of study. This model describes the elements that define the knowledge of an agricultural production unit from the university. The idea of this model is to allow it to incorporate the “know-how” of agricultural knowledge management [14] and collaborative learning [10] articulated with intelligent technology.
An ontology is a formal and explicit specification of a shared conceptualization [6]. It provides a formal representation of structures knowledge in a reusable and sharable way. Ontologies provide a common vocabulary with different levels of formality for a domain. Also, they define the semantics of the terms and the relationships between them. Knowledge management process requires determining the structure of the knowledge in order to facilitate the problems solution. Ontology is used as the main mechanism to represent knowledge, to define the meaning of the terms and language used as well as the relationships in the knowledge system of the UAE Milagro campus. Ontology is developed under the methodology Methontology [8].
This research presents a description of the agricultural knowledge management model, then discusses the most relevant investigations of the topic addressed. The following section describes the methodology used for model development and concludes with the ontology model obtained, the conclusions and future research work to be carried out.

2 State of the Art

In [10] summarize the background and current state of agricultural models, methods and data that are used for a range of purposes. It summarizes a history of events that contributed to the evolution of agricultural system modeling. It includes process-based bio-physical models of crops and livestock, statistical models based on historical observations, as well as economic optimization and simulation models at household and regional to global scales. This history is followed by an overview of the characteristics of agricultural systems models and the wide range of purposes that various researchers in different disciplines had when developing and using them. These purposes have led to systems being defined, modeled and studied at a wide range of space and time scales. They also summarize the capabilities and limitations associated with these models, data, and approaches relative to what may be needed for next generation models.

In [9] presents ideas for a new generation of agricultural models and data that could meet the needs of a growing community of end-users exemplified by a set of use cases. They envision new models and knowledge products that could accelerate the innovation process that is needed to achieve the goal of achieving sustainable local, regional and global food security. They identify desirable features for models, and describe some of the potential advances that they envisage for model components and their integration. They also discuss possible advances in model evaluation and strategies for model improvement. They conclude with a multi-pronged implementation strategy that includes more through testing and evaluation of existing models, the development and testing of modular model components and integration, improvements in data management and visualization tools, and development of knowledge-products for end users.

In [16] identify the possible areas of knowledge management intervention in agricultural projects and how they can contribute to the achievement of their impacts. The areas of intervention of the knowledge management that they identified are: research planning, use of knowledge management tools, management of the information generated in the research processes, sharing of research processes, use of information technologies and communication, co-creation of information and knowledge products, and communication for development. At the beginning of each project the implementers carry out a planning involving the immediate partners, with the first results and in a collaborative way with the partners, they develop tools and methodologies that adapt to multiple audiences. Through strategic networks, these products are shared and their use is generated at scale, and the social media are used to make visible the solutions developed.

Based on the needs identified in [10] and [9] and the [16] vision of knowledge management for agricultural projects, this paper develops the knowledge management model for agricultural education using ontologies as a means of representing knowledge.

3 Ontology Model for the Knowledge Management in the Agricultural Teaching at the UAE

The Milagro campus is an academic-investigative campus with an approximate area of 90 hectares belonging to the Agrarian University of Ecuador in which the careers of the third level of agronomic engineering, agricultural engineering mention agro-industrial, agricultural economy and the engineering in computation and informatics are imparted. The learning system is carried out using the learning by doing methodology as well as project-based learning. This is done through the management of agricultural production in their facilities and the development of projects with the communities.

The Milagro Campus manages three major areas: academic, administrative and production area. In the academic area, they define projects for the learning in the agricultural area and have carried out projects of: horticulture, fruit-growing and irrigation systems, as well as crops of tomato, cucumber, watermelon and melon. In the productive area, projects are developed on productive land of short-cycle crops: rice, soy, beans cotton and maize; and perennial and semi-permanent crops are developed such as cocoa, African palm and sugarcane. The administrative area supports production activities such as the administration and sale of processed foods from the cultivation projects. The learning process is carried out according to the production process and then the teaching is replicated by students in their practices with the community.

The methodology used to develop the model proposed in this work was adapted from the presented in [11] and [12]. The structure of this model is composed of three layers: business model and processes, knowledge management, and knowledge management technologies. These layers are represented by means of ontological models. The business model describes how the organization creates, delivers, and captures value [14]. This concept of business model is used to describe the business model ontology of Milagro campus, as shown below.

It is important to note that the Ontology for Knowledge Management of the Milagro campus was developed with the methodology Methontology [7] and its implementation was carried out with the Protégé-OWL ontology editor.

3.1 Business Model Ontology of Milagro Campus

Osterwalder [15] defines the business model as an abstract representation of the business logic of an organization through an ontology for the business model, consisting of three large blocks, a block representing the resources, activities and third parties that act as allies, necessary to produce and maintain the value offering. A second group of blocks representing the revenue and cost reflection of the previous set. And a third block of customer-related activities.

This model is aimed at students, professors, researchers and workers of the Milagro campus, as well as surrounding communities. The value proposition is the creation of an agricultural knowledge management model that guides innovation in the Milagro campus. This model will indicate know-how through the processes of knowledge management, and support the generation of new learning and innovation. Key activities are defined in the following areas:

Academic. The activities of teaching learning, and research and innovation.

Teaching learning is formed by activities such as academic planning, planning and project management, creation of learning objects (supports to the theoretical and practical classes) and evaluation.

Research and innovation are all activities required before starting the production project of learning activities.

Agriculture, the different components of the agricultural value chain [10] are:

Technology Inputs. This process describes the technological solutions or applications that support agriculture process. Physical: Seeds, fertilizer, water, fuel, weed, insect and disease control. Information: Precision farming (Yield mapping, UAVs, on-the-go sensors, diagnostics and analytic packages).
Crop Production: Equipment (Tillage, irrigation, harvesting, storage, etc.). Management Strategies (conservation tillage, crop rotation, integrated pest management). Marketing of production.
Animal Production: Livestock and aquaculture: genetics, precision feedings, nutrition, healthcare, animal wellness, diagnostics, drug delivery.
Transformation: Processing: carbohydrate, protein, fiber, meat-milk-eggs, food and feeds safety, logistics, bioenergy, biomaterials.
Distribution: Production, packaging, transportation, distribution, product development, supply chain management, traceability, retail.
Consumption: Food, Feed, Fiber, Fuel.
The business model ontology is show in the figure 1.

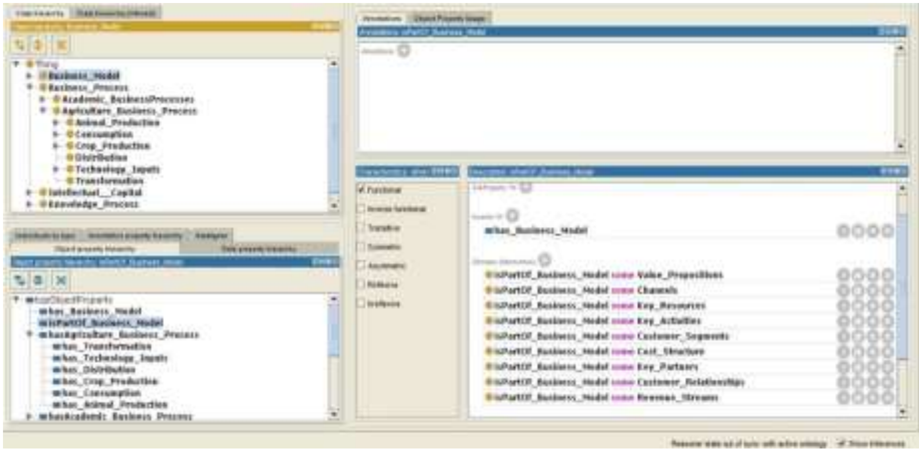

Fig. 1. Business Model Ontology of Milagro Campus.

3.2 Business Process of Milagro Campus

The following describes each of the business processes of the Milagro campus, obtained from the key activities of the business model. These business processes are modeled from the ontologies as shown below.
Academic Process. In this process, as shown in figure 2, the activities of teaching learning, and research and innovation are described, which support the projects that develop in each lapse that make up the careers. This process is supported by project-based learning methodologies and learning by doing. It is divided into two major threads: teaching learning, and research and innovation. The learning sub-process is formed by the activities of academic planning, project planning, creation of learning objects (supports to the theoretical and practical classes) and evaluation. The research, development and innovation sub-process is formed by the activities such as promotion

work, creation of new products and services, publications, management of research lines, thesis of degree.

Agriculture Production Processes. The different components of the agricultural value chain [10], is shown in the figure 2.

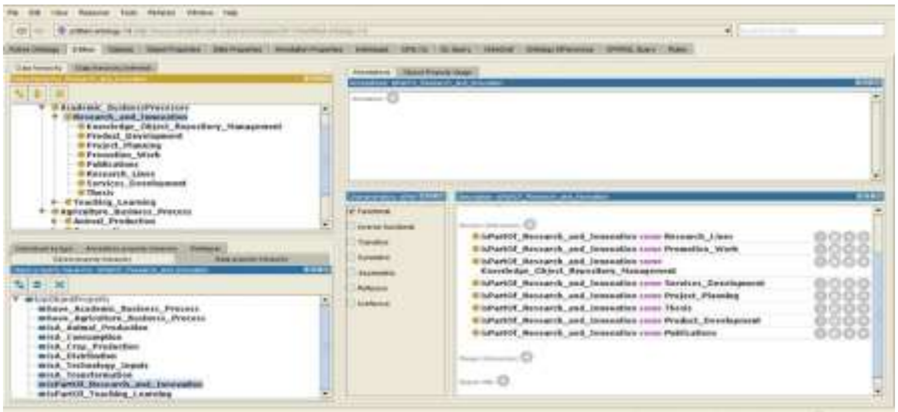

Fig. 2. Ontology of Academic and Agriculture Process at the Milagros Campus

3.3 Knowledge Management Model

Intellectual Capital. Davenport and Prusac [2] take the knowledge as a fundamental asset for higher education, and they say that knowledge management is a business model that uses knowledge as the organization's asset to achieve competitive advantage, as well as the tools of knowledge management support and promote evaluation, utilization, creation, expansion, protection, Division and application of the intellectual capital of the organization. From this vision and using the Model Euroforum [1] to represent the intellectual capital of an organization, the figure 3 shows the model of intellectual capital and its structure for the Milagro campus.

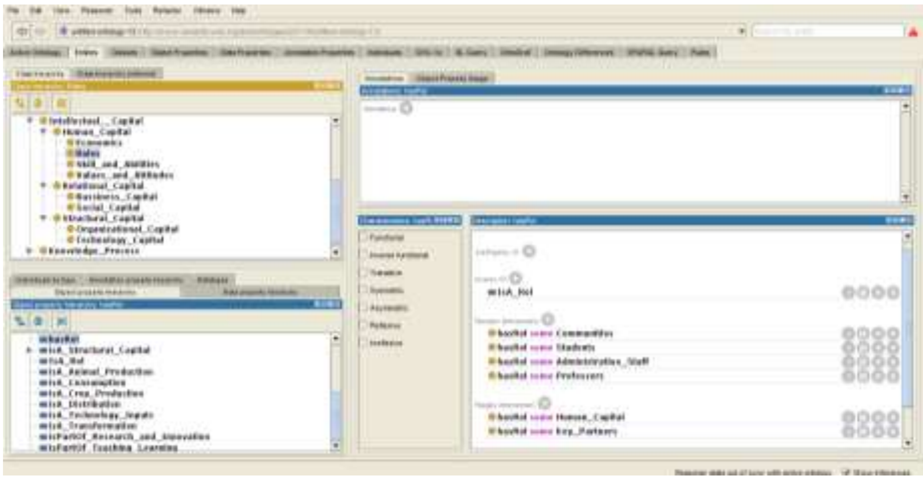

Fig. 3. Intellectual Capital Ontology for Milagro Campus

This model defines the elements of knowledge that create value and describe the behavior of the organization.

Human capital is formed by professors, students and researchers from an academic point of view. From the productive point of view there must be roles such as: Experts in food, veterinarians, livestock experts and experts in agricultural and livestock management. These roles must be complemented by the sense of belonging and learning to do collaborative work within the organization.

The Structural capital is formed by the organizational capital, associated with the structural scope of the designs, processes and culture of the Organization; such as the business model, organizational memory and systems that support the organization. And the technological capital linked with the effort in R&D, the use of technological endowment and the results of R&D in organizational management, product technology, process technologies, social innovation and business models.

The Relational capital divided into two, on the one hand, the relational capital of business in which they have to see the flows of information and knowledge of external character to the business (suppliers, clients-users, allies, etc.) and, on the other hand, social relational capital, which has to do with relationships outside the business sphere (social commitment, public image, reputation, prestige, social action, etc.). All of them allow us to obtain a panoramic view of the intangible assets that the miracle extension possesses, thus generating the information necessary for the decision-making.

The knowledge processes, is composed of a group of strategic processes that occur cyclically [13]. The knowledge creation cycle, covers all phases where it can intervene knowledge management tools, allowing a total link between them. Designed knowledge creation cycle is based on the following phases.

Knowledge Identification. Determine the knowledge necessary for the operation of the knowledge processes and ensure the conformity of products or services. The knowledge audit should be at this stage. Knowledge management has various tools to identify knowledge: directories and yellow pages experts, knowledge maps, topographies of knowledge, assets of knowledge maps, maps of sources of knowledge, which are used interchangeably depending on the objectives, but all with results proven in different contexts.

Knowledge Acquisition. It is performed through the fault log and successes, capturing undocumented experiences, improvements in processes, products and services. As well as the acquisition of external knowledge that should be sought through existing elements as external sources: standards, academic institutions, conferences, knowledge compiled with customers or suppliers. Information and document management systems are used for this purpose.

Knowledge Maintenance. This lessons learned systems can be used for example. Threads are inside this process:

Knowledge Use. Through creation of knowledge platforms, intranets, portal, scenarios, among other tools.

Knowledge Retention. This can be done through a document management system to support the work of the organization and facilitate an inquiry at the necessary time.

Knowledge Measurement. The process of evaluation and measurement of knowledge can be determined through various parameters established by the organization.

Knowledge Distribution (Share). Produce measures to make available the knowledge to those who need it at the right time (for example, with communities of practice).

3.4 Technology Architecture for Knowledge Management Model of Milagro Campus

From the definition of the business model, business processes, the model of intellectual capital and knowledge management processes the technological architecture that supports it is defined. Figure 4 shows the architecture and its components.

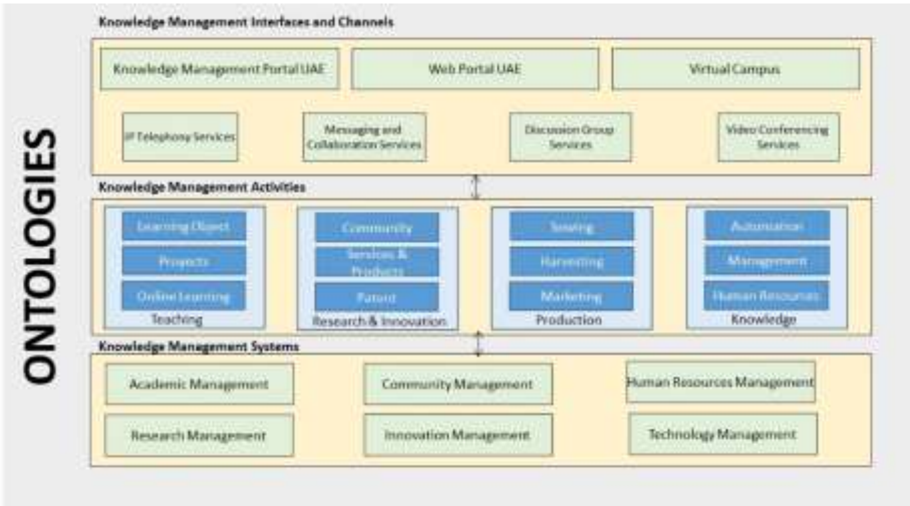

Fig. 4. Technological architecture to Management Knowledge Model for Milagro Campus.

Interfaces and channels are the elements that provide the input interface to the knowledge management of the Milagro campus and are the Web and Knowledge Portals and Virtual Campus. Business processes are those that represent key activities for knowledge management. And the knowledge management layer in which academic management, communities, human resources, research and innovation and technology management are carried out, which in turn are supported by elements such as:

- Content management systems to manage the content and Knowledge Portal, as well as wiki, blogs and manage users (yellow pages and white pages to find out who knows what and for collaborative work).

- Learning Management Systems (LMS) that will support the management of water-courses. The management systems of learning contents (LCMS) for the creation, reusability, location, development and management of learning content.
- Systems of document management will enable to carry out the registration and tracking of documents generated during the academic activities and production of Milagro Campus. System of registration activities indicating what makes who, how and with what tools to record experiences.
- Organizational memory that holds elements that make up the organization, work-flow, and projects that are being carried out. A first version of this report for projects is shown below, developed through a database.

All these elements are linked and target by the ontologies represented as shown below.

3.5 Ontology of Knowledge Management of Milagro Campus, UAE

In order to produce some phenomenon or part of the world, called domain, is necessary to focus or limit the number of concepts that are relevant and sufficient to create an abstraction of the phenomenon. Thus, the central aspect of any activity of modeling consists of performing a conceptualization; that is, identify concepts (objects, events, behaviors, etc.) and the conceptual relations that it is assumed that they exist and are relevant. Regardless of the field in which are developed, the basis for an ontology i.e. conceptualization, which constitutes a controlled vocabulary to refer to entities of a particular domain. Therefore, one of the uses of ontologies is to specify and communicate the knowledge of an area of knowledge, generically, that are very useful to structure and define the meaning of the terms. The ontologies to represent knowledge, require the following components [6]: concepts, relations, functions, instances and axioms. If you specify the components and their relationships of a field of knowledge following a strict formalism encoded in a computer language (no programming, but description), then it is an ontology.

The following table 1 describes formally the knowledge management processes at Milagro Campus. These processes are shown in the form of sentences in natural language and first-order predicate logic, which allows the formalization of the axioms will give support to the reasoning to find new knowledge.

Table 1. Knowledge Management Process of Milagro Campus

NATURAL LANGUAGE	FIRST-ORDER PREDICATE LOGIC (FOPL)
To identify the knowledge is carried out through knowledge audit.	∀ x IdentifyKnowledge(x) ═> isCarriedOut (x, KnowledgeAudit)
The audit knowledge has knowledge inventory, knowledge flow, knowledge networks and knowledge map.	∀ x KnowledgeAudit (x) ═> has (x, KnowledgeInventory) Λ has (x, KnowledgeFlow) Λ has (x, KnowledgeNetworks) Λ has (x, KnowledgeMaps)
The knowledge inventory has role and has business process	∀ x KnowedgeInventory (x) => has (x, BusinessProcess) Λ has (x, Rol)
The knowledge flow has a knowledge	∀ x KnowledgeFlow(x) => has (x, Knowledg-

transfer that is shared between knowledge networks.	eTransfer) Λ has (x, Rol) Λ has (x, KnowledgeNetworks)
A knowledge network is defining who does what within the Organization, and who knows what each process.	∀ x ReddeConocimiento (x) => isDefined (x, BusinessProcess) Λ isIntegrated (x, Rol) Λ isRegistered (x, YellowPagesRepository)
The knowledge acquisition is to record by not documented experiences in the practice log repository	∀ x KnowledgeAdquisition (x) => isA (x, NoDocumentedExperience) Λ isRegistered (x, PracticeLogRepository)
Not documented experiences are videos and results of meetings, and learning.	∀ x NoDocumentedExperience (x) => isA (x, Video) V isA (x, ResultofMeeting) V isA (x, ResultofLearning)
Knowledge Maintenance is the knowledge use, is a knowledge retention, or is a knowledge measurement.	∀ x KnowledgeMaintenance (x) => isA (x, KnowledgeUse) V isA (x, KnowledgeRetention) V isA (x, KnowledgeMeasurement)
The knowledge retention has learned lessons and this are registered in knowledge repository	∀ x KnowledgeRetention (x) => have (x, LearnedLesson) V registeredIn (x, KnowledgeRepository)
The knowledge use is an application platform or is a storage repository or is an artificial intelligence technologies or is a network technologies	∀ x KnowledgeUse (x) => isA (x, ApplicationPlataform) V isA (x, StorageRepository) V isA (x, ArtificialIntelligenceTechnology) V isA (x, NetworkTecnologies)
Application platforms is a content learning management platform or user management platform or content management platform or knowledge management platform or online learning platform	∀ x ApplicationPlatform (x) => isA (x, ContentManagementLearningPlatform) V isA (x, UserManagementPlatform) V isA (x, KnowledgeManagementPlaform) V isA (x, OnlineLearningPlatform)
Storage Repository is a knowledge repository or an organizational memory repository or a practice log repository or a yellow pages repository	∀ x StorageRepository (x) => isA (x, KnowledgeRepository) V isA (x, OrganizationalMemoryRepository) V isA (x, PracticeLogRepository) V isA (x, YellowPagesRepository)
Network Technologies is an extranet or a Portal or an Intranet or an Internet	∀ x NetworkTecnologies (x) => isA (x, Extranet) V isA (x, Portal) V isA (x, Intranet) V isA (x, Internet)
Artificial Intelligence Technologies is an expert system or a semantic web or a machine learning or an ontology or a multiagent systems or a knowledge based systems	∀ x ArtificialIntelligencetechnologies (x) => isA (x, ExpertSystem) V isA (x, SemanticWeb) V isA (x, MachineLearning) V isA (x, Ontology) V isA (x, MultiAgentSystem) V isA (x, KnowledgeBasedSystem)
Knowledge retention is an organizational memory.	∀ x KnowledgeRetention (x) => isA (x, OrganizationalMemory)
Knowledge measurement has measurement parameters.	∀ x KnowledgeMeasurement (x) => have (x, MeasurementParameters)
The knowledge distribution is a community of practice, or a forum or a training or an event.	∀ x KnowledgeDistribution (x) => isA (x, CommunityofPractice) V isA (x, Forum) V isA (x, Training) V isA (x, Event)

Using the concepts, properties, relations and axioms defined above is shown below the ontological model for the knowledge management of Milagro Campus UAE, using Protégé OWL extension, which allows its representation and validation. The figure 5 show the Ontology for the Knowledge Management in the Teaching of Agricultural Sciences of Milagro Campus and the figure 6 show the class hierarchy and object property of Ontology.

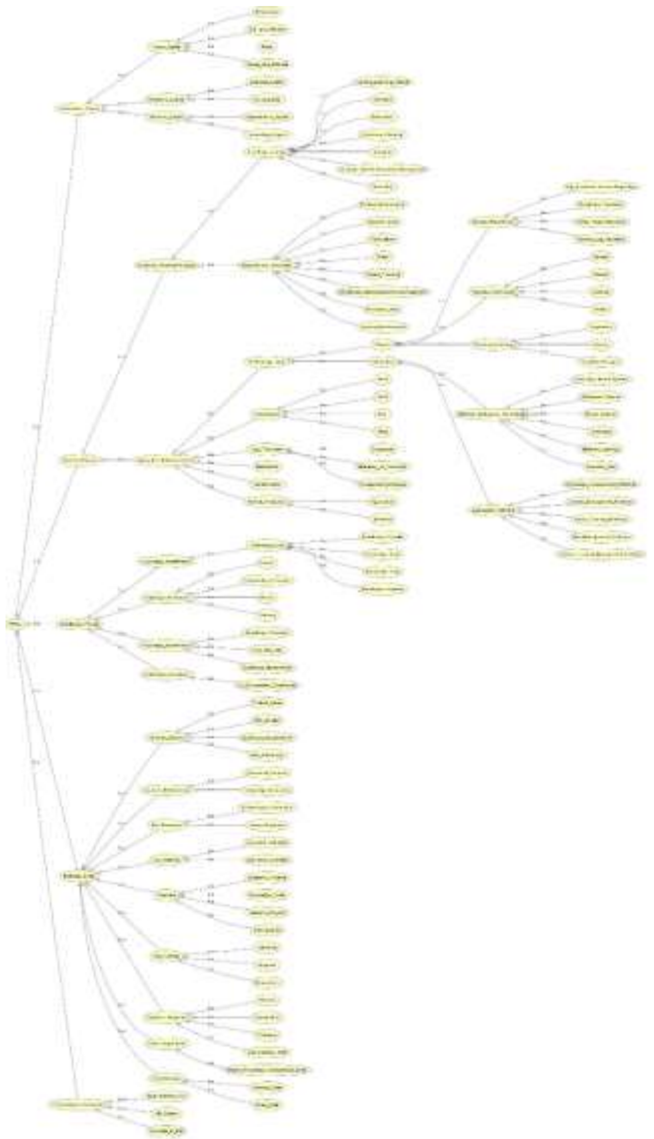

Fig. 5. Ontology for the Knowledge Management in the Teaching of Agricultural Sciences of Milagro Campus

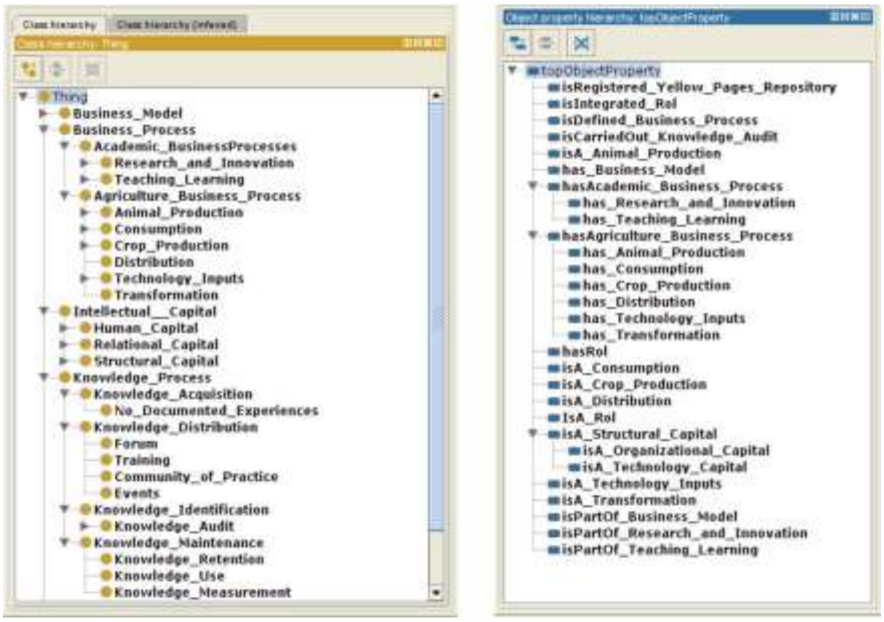

Fig. 6. Class Hierarchy and Object Property of Ontology for the Knowledge Management in the Teaching of Agricultural Sciences of Milagro Campus

The ontology is classified using the Fact++ reasoner, which is executed as part of the Protege OWL. The classification of the ontology in OWL 2 is supported by the Manchester Syntax[1].

[1] https://www.w3.org/TR/owl2-manchester-syntax/

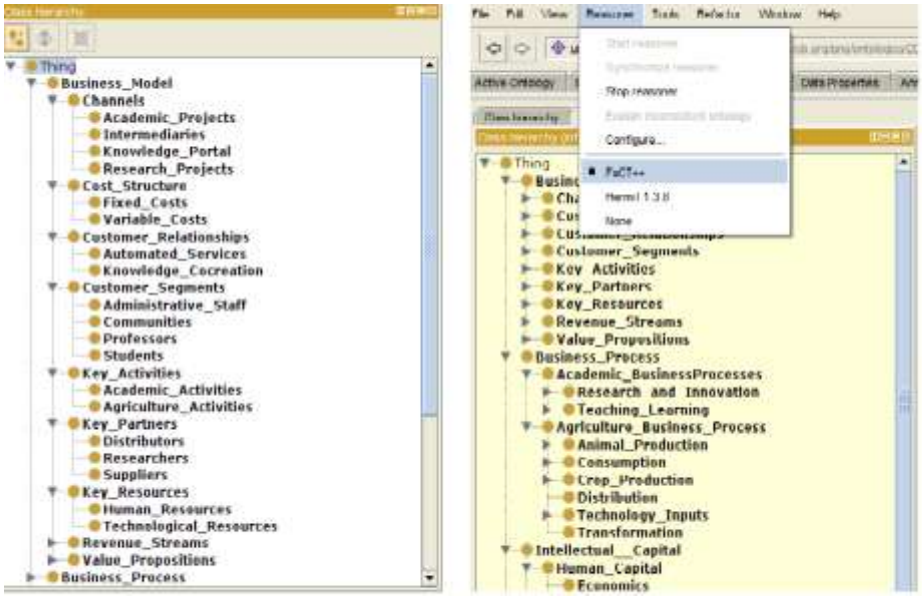

Fig. 7. Ontology Classified

4 Conclusions

In this work the ontology was developed from the vision of the knowledge management that the user should use, and how that knowledge can serve to improve their services. The ontological model represents the knowledge of the agriculture teaching domain and describes the logic of its processes through the axioms defined in Table 1. The ontologies to represent knowledge, require the following components: concepts, relations, functions, instances and axioms. In this research are concepts, relations and axioms of the elements that make up the knowledge management for the domain of the agricultural college, using Milagro Campus as a study case. This ontological model will support the university to define the elements of knowledge that it requires to support innovation in all its activities.

This model represents the starting point and a guided work to create an innovative University, through knowledge management that supports the growth of the area in which it is located.

This research represents the beginning of the following projects to develop:

- Knowledge Base of communities in Milagro area, that allows to identify and register people and communities as well as expertise in the agricultural area.
- Organizational Projects Memory that are carried out between the communities and the University to perform logging practices and measure the quality of them. This project is starting.

- Portal of knowledge for agricultural production in Milagro area, this portal manages the repositories of knowledge, ontologies and practices between the University and the community.
- Integration ontologies for the Knowledge Management Model.

Ontologies are used in bio-health, e-science, and Semantic Web applications to capture the meaning of terms. Designing ontologies is a non-trivial task that requires sophisticated tool and service support. One of the most important services for logic based ontologies. In this work, through the axioms proposed in Table 1, the formal logic of the Milagro Campus knowledge model is represented.

The growing presence of ICTs in agriculture chains tends to generate automation and efficiency, either through the use of machinery and equipment, or in the knowledge fields, to facilitate the productivity of crops. Its main objective in agriculture is to support the improvement of processes and products, together with the intermediation of the people who develop and operate. Technology may be within the reach of everyone, but it is necessary to have the proper education to use it, without forgetting the capabilities of people. It is why this ontological model of knowledge management describes the processes and intelligent technologies that support teaching in the agricultural area from vision learn making and collaborative work in conjunction with the communities.

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