An Extension of the AgroXML for the Sugar Cane Crop Operations Interoperability

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ABSTRACT

The sugar cane crop has been growing in the last decade due to the great demand of ethanol in the energetic chain as a cleaner alternative to the traditional petroleum derivates. The intensive utilization of modern agriculture techniques and engineering increased the sugar cane production in 40.8% from 2000 to 2008. The high competitive scenario among sugar cane companies make it even more necessary to have a better data exchange methods to support management decisions with quality and in real time. The entities involved in the sugar cane operations (farmers, sugar mills, transporters, mechanics, etc) need access to information in order to make decisions and manage the resources involved in the operations. The automation of the data collected in the field and large utilization of sensors, mobile devices end other wireless technologies make it necessary to use a standard to assure communication between them. The entities and the devices are geographically distributed and the internet is an excellent alternative to exchange data. The contribution of this work is an extension for the sugar cane operations of a well known XML open standard for data exchange in agriculture called AgroXML. The new extension, called SCAgroXML, considers sugar cane ontology to define specific semantics that describes the characteristics that differ sugar cane operations from the standard operations considered in the AgroXML. The SCAgroXML defines yet a hierarchy of operations and a mechanism to filter the exceeded data generated in the operations life-cycle without losing the AgroXML compatibility. The SCAgroXML will increase the quality of data exchange and decrease the time of decision-making in the management chain of sugar cane crop operations, allowing the interoperability between the entities and devices involved.

Keywords: Sugar cane, operations, XML, management, interoperability, AgroXML, Brazil.

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1. INTRODUCTION

According to CONAB – The National Supply Company (Porto, 2008) in a study for the Brazilian Ministry of Agriculture, the Brazilian sugar cane production could reach the 633,72 million tons in 2009, an increase of almost 10,7% on the 572,57 million tons from 2008. According to the same study, this increase in the production is the consequence of the 28 million tons of mature sugar cane left from the 2008 crop that was harvested in 2009, the beginning of the production of 25 new sugar mills and the increase in the cropped area from 7,08 to 7,79 million hectares. This positive scenario was encouraged by the internal consumption (popularization of flex fuel vehicles) and the exportation of sugar and ethanol (increased by the high demand for recycled and cleaner energy sources).The good moment for the sugar cane industry brings new challenges for the producers, that must reduce the costs and increase the quality of the raw material to keep competitive in a very aggressive market. To achieve this goal this paper selected the agriculture operations that, according to Marques (2009), represent 65.57% of the total cost of sugar cane industrialization. Modern technology, process management, project planning, people training, and other important administration techniques are very important to lower the costs of sugar cane agriculture operations, but all entities involved, that is, farmers, contractors, support companies, government regulation agencies, and industry should have access to information in real time and with high quality in order to make the right decisions. The main characteristic of the data generated in sugar cane operations is the geographical distribution and the big number of equipment suppliers at the data collection area, each one using a different standard to communicate with each other. The entities involved have to deal with the same problem when processing this data in different computer platforms and architectures. The heterogeneous and distributed network makes the internet and the wireless technologies the perfect way to connect entities and make the XML (W3C, 2008) – Extensible Metadata Language the best alternative to describe and transport data on the internet. The contribution of this work is to present an extension of the AgroXML (Doluschitz et al. 2005), named SCAgroXML (*Sugar Cane AgroXML*) to describe and transport data generated in sugar cane agricultural operations.

2. BACKGROUD

2.1 Interoperability on agricultural operations

Many efforts have been made in the last years in order to improve the data exchange in the agricultural area. All initiatives have to deal with some common characteristics of the agricultural environment, especially the geographic distributed data collecting points, heterogeneous types of collecting and processing equipment, a great number of entities involved (data consumers) and the lack of a common semantic in the respective operation domains. The internet is a common sense solution for distribution of data in heterogeneous platforms. Moreover, to assure the interoperability between the data consumers, a common standard to represent and describe data is needed. EDI (Electronic Data Interchange)(FIPS-PUB 161-1, 1993) was one of the first efforts made to normalize the electronic exchange of data and is still utilized today. However, the most utilized standard to transport and describe data is the XML – eXtensible Markup Language, a tag based markup language developed by the W3C (World Wide Web Consortion) that could transport data and in the same structure provide the respective metadata (explanation of the data transported). The XML hierarchic structure could be easily manipulated by human beings and by other automated systems and could be extended and adapted to other domains of interest without losing compatibility. Industrial and service sectors selected XML as the best solution to transport data over the internet and the agricultural sector already defines some standards based on XML too. It is possible to cite many individual and small domain standards: AgXML(AgXML 2004) for general agriculture data exchange, AgrisAP (Agris, 2008) for the grain and soybean domain, PALM (Murakami, 2007) for the precision agriculture domain. One of the most well structured standards developed by KTBL (*The Association for Technology and Structures in Agriculture , Germany*), is the AgroXML that will be described in detail below.

2.2 AgroXML

According to (Sicilia et al., 2009) the agroXML schema is a model of the real-world objects and their attributes and of the processes in agricultural production. It is based on the eXtensible Markup Language (W3C, 2008). A definition of document structures is done using the XML Scheme Language from the W3C (W3C, 2007). The content of agroXML instances can be basically classified into five categories: a. A block providing information about the farm in general, e. g. address, name of farm manager etc. b. A block of data about the fields, e. g. area and geographic coordinates. c. A block of data about the cultivation on different fields, e. g. the plant species, catch crops. d. A block about the individual measures carried out: fertilization, seeding, pest control, tillage. e. A block of data about supply items like fertilizers, pesticides, machinery. According to (Sicilia et al., 2009), agroXML can also be used to generate consistent stand-alone XML documents containing each of the five parts, but following the extensibility paradigm of XML. It also offers a collection of data types and elements that are reusable and embeddable in other documents. Besides the schema, agroXML also provides content lists. Several lists exist containing soil types, machine types, fertilizer types, pesticides and plant variety names. Wherever possible, content for these lists is obtained from the respective official agencies, for example, the plant variety offices. Software systems implementing agroXML can either use a local copy of the content lists for filling instances or use a version hosted on the web. AgroXML development was mostly done by KTBL (The Association for Technology and Structures in Agriculture, promoted by the German Federal Ministry of Food, Agriculture and Consumer Protection), that provides and maintains an infrastructure consisting of a source code, management system and documentation. However, the agroXML is open to contributions from other stakeholders and there is an international effort to lift the developed XML technology to a broader international level.

2.3 Looking for a global standard

Some researchers are very worried about the interoperability, traceability and data exchange in the food and environment supply chains. The utilization of one standard for each micro domain will difficult the integration among farms, suppliers, consumers, government agencies and other entities involved in the agricultural environment. The common sense point for the adoption of only one standard is that it could bring the best characteristics of all other existent solutions and could be, at the same time, expansible and comprehensive all over the agricultural domain.

European researchers as Wolfert (2009) are working on the European Data Exchange in Agriculture – (AgriXchange) that has the mission of supporting harmonization and standardization of information in agriculture across Europe and contributing to the standardization of agriculturally related information in the context of Information Sharing & Information and Communication Technologies (ICT) over the Agri-Food Supply Chain Networks. This work focus on all the supply chain (information for production), from the fertilizer supplier to the final consumer and the value chain (product Information) that allows traceability, residual level detection and other products related to information retrieval. Still according Wolfert (2009), AgriXChange aims at merging some present standards like: a. agroXML, b. KodA, a geographic fertilization advise system, c. GeoFarms, an application of geo-information and digital communication in the agro sector that aims to develop a standardized digital exchange platform that enables farmers and the government to exchange geo-information, d. AgroEDI, a standard data-processing format of exchange for the agricultural and agro-industrial sectors and e. ISOBUS, a bus system for the data communication between tractor, implement, virtual terminal and personal computer, in order to reach their goals. Perhaps this effort or other collective initiatives could bring a good and applicable solution for the agricultural data exchange.

2.4 Sugar cane agriculture operations ontology and semantics

Most of the already developed XML based languages to transport and/or describe data in agriculture are related to a specific domain and cover the data exchange in the supply chain, mostly, from the farmer to the consumer. According to (Sicilia et al., 2009), one of the most important challenges of a new standard XML based language, as agroXML, is to allow new expansible structures, country specific languages and local legislation accomplishment. Based on the concept of reutilization and standardization, the most logical choice is to find the best structured XML based language and expand this language into a specific new domain instead of developing a new language from scratch. However, these modifications should not jeopardize the compatibility with the original language, otherwise a new XML based language would be created and that is not desirable. Analyzing all present XML based languages and the above restrictions, the most mature candidate for a unique standard is the agroXML, so it was chosen to be the SCagroXML (Sugar Cane agroXML) base of this work. The figures 3 and 4 will show the agroXML and SCagroXML structures in detail. Before defining the agroXML elements to be expanded and the lists to be added to turn the agroXML into the SCagroXML, it is necessary to define the sugar cane operations ontology and semantics. According to the Dictionary.com website (Dictionary, 2009) ontology: "*1. A systematic account of existence*. 2. (from philosophy) *An explicit formal specification of how to represent the objects, concepts and other entities that are assumed to exist in some area of interest and the relationships that hold among them*". In this case, the area of interest is the sugar cane agriculture operations domain. According to the Merriam-Webster.com website (Merriam-Webster, 2009) semantics means: "1. *The study of meaning*. 2. *The study of linguistic development by classifying and examining changes in meaning and form*". Specific and significant names must be chosen for each operation and resource not already described in agroXML. The ontology study implies on defining the type and hierarchic precedence of each agricultural operation in order to assure not invalid sequences of operations or inappropriate utilization of resources. Examples are: trying to use a harvester to planting plantlets or transport cane with subsoilers . Possible and allowed associations between operation types, supplier products and appliers, according to the sugar cane ontology (figure 1). This information will be utilized in the SCagroXML schema to describe the hierarchy of operations and resources (figure 2). The semantic study implies on defining names for the operations and resources that are unique and by preference self-explanatory. Table 2 presents a list of sugar cane operation names and respective descriptions. These names will be utilized on the SCagroXML lists and it can be translated into the local language and updated as necessary. To keep consistence, all names and descriptions are in English in this paper.

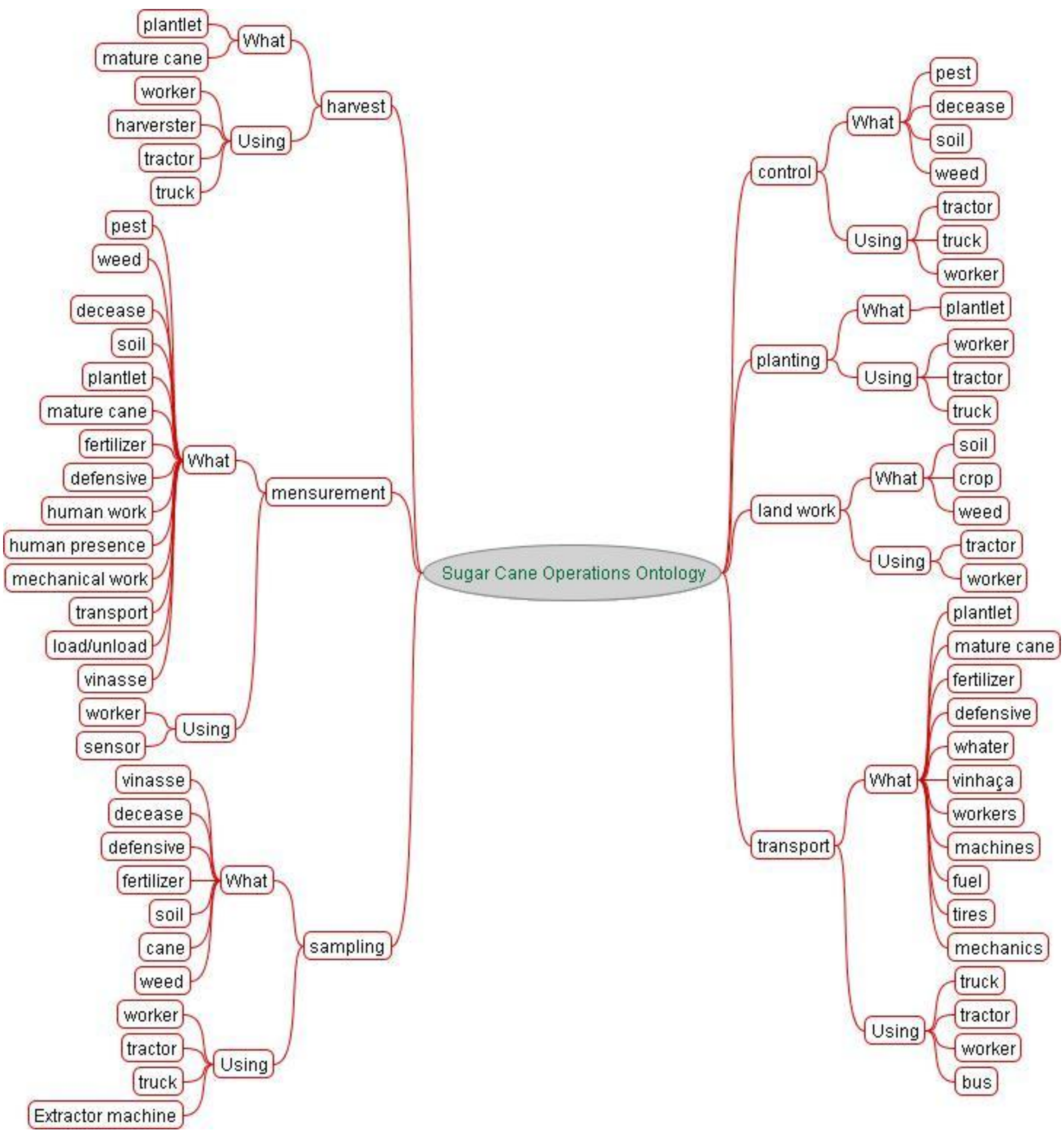

Figure 1. Partial classification of operations based on sugar cane crop ontology.

3. SCAGROXML

3.1 Expanded XML schema

As described by (Doluschitz et al., 2005), agroXML describes its structure using the XML Schema (W3C, 2007). The agriculture operations are described in a schema file named WorkProcess.xsd. One schema file can add the structure from other schema into itself through the “include” directive.

SUGAR CANE OPERATIONS

Planting	Cultivation	Harvest	General
SoilSample	Irrigation	BurnCrop	LoadUnloadFertilizer
TopographicMeasure	WeedSample	BunedCaneManualCut	LoadUnloadDefensives
LeftoverCleaning	DiseaseSample	GreenCaneManualCut	LoadUnloadWhater
SoilPreparation	PestSample	MechanicalCut	TransportSolidFertilizer
MarkingCurves	PosEmergHerbicydeApp	LoadChoppedCane	TransportSolitDefensive
BuildCurves	PreEmergHerbicydeApp	LoadEntireCane	TransportLiquidFertilizer
CorrectiveApplication	DefensiveApp	InsideFieldTransport	TransportLiquidDefensive
MarkingPathway	ByologicControl	CargoTransfer	TransportWhater
OpenningRoads	ProductionSample	CaneTransport	PresenceRegister
Fertilization	QualitySample	WighCane	TransportWorkers
ManualCut	EnlargePathway	PaymentSample	TransportMachines
CutRegistration	Cultivation	LongDistanceTransport	MechanicalRepair
LoadPlantlet	LoadVinasse	Unload	FuelSupply
TransportPlantlet	TranportVinasse	CutRegistration	TiresSupply
WeighPlantlet	UnloadVinasse	BitPickUp	
Planting			
RegisterPlanting			
CloseGrooves			
PestecydeApplication			
HerbicydApplication			

Figure 2. Sugar cane operations break down structure according category. Font: adapted from: (Marques 2009)

After that, all definitions in the included file will be part of the present schema. This type of approach allows the XML schema add complexity to a main file without repeating the same structure definitions. Each included definition could be reused by other schemas. The solution to add new definitions for the sugar cane operations and maintain the compatibility is to include a new schema file that will describe the sugar cane specific definitions. The expanded schema is in the file *SugarCaneWorkProcess.xsd* and begins with the definition of a complex type named *SugarCaneOperationsType* and it is derived from an abstract type named *AbstractWorkProcedureType* that defines the basis for an agriculture operation inside agroXML. The *SugarCaneOperationsType*, in its turn, defines four different categories of allowed elements: *SCPlantingType, SCCultivationType, SCHarvestType* and SCGeneralType

Table 2. Sugar cane operations name, category, type and description. Font: adapted from Marques (2009)

Short Name	Category	Description
soil_sample	planting	Collect soil samples to prospect the buy or rent of crop areas
toph_measure	planting	Topographic measurement of crop area
leftover_cleaning	planting	Cleaning of last crop leftovers and opening of jungle areas
soil_preparetion	planting	Soil preparation for area marking
soil_sample	planting	Collect soil samples to fertilization and ph correction
marking_curves	planting	Topographic marking of level curves
construct_curves	planting	Construction of level curves and pluvial water tank containers
calcarium_app	planting	Limestone and plaster application for soil correction
pathway_mark	planting	Marking of crop squares and around pathways;
road_opening	planting	Opening of pathways, expansion and reconstruction of access roads
fertilization	planting	Make land grooves and soil fertilization
manual_cut	planting	Manual cut of sugar cane plantlet
cut_register	planting	Manual cut of plantlet productivity register
load_sedding	planting	Plantlet load
transport_sedding	planting	Plantlet transport
weigth_sending	planting	Plantlet weighing
planting	Planting	Sugar cane planting
planting_register	Planting	Planting productivity register
close_grooves	Planting	Closing land planting grooves
pestecyde_app	Planting	Preventive treatment against soil pests
pre_herbicyde_app	Planting	Pre emergency herbicide application
irrigation	Cultivation	Irrigation (when applicable)
weed_samples	Cultivation	Collect of samples to control weed competition
pest_samples	Cultivation	Collect of samples to control pests and deceases
pos_herbicyde_app	Cultivation	Post emergency herbicide application
pre_herbicyde_app	Cultivation	Pre emergency herbicide application
byologic_control	Cultivation	Biological enemies liberation
production_samples	Cultivation	Crop samples collecting for production estimation
brix_samples	Cultivation	Collect samples to measure brix (sugar concentration)
enlarge_pathways	Cultivation	increase width of access pathways
crop_burn	Harvest	Crop burn to manual cut

burned_manual_cut	Harvest	Burned sugar cane manual cut
manual_cut	Harvest	Not Burned sugar cane manual cut
mechanical_cut	Harvest	Not Burned sugar cane mechanical cut
minced_load	Harvest	Load of minced sugar cane
entire_load	Harvest	Sugar cane load
crop_area_transport	Harvest	transport on crop area
transfer_cargo	Harvest	Trasnfer of sugar cane cargo
transport_cane	Harvest	Sugar Cane transport
weigthing_cane	Harvest	Sugar Cane weighing
payment_sample	Harvest	Collect sugar cane sample for quality and quantity payment
distance_transport	Harvest	Long distance transport
unload	Harvest	Unload sugar cane
load_unload_fertilizer	General	Load / Unload of fertilizer
load_unload_pesticydes	General	load / Unload of defensives
transport_solid_fertilizer	General	Solid Fertilizer transportation
transport_solid_pesticide	General	Solid Defensive transportation
transport_liquid_fertilizer	General	Liquid fertilizer transportation
transport_liquid_pesticyde	General	Liquid defensive transportation
cultivation	Cultivation	Stamps cultivation and fertilization
load_vinhaça	Cultivation	Vinasse load
tranport_vinhaça	Cultivation	Vinasse transportation
unload_vinhaça	Cultivation	Vinasse unload
cut_register	Harvest	Manual cut productivity register
point_register	Harvest	Manual cut point register
point_register	General	Mechanization point register
tranport_workers	General	Crop Workers transport
tranport_workers	General	Mechanical workers transport
transport_machines	General	Transport machines
mechanical_support	General	Mobile machine mechanics
fuel_supply	General	Machines and trucks fuel suppliers
tires_supply	General	Machines and trucks tires maintenance

(figure 3). Each category, then, will define the allowed operations (figure 4) and then the elements of each operation (figure 5). All other information about farm identification, field identification, crop types, producers, machinery work, personal work, and other standards will be treated by the already existent agroXML structures. The full expanded schema file is available for download on http://www.qpainformatica.com.br/research/scagroxml/schema/SugarCaneWorkProcess.xsd.

3.2 Resource lists

The agroXML standard allows the creation of resource lists. Resource list is a group of resources that could be machinery names and types or fertilizer formulas and concentrations or other supply product description that could be referred inside the agroXML XML. To support sugar cane operations it will be recommended to create specific resource lists to the country and region involved. As these resources are different from location to location it doesn't make sense to provide standard names and technical definitions for one country that are not used in another one. A sample list for Brazilian types of trucks was provided for download on http://www.qpainformatica.com.br/research/scagroxml/resourcelists/brptsc trucks.xml. Other different lists could be added to SCAgroXML as needed.

```
<xsd:schema xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns="http://www.agroxml.de/schema/agroxml1.4"
attributeFormDefault="unqualified" elementFormDefault="qualified"
targetNamespace="http://www.agroxml.de/schema/agroxml1.4"
version="1.4" xmlns:xsd="http://www.w3.org/2001/XMLSchema">
  <xsd:include schemaLocation="./CommonBasicComponents.xsd" />
  <xsd:include schemaLocation="./WorkProcess.xsd" /> <!-- Include the
Original AgroXML Work PRocedures -->
  <xsd:complexType name="SugarCaneOperationType">
    <xsd:annotation>
      <xsd:documentation xml:lang="en">Parent abstract operation for
sugar cane.</xsd:documentation>
    </xsd:annotation>
    <xsd:complexContent mixed="false">
      <xsd:extension base="AbstractWorkProcedureType">
        <xsd:choice>
          <xsd:element minOccurs="0" ref="SCPlantingType" />
          <xsd:element minOccurs="0" ref="SCCultivationType" />
          <xsd:element minOccurs="0" ref="SCHarvestType" />
          <xsd:element minOccurs="0" ref="SCGeneralType" />
        </xsd:choice>
      </xsd:extension>
    </xsd:complexContent>
  </xsd:complexType>
  <xsd:element name="SugarCaneOperation"
substitutionGroup="_WorkProcedure" type="SugarCaneOperationType">
    <xsd:annotation>
      <xsd:documentation xml:lang="pt">Elemento abstrato que
representa o conjunto de operações da cultura de cana de
açúcar.</xsd:documentation>
      <xsd:documentation xml:lang="en">Abstract element that
represents the group of sugar cane operations.</xsd:documentation>
    </xsd:annotation>
  </xsd:element>
```

Figure 3. Begin of the schema document for the SCAgroXML (*SugarCaneWorkProcess.xsd).*

```
<xsd:complexType name="SCPlantingType">
    <xsd:annotation>
      <xsd:documentation xml:lang="en">Parent group for sugar cane
planting operations</xsd:documentation>
    </xsd:annotation>
    <xsd:complexContent mixed="false">
      <xsd:extension base="AbstractWorkProcedureType">
        <xsd:choice>
          <xsd:element minOccurs="0" ref="CaneSoilSampleType" />
```

```
            <xsd:element minOccurs="0" ref="TopographicMeasureType" />
            <xsd:element minOccurs="0" ref="LeftoverCleaningType" />
            <xsd:element minOccurs="0" ref="SoilPreparationType" />
            <xsd:element minOccurs="0" ref="MarkingCurvesType" />
            <xsd:element minOccurs="0" ref="BuildCurvesType" />
            <xsd:element minOccurs="0" ref="CorrectiveApplicationType" />
            <xsd:element minOccurs="0" ref="MarkingPathwayType" />
            <xsd:element minOccurs="0" ref="CaneFertilizationType" />
            <xsd:element minOccurs="0" ref="ManualCutType" />
            <xsd:element minOccurs="0" ref="CutRegistrationType" />
            <xsd:element minOccurs="0" ref="LoadPlantletType" />
            <xsd:element minOccurs="0" ref="TransportPlantletType" />
            <xsd:element minOccurs="0" ref="WeighPlantletType" />
            <xsd:element minOccurs="0" ref="PlantingType" />
            <xsd:element minOccurs="0" ref="RegisterPlantingType" />
            <xsd:element minOccurs="0" ref="CloseGroovesType" />
            <xsd:element minOccurs="0" ref="PestecydeApplicationType" />
            <xsd:element minOccurs="0" ref="OtherOperationType" />
          </xsd:choice>
        </xsd:extension>
      </xsd:complexContent>
    </xsd:complexType>
    <xsd:element name="SCPlantingType">
      <xsd:annotation>
        <xsd:documentation xml:lang="en">Sugar cane planting category
operations.</xsd:documentation>
      </xsd:annotation>
    </xsd:element>
```

Figure 4 – Definition of the planting category.

```
    <xsd:complexType name="ManualCutType">
      <xsd:annotation>
        <xsd:documentation xml:lang="en">Comment.</xsd:documentation>
      </xsd:annotation>
      <xsd:sequence>
        <xsd:element minOccurs="0" ref="Date" />
        <xsd:element minOccurs="0" ref="Area" />
        <xsd:element minOccurs="0" maxOccurs="unbounded" ref="PersonWork"
/>
        <xsd:element minOccurs="0" ref="CutWayLength" />
        <xsd:element minOccurs="0" ref="CutDiaryQuantity" />
        <xsd:element minOccurs="0" ref="CutDiaryPrice" />
      </xsd:sequence>
    </xsd:complexType>
    <xsd:element name="ManualCutType">
      <xsd:annotation>
        <xsd:documentation xml:lang="en">Comment.</xsd:documentation>
      </xsd:annotation>
    </xsd:element>
```

Figure 5 – Definition of the manual cut operation.

4. CONCLUSION

This paper presents a standard XML based language named SCagroXML, expanded from the original agroXML that will allow data exchange and interoperability among all entities involved in the sugar cane agriculture operations. The modifications will keep the compatibility with the original agroXML standard while using local semantics for the specific sugar cane operations domain. The SCagroXML will allow better and faster access to operations data in real time and with high quality. All entities involved could make better decisions, lower operation costs and increase raw material quality, while benefiting the standardization of the XML structure. If a unique standard could be utilized in the near future, data collector manufacturers and software developers will benefit too, while no multiple interfaces must be used anymore. This kind of approach could be used with other culture crops and countries. Then, another local ontology and semantics could be the theme for future works.

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