SustenAgro a Decision Support System for Agricultural Sustainability based on Domain Specific Language and Ontologies.

John Garavito, Dilvan Moreira, Sergio A. Torquato, Katia Regina, and Ivo Pierozzi

Institute of Mathematical and Computer Sciences , São Paulo University, Avenida Trabalhador São-carlense, 400 São Carlos - SP, Brazil

Abstract. Agricultural production systems have the need of measuring sustainability, an approach to achieve this goal is the use of Sustainable Indicators (ISDs). With the aiming to develop a new methodology and a software system that are able to access the sustainability of Sugarcance production system in Brazil, was developed the SustenAgro Project. The main challenge was the formulation of specific sustainability indicators considering the complexity and diversity of agricultural scenario in this country. This propose uses Ontologies to represent indicators and organize the information as the base for SustenAgro. his Project shows better and accurate results in comparison with others Knowledge Organization Systems used in the área. In this paper we present two ontologies and a Domain Specific Language (DSL) associated that support the decision making process and represent the domain knowledge, both based on Semantic Web technologies. This association proposes an architecture to implement and a manage Decision Making Systems like SustenAgro Software.

Keywords: Indicators of Agricultural Sustainability, Sustainability Assessment, Decision Making System, Sustainable Ontology, User Interface Ontology, Domain Specific Language

1 Introduction

The development of a sustainability assessment method in agriculture is a latent requirement. Whereby, researchers of Embrapa Environment and scientific partners developed a sustainability assessment method, entitled SustenAgro Method. It focuses on the sugarcane production system in the center-south region of Brazil. This method allows the scientific community to integrate knowledge, related to sustainability, providing metrics and generating recommendations or strategies to improve sustainability. It also can be used to enable public policies formulation.

Sustainability assessment involves many environmental, social and economic aspects. From this natural complexity arises the need to maintain a formal conceptual basis to organize and represent the knowledge concepts used by the team

of experts. An ontology, a formal way to define the structure of knowledge for a domain, can be used to formalize these knowledge concepts. An ontology is a formal naming and definition of the types, properties, and interrelationships of the entities that exist in a particular domain.

The SustenAgro Method uses an ontology to represent knowledge about sustainability in sugarcane. In this ontology, indicators are used to represent and measure complex aspects of sugarcane agricultural sustainability. They try to synthesise information about critical aspects of an agricultural production system. The scientific basis for the creation of SustenAgro's indicators was research, carried out by Embrapa Environment, to identify and define sustainability indicators for sugarcane production units (farms and production plants). Indicators have values, generally categorical, to indicate their status. For instance, such as biodiversity, soil fertility, water resources, among others. The method combines indicator values, using formulas and weights, to calculate two key indexes for sugarcane production units: the sustainability and efficiency indexes. The values of these indexes reflect a trade off between sustainability and efficiency and are used to determine which recommendations will be offered. Users should use the indexes and recommendations to develop their own strategies to increase sustainability in their production units.They are important to measure critical situations to prevent future problems.

The SustenAgro Method was planned to be implemented as a web application and be available online for users. In a traditional development cycle, Embrapa Environment would hire a web developer contractor and give him mockups of the interfaces they wanted and the formulas they developed. Embrapa had, in the past, many problems with this development model. At this stage, the SustenAgro Method is just a plan with some mockups in PPT and formulas written in an Excel spreadsheet. A first system is designed after many trials and errors. Contractors are not domain experts on sustainability and that can lead to many errors and delays. After the first system is running, users will express their views, indicators may have to be redesigned, there will be changes to the ontology, etc. A modified system will have to be created and that can be repeated a number of time. Each cycle will be slow and expensive.

A better solution would be a system where domain experts can directly express the ontology, they already created for SustenAgro, the formulas, to calculate the indexes, and their recommendations in a machine readable format.

In this paper, we present how the SustenAgro System, a web-based Decision Support System (DSS) for the SustenAgro method, allow domain experts to create, by themselves, their ontologies, formulas and recommendations. It uses a Domain Specific Language (DSL) and graphic user interfaces specially designed for the use of domain experts. Using just the ontology and DSL programs, entered by the domain expert, the SustenAgro system is capable to automatically generate the application's user interface, get answers from logged users, calculate the indexes and show graphics and recommendations.

This approach allows a faster development cycle for SustenAgro System. Domain experts have to learn to use the system and its associated DSL, but

after that they can implement changes immediately (at runtime). The DSLs are compact and easy to learn, generating a tool for supporting the sustainability assessment process in sugarcane production systems.

This tool was analysed and tested by domain experts concluding that the SustenAgro system allows the re-definition of sustainability domain knowledge represented in the ontology and of the functionalities for generating the visual representation of this decision support system.

2 Ontologies.

Ontologies support the representation and organization of knowledge, allowing the concepts integration, even when they belong to domains without apparent relationship. In the SustenAgro system was necessary interrelate sustainability knowledge with graphical user interfaces knowledge, to support the generation of Decision Support Systems (DSS) for sustainability assessment.

Expert knowledge was initially modeled through conceptual maps that facilitate a communication of concepts but increase the steps of modeling process, which was identified the need for a tool for supporting the domain expert's modeling of ontologies.

The development of ontologies were modeled by techniques of rapid prototyping of coverage and increased complexity, starting with the most relevant components of the model to the experts and incorporating each one of the other components, these prototypes were validated through questions of expert interests and validate through queries and performs a validation and integration, this cyclical method obtains a prototype in each cycle.

The SustenAgro knowledge representation was divided into two ontologies, SustenAgro Ontology and DSS ontology.

2.1 SustenAgro Ontology: sustainability assessment

SustenAgro ontology represents the base knowledge to perform a sustainability assessment of sugarcane production in Center-South of Brazil, it is composed of several concepts in the agronomic, economic, social, environmental areas.

The SustenAgro Ontology support concepts that are constantly changing, for example in the process of "sustainability assessment" the indicators and indexes are continuously redefined.

The fundamental classes are Production Unit, Indicator, Variable, Value, Microregion, and so forth. Which are integrated and related to represent the domain of sustainability assessment in sugar-cane, below are presented the main classes of this ontology:

Production Unit class, represents the organizations that can be assessed by the SustenAgro system to obtain a sustainability measure, currently they can be sugar-cane providers and / or sugar-cane processing plants, each assessment process requires data that defines the Production Units through the properties that make up them, was defined a set of required properties for the production units:

– Name: define the name of the production unit
– Harvest year: define the year of harvest
– Agricultural production system: relates the agricultural production system being assessed.
– Has microregion: relates the microregion of the production unit.
– Has state: relates the Brazilian state.
– Availability of assessment results: relates the type of availability of results.
– Sugarcane source: relates the sugarcane source type

Figure 1 it presents the modeling of Production Unit, accomplished in Protégé

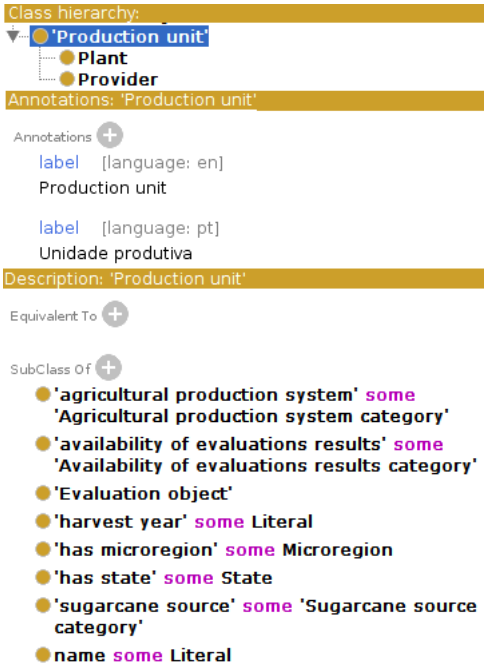

Fig. 1. Modeling of Production Unit class

References