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BiodieselFAO: an Integrated Decision Support System for Investment Analysis in the Biodiesel Production Chain

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ABSTRACT

In the short and medium term, biofuels are the most viable alternative to reduce the environmental impact of fossil fuels. The recent controversy over the competition between biofuels and food production increases the complexity of investment decisions in the biodiesel production chain. In this context, decision support tools are highly relevant. The purpose of this article is to describe the BiodieselFAO using the Unified Modeling Language (UML). An integrated analysis considering both agricultural and industrial sectors was identified as a key requirement to the system. Therefore, *farmers* and *industry* are the main actors in the use case diagram. As the raw material represents around 70% of the industrial cost of biodiesel production, the *price negotiation of raw material (oilseeds)* is the central use case. Configuration, agriculture, industry, results and scenarios are the modules, which encompass the functionalities derived from the UML diagrams. The Food and Agriculture Organization of the United Nations (FAO) has made the BiodieselFAO available, free of charge, to around 180 professionals from 17 Latin American countries. Additionally, the developing team has supported the usage of the BiodieselFAO in several biodiesel investment analyses throughout Latin America. The system was also useful in the design and analysis of policy related to biodiesel industry in Brazil.

Keywords: Biodiesel, Biofuels, Investment analysis, Decision support system, Unified modeling language, Latin America and the Caribbean.

1. INTRODUCTION

The supply and consumption of energy is a central theme in the global economic and geopolitical agenda since the first oil crisis in the early 70s. World reserves of oil are concentrated in a few countries, and for this reason the search for alternatives has become a strategic priority for the major world economies. Evidence of the environmental impact of fossil fuel usage, particularly on climate change, has turned the

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energy question even more complex and urgent. According to an International Energy Agency (IEA) scenario for the next twenty years, the energy demand will increase by about 30%. Despite the growing importance of the renewable energy, the supply will continue to depend on fossil sources (IEA, 2012).

Liquid fuels are virtually the only source of energy for the transportation sector. Gasoline, diesel, and kerosene are ease to carry and storage having also a high energy density. The use of electricity and hydrogen as an alternative source of energy for vehicles still faces technical and economic barriers. Therefore, ethanol, biodiesel and bio-kerosene are the only viable alternatives in the short and medium term to fossil fuels.

The high expectations regarding the potential of the biofuels as an alternative to mitigate global climate change, contribute to energy security and support agricultural producers worldwide was replaced by criticism (FAO, 2008). The controversy over the competition between biofuels and food production demonstrate the complexity of the decision making in the design of policies and the investment decisions at the farm and industrial levels.

Based on a 40-year experience on an ethanol fuel program, the Brazilian government resumed, after 30 years, its biodiesel program in 2004. The social aspect, namely the inclusion of small scale farmers in the oilseed production chain, is a key objective of the National Program for Production and Use of Biodiesel (PNPB). The program sets differentiated taxes, financing schemes and selling conditions for the biodiesel industry. On the other hand, the industry has to enter into a contract with small scale farmers (Silva Junior, 2013b). The contract negotiation has to be monitored by a farmers´ association. Another important aspect of the program is the incentive to intercrop and crop rotation. In this context, the investment decision involves several aspects and challenges both industrial and agricultural investment analysts. Therefore, the development of a decision support system is highly relevant.

In 2005, the Brazilian Ministry of Agrarian Development (MDA), requested the Federal University of Viçosa (UFV) to develop a system to support the decision making related to biodiesel projects. The system, named Biosoft, should consider both the industrial and agricultural sectors (Perez, 2008). The MDA distributed the Biosoft to technicians of the industry, finance and agricultural sectors after a training course. The Biosoft developing team also carried out several investment analysis for the MDA using the system (Silva Junior,2013a). The positive outcome for the Brazilian biofuels experience led the United Nation Organization for Food and Agriculture to sign an agreement with the UFV. The agreement aims at developing an improved version in Spanish of the Biosoft system, renamed as BiodieselFAO. The objective of this article is to describe the system developed for the FAO.

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2. UML: UNIFIED MODELLING LANGUAGE

The UML is a modeling language for specification, visualization, construction and documentation of software and business processes developed in the early 90s. Since 1997, a consortium of leading companies in the computer industry manages the UML. In 2000, the International Organization for Standardization (ISO) included UML as a worldwide standard for software development. The UML encompasses diagrams divided into the following categories: (Denis, 2012; OMG, 2013).

Structure Diagrams include the Class Diagram, Object Diagram, Component Diagram, Composite Structure Diagram, Package Diagram, and Deployment Diagram. The focus is in the components of the system. Therefore, the structure diagrams are used mainly in the documentation of the system.

Behavior Diagrams include the Use Case Diagram (used by some methodologies during requirements gathering); Activity Diagram, and State Machine Diagram. The actions performed in the system are the focus of behavior diagrams, which permits the description of the systems' functionalities.

Interaction Diagrams, all derived from Behavior Diagrams, include the Sequence Diagram, Communication Diagram, Timing Diagram, and Interaction Overview Diagram.

Karetsos (2011), Fountas (2006), Perini (2004) and Kaloudis (2003) reviewed and presented examples of agricultural decision support systems developed or described using the UML approach.

3. RESULTS

In the biodiesel industry, the raw material represents around 70% of the total production costs. The definition of the price of oilseed is a key task in the analysis of biodiesel projects. Therefore, *FARMERS* and *INDUSTRY* are the main actors and the use case *price negotiation of raw material (oilseeds)* is the central use case, as depicted in the following figure.

Figure 1. Use cases diagram.

One of the steps in the oilseed price negotiation process is depicted in the following sequence diagram. Price of oilseeds is the main industrial cost and an important income source to the farmers. Consequently, the system responds to both actor´s messages considering the impact of the oilseed price on both agriculture and industry profitability (Figure 2).

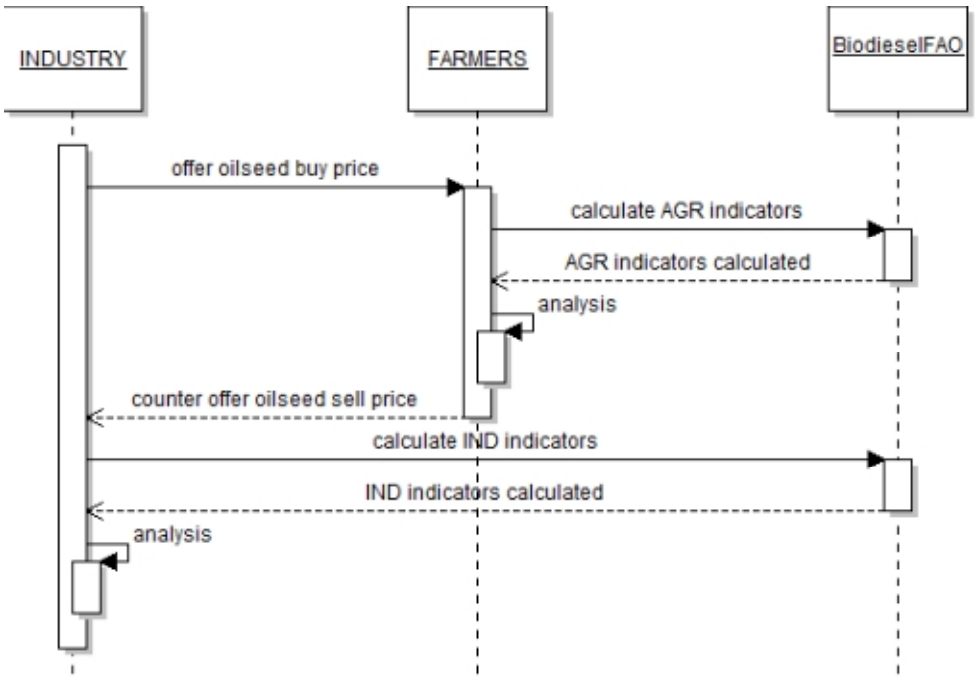

Figure 2. Sequence diagram.

The class diagram, showed in the Figure 3, has been derived from the use cases. The class *PROJECTS* relates to the *AGR MODULES* and *IND PROCESS* classes. The cardinality *0 to n* between the classes *PROJECTS* and *AGR MODULES* indicates that a project may contain *N* agricultural modules or even has no direct link to the agriculture (*0*). In the last case, the biodiesel industry buys the raw material (oil seed or vegetable oil) in the spot market without negotiation with the suppliers. The class *OIL SEEDS* relates both to the class *AGR MODULES* and the class *IND PROCESS*. Oilseed characteristics influence the selection of the appropriate industrial process and its corresponding attribute *price* determines the industry production cost. The class *ASSOCIATE ACTIVITIES* considers the possibility of intercrop and crop rotation in agricultural producing modules.

In the process of extraction of vegetable oil, the produced meal has high protein content. The income generated by the selling of the co-product of biodiesel production chain

influences substantially the profitability of industrial investment. For this reason, the class *IND INCOME* has also the attributes *meal* and *glycerin.* Using the BiodieselFAO, Silva Junior et al. (2008) showed that biodiesel projects, using the produced meal as feedstock, can boost the animal production in deprived regions. Simulations and what-if analyzes can be stored in the class *SCENARIOS*, which encompass one or more projects. This relationship is represented by the *N to N* cardinality between the classes *PROJECTS* and *SCENARIOS*.

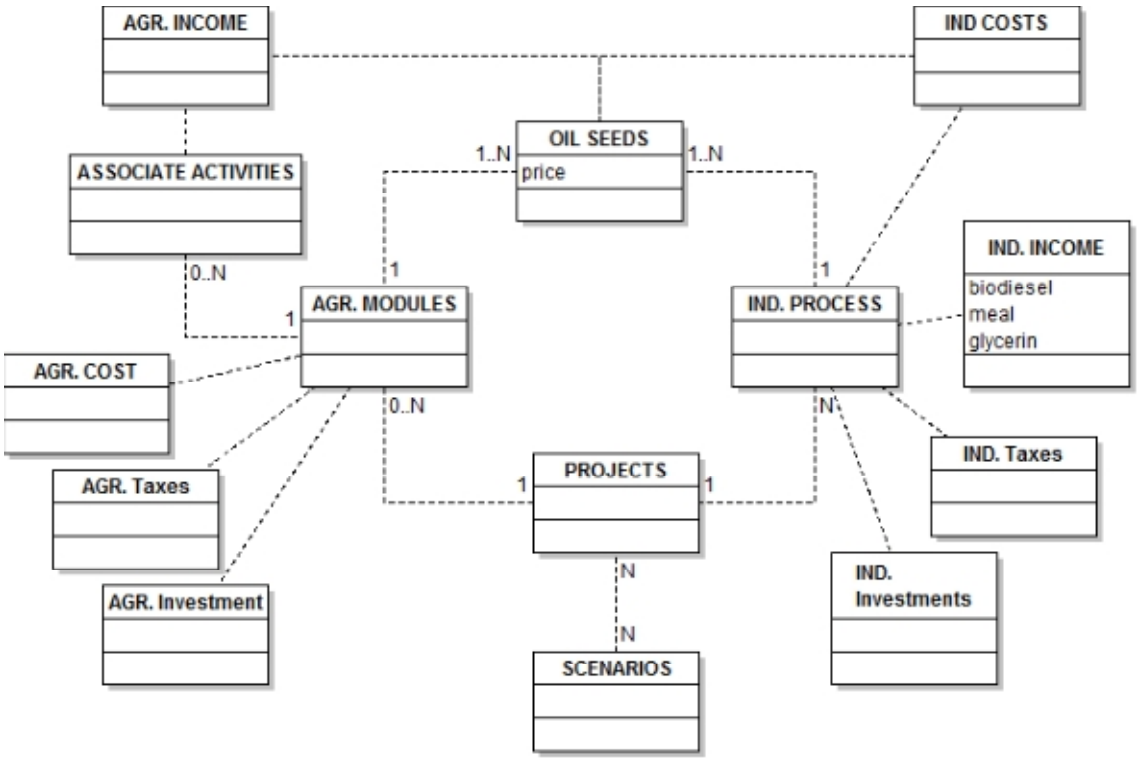

Figure 3. Class diagram

The system encompasses 5 modules, namely:

- Configuration,
- Agriculture,
- Industry,
- Results and
- Scenarios.

The graph below (module results) exemplifies the impact of raw material price increase on the profitability of agriculture (increasing income) and industry (increasing production cost).

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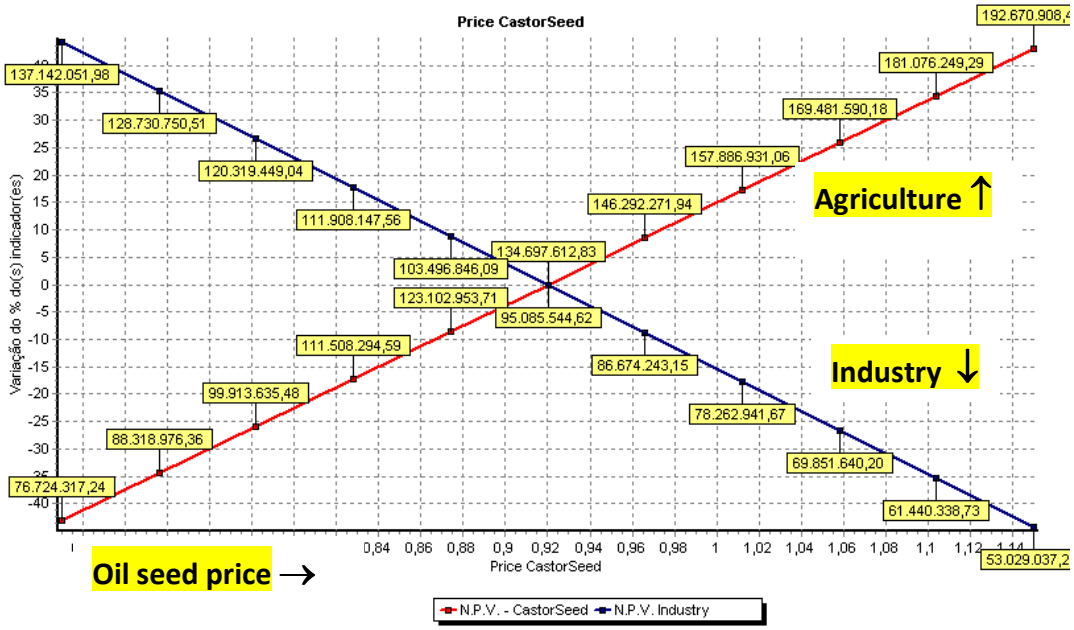

Figure 4. Example of graph in module results.

Besides the investment analysis, the system partially supports the design and analysis of biodiesel policies, especially considering the social and economic impact of projects. Despite not allowing environmental impact analysis, the system provides basic data (input quantities) for a potential life cycle assessment (LCA).

The following use case diagram (Figure 5) shows the behavior of the system in supporting the design and analysis of public policies performed by the actor *POLICY MAKERS*. In the Brazilian biodiesel program, for example, the *price negotiation* use case is an extension of use case *contract agreement*, which must be monitored by the actor *FARMER ASSOCIATION*. The use cases design and analysis of *financial scheme* and *taxes scheme* can be played by the actor *POLICY MAKERS*.

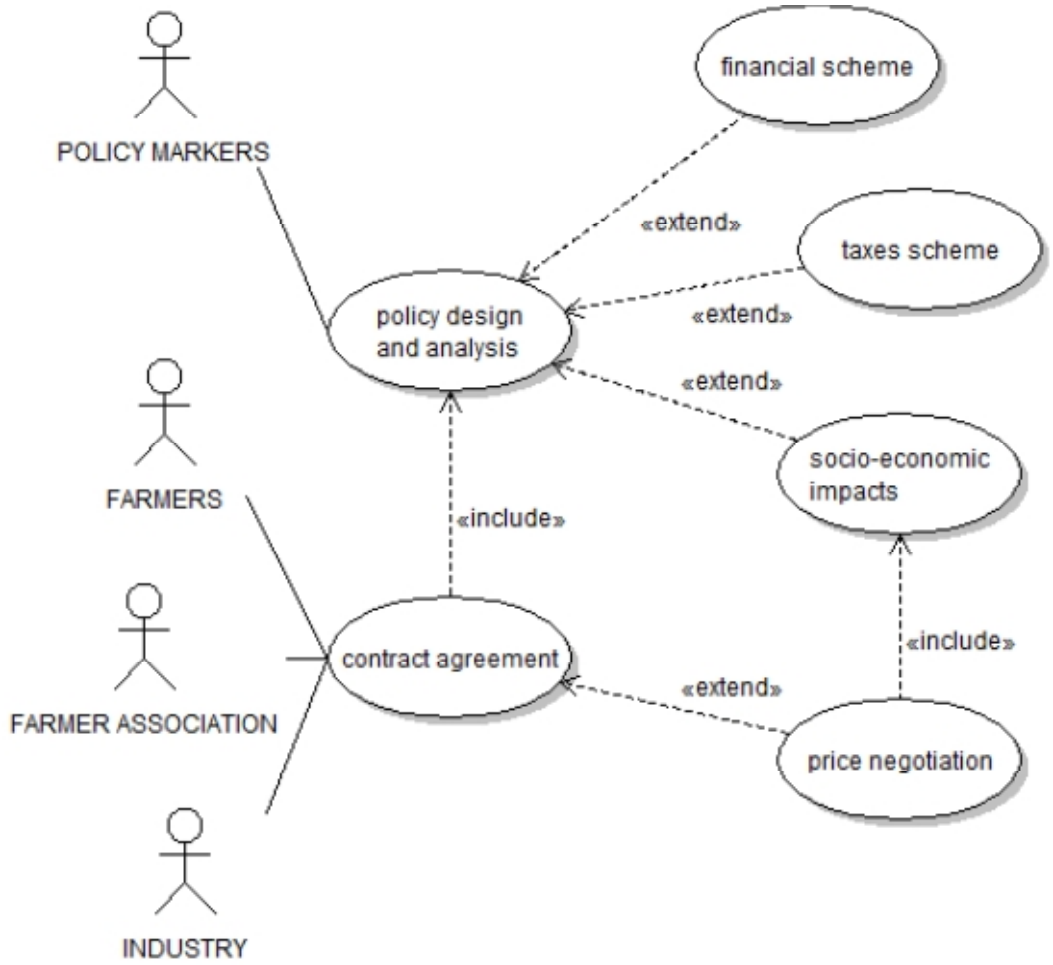

Figure 5. Biodiesel policy design and analysis use case diagram.

4. CONCLUSION

The Food and Agriculture Organization of the United Nations (FAO) has made the BiodieselFAO available, free of charge, to around 180 professionals from 17 Latin American countries. The system has been used in several biodiesel investment analyses throughout Latin America. The system was also useful in the design and analysis of policy related to biodiesel industry in Brazil.

The negotiation of raw material price is a key point in the analysis of agro- industrial projects, especially when the agricultural product is not a commodity. For this reason, the basic structure of the BiodieselFAO system could be applied for the developing of further decision support system relevant to the agribusiness sector.

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