

Assist the Sustainable Development within Industries through the Territorial Knowledge Ontology

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Abstract: Studying of territory as the main dimension of sustainability impact in the industrial activities and decision makers' information when considering the sustainability in their activities. Therefore, exploring of territorial knowledge in order to integrate into industries activates is needed. So, this research is proposed a descriptive ontology for territorial knowledge (DOTK) which make explicit the knowledge of actors within industries about the sustainable development goal. Also, implementation of this ontology to a real case is proved that it can identify the intangible and tangible resources of territory for sustainability. Moreover, a semantic graph is proposed which shows the relationships between entities of DOTK ontology. Final validation of DOTK ontology is performed by the interview with the organizations of sustainable development implementation.

1 INTRODUCTION

The growing attention given to sustainable development is encouraging companies to integrate sustainability issues into their activities. To increase the performance of this integration, some literature points out that sustainable aspects should be embedded at all corporate hierarchical levels from a global strategic decision by the top manager to daily engineering and production activities area (Zhang et al., 2013). Therefore, a sustainable strategy cannot be considered an independent issue: it must be integrated into the corporate global development strategy. This integration needs to support sustainable goals to be in line with other existing global corporate tendencies. To do, the companies need to carefully breakdown sustainability into several actions or attributes to help its comprehension (Hallstedt et al., 2010). In this research, an anthropic centered definition of sustainability with 5 dimensions(5D) has been adopted. Social, ecological, economic, territorial and political dimensions are explored as 5 dimensions of sustainability (Figuere et al., 2008). A territory is a complex combination of a set of actors and the geographical space that these actors use, landscape and manage (Moine, 2006). It is considered a value creation network where tangible and intangible resources flow and can be clustered into natural,

industrial and anthropized ecosystems and the social space (Allais et al., 2015). Some literature points out that lack of knowledge about the territory's feature is a barrier for searching a possible concept and knowledge for improving the sustainability within industries (Ezoji & Matta, 2018). The aim of this paper is to present a tool for representing territorial knowledge toward 5 dimensions of sustainability. So, ontology is one of the useful tools which can explicit territorial knowledge. Therefore, the main question researches in this paper are: which type of territorial knowledge can help the industries for sustainability? how territorial knowledge can assist the industries? And territorial knowledge helps to which level of enterprise for sustainable development goal?

In order to answer the questions, a descriptive ontology for territorial knowledge (DOTK) based on foundation ontology is presented. DOTK ontology can explicit the territorial knowledge for hierarchical levels of the enterprise and help them to integrate sustainability in their activities. Then, DOTK ontology is applied to a real case to identify the resources of specific territory for sustainability. This real case is City of Troyes in France. In consequence, DOTK ontology of Troyes is presented through the implementation of DOTK ontology on the territorial resources of Troyes. The aim is to demonstrate the usability of DOTK ontology for extracting of

territorial resources for sustainable development objective within industries. Moreover, a semantic graph by Text Mining is modelled which assist in the comprehension of relationships between entities of DOTK ontology. Finally, DOTK ontology of Troyes is presented to the manager of three organizations in order to find the answer for third research question. Moreover, these interviews with managers show the usability of DOTK ontology for enterprises.

2 TERRITORIAL KNOWLEDGE FOR SUSTAINABILITY WITHIN INDUSTRIES

As mentioned, in this research an anthropic centred definition of sustainability with 5 dimensions has been adapted. It focuses on sustainability objectives on human development (social sphere). The environment is considered as the limiting factor for anthropic activity (ecological sphere). The economic sphere is addressed as means (not a goal) which enable the realization of the social objective with respect to ecological boundaries. The political is investigated as the place for the coordination of sustainable industrial strategy and expectations from civil society. The territorial dimension should be evaluated, adapting global policy to local specificities to develop appropriate solutions (Allais et al., 2017). A territory is, therefore, a place where decisions are made and where stakeholders gather around the common question (e.g., sustainability) (Nitschelm et al., 2016). So, the territory is a network where all tangible and intangible resources flow and integration of these resources need to organizational innovation within industries for sustainability goal (Allais et al., 2015). Furthermore, identifying territorial knowledge adapting with five dimensions of sustainability can increase the knowledge of actors of hierarchical level (strategy, tactics and operation) within industries and assist in the implementation of sustainability. So, at first, it should be identified the type of territorial knowledge which can assist the sustainability within industries. In addition, this knowledge must be represented by a method to share the common understanding between the actors of the hierarchical level. This research is focused on ontology as a tool for representing dispersed knowledge of the territory. Ontology makes the assumptions explicit and analyses domain knowledge (Heales et al., 2015).

3 UNDERSTANDING OF TERRITORIAL KNOWLEDGE BY AN ONTOLOGY OF THE DOMAIN

An ontology is a formal, explicit specification of a shared conceptualization. Basically, the role of ontologies is to facilitate the construction of a domain model (Gangemi et al., 2003). So, a domain ontology for the understanding of territorial knowledge is proposed which name descriptive ontology for territorial knowledge (DOTK). DOTK ontology can explicit the structure of territorial knowledge and analyze this domain knowledge based on the nature of the reasoning. It can assist the industry to be aware of territorial knowledge to enhance sustainability in their activities. Therefore, the procedure for modelling of DOTK ontology in the following subsection is presented. In this procedure, the principles are mentioned which should use for modelling of DOTK.

3.1 Steps for Modelling of DOTK Ontology

The first step for modelling an ontology is knowledge representation because there are not complete definitions for the categories of objects by descriptive knowledge. Then, normalizing help the use of notions and it is an agreement on the meaning of domain notions by their explicit descriptions (Bouaud et al., 1995). So, the conceptual categorizations of elements of territorial knowledge are necessary. This taxonomy is done according to four categories of geographical, human, economic and political capital in adaptation with 5 dimensions of sustainability. Moreover, the sub-elements of this taxonomy are identified separately (Ezoji & Matta, 2018). So, the type of territorial knowledge is identified in this step.

The second step is normalizing (Bachimont, 2000) by necessary and sufficient conditions. A usual way of normalizing of the descriptive knowledge consists in stating the necessary relations between domain notions. So, the normalizing condition makes the explicit distance between the intentional definition of a type and its extension. The knowledge normalization must be carried out to assign the complete definitions of types. The normalizing of the taxonomy of elements at first step is done based on the foundational ontology of DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering) (Gangemi, 2003) which extracted their basic meaning (Bouaud et al., 1995). Foundational Ontology are



Figure 1: Hierarchical entities of Endurants of DOTK.

are ontologies that: (i) have a large scope, (ii) can be highly reusable in different modelling scenarios, (iii) are conceptually well founded, and (iv) are semantically transparent (Borgo, 2014). DOLCE is the module of a library of foundational ontologies and it is in the categories as a resource for designing knowledge system belong ontologies and formal description of the structure of knowledge bases (Mascardi et al., 2007). DOLCE is based on the distinction between enduring and perduring entities and abstract. Endurants can change in time such as physical objects while perdurants cannot change in this sense since none of their parts keeps its identity in time as events and process. Abstract includes both object-level concepts, such as set, time, space, and meta-level concepts such as attribute and relation. The entities of Abstract exist neither in time nor in space (Gangemi, 2003). Moreover, there are physical and non-physical elements in the taxonomy of territorial knowledge that they are close to the 3 and 4-dimensional entities of DOLCE. So, DOLCE ontology can normalize the elements of territorial knowledge taxonomy for modelling a territorial ontology.

The last step is characterizing the essential and taxonomy. The essence of notions should be captured by assigning the definitions of notions and their essential properties. Thus, defining types by deciding the essential characteristics to build the ontology of the domain which consists of its properties and their meaning must be understood through its positions in the ontology (Bachimont, 2000). So, after following

these steps, DOTK ontology as a domain ontology can present.

3.2 Descriptive Ontology for Territorial Knowledge (DOTK)

Entities in the DOTK ontology represent the nature and why reasoning of territorial knowledge which can share the common understanding of territorial knowledge for hierarchical level of industries. So, it can be said that DOTK ontology as a domain ontology can assist the understanding of territorial knowledge.

Three main entities of DOTK ontology are endurants, perdurants and abstract. Endurants are presented at any time at which they exist and as a physical object. Substantial and quality are the two main entities of endurants. Qualities can be perceived or measured and they constantly dependent on the entity that they inhere. Substantials are aggregates of qualities but are not themselves qualities. They are physical and non-physical, according to whether they have entities with spatial qualities or not (Gangemi, 2003). Many elements of territorial knowledge taxonomy are normalized in the substantial category according to its meaning as is shown in figure 1.

Perdurants is another entity of DOTK ontology which identifies the territorial knowledge such as event, stative phenomena, etc. Perdurants represent the spatial and temporal parts of territorial knowledge. The entities of territorial knowledge are normalized in the stative as the process (see figure 2).



Figure 2: Entities of perdurants of DOTK ontology.

Abstract represent the entities of DOTK ontology which don't have spatial or temporal qualities and they fit the terms such as attribute, relation and quantity. The elements of territorial knowledge are matched with the essence of entities such as attribute, action and region as abstract of DOTK ontology (see figure 3).



Figure 3: Entities of DOTK ontology as abstract.

DOTK ontology represents the necessary semantic as vocabulary, to establish unambiguous information sharing of territorial knowledge. In this way, it provides detail of the intention of territorial knowledge to help the understanding of meaning and position of elements of territorial knowledge. Moreover, DOTK ontology act as a guide to identify the resources of a specific territory and assist to extract the knowledge of the special domain. In the next sections, DOTK ontology compare with other related works. Then, it applies in the specific real case to identify the territorial resources for sustainability.

4 RELATED WORKS

The aim in this part is to compare DOTK ontology with other research of sustainable and territorial ontology to identify the intention of each ontology. This comparison assists to understand the construction of other ontologies and clarify the

entities of sustainability in different foundation ontology.

Upward et al. proposed the ontology that enables to describe of strongly sustainable business models, as validated by ecological economics and derived from natural, social, and system sciences (Upward et al., 2016). Governance, stakeholders, natural resource, social impact and satisfaction is considered in this ontology. Also, it cannot be seen how the available element link to other elements of sustainability. This ontology is valued, not only to the groups of stakeholders (manager in the company) but also to those outside the realm of business, such as public policy analysts. it was not considered all of the aspects of sustainability as politic and geographic views (Upward et al., 2016). Another research provided the improvement of understanding of interactions between natural and social systems to guide these interactions toward more sustainable assessment (Konys, 2018). It provides complete domain knowledge of sustainable assessment solutions which can be directly applied by the experts in the process of sustainable assessment evaluation. This ontology is constructed by a domain of usage as the production and manufacturing sector, issues as environmental impact, scope as assessment, receivers as a company. But, several missing can be seen in this research in comparison with DOTK ontology. Table 1 shows the concepts and level of some other main ontologies for sustainability by territorial knowledge.

As a result, it can be concluded that the most of other researches consider only three aspects of sustainability (environmental, economic and social) and some of them only consider the environmental aspect of sustainability in their ontology. Political capital, almost, is not considered. So, it can be concluded, there is a lack of some dimensions of territorial knowledge in the other ontology in comparison with DOTK.

5 IDENTIFY OF TERRITORIAL RESOURCES BASED ON DOTK ONTOLOGY

Each concept of DOTK conducts to find the corresponded concepts for modelling of applied ontology and identify the resources of a specific territory. So, DOTK ontology is applied to extract the tangible and intangible resources of the case study of Troyes. Troyes is the capital of the department of

Table 1: Concepts of territorial ontology of other researches for sustainability.

Reference	objective	Main concepts	Level of ontology
Heales, J et al, 2015	Develops ontology-based dimensional view to environmental management	Social aspects of environmental management, optimizing resource, social	Taxonomy for ontological views
Konys, A., 2018	The interaction between natural and social systems	Production, environmental dimensions	Formal description
Borsato, M., 2014	Facilitate the use of sustainability through the product's lifecycle	Product, process, organization, material	process ontology
Lin, J et al., 2013	The balance between economic benefits and environmental protection by ontology	Product, organization, and process(environment and economy)	Ontology-based on design
Upward, A et al., 2016	Ontology-based on sustainable business model	Product and development, governance and industrial ecology	Relationship diagram generally

Aube in north central of France. DOTK ontology aids to extract the territorial resources of Troyes for sustainability according to the essence of each concept. The methodology for identifying territorial resources of Troyes is the searching on the internet according to the concepts of DOTK ontology which each concept of DOTK ontology guide to find the corresponded territorial resource in Troyes. The aim of this implementation is to validate that DOTK ontology can act as a guide for modelling an application ontology. Another goal is to prove that DOTK ontology can identify the tangible and intangible resources of each geographical territory to represent these resources as knowledge for the hierarchical levels of enterprises for the sustainable development objective.

5.1 DOTK Ontology of Troyes

Concepts of DOTK of Troyes as abstract (see figure 4 with bolded blue frame), are learning, client satisfaction, skill, product system optimization and environmental geographical concepts. For example, physical impact on the environment such as safety, the quality of soil, declining the influence on the natural environment and reducing the influence on the human health are some main concepts of environmental geography of Troyes. In addition, Rés'Aube Competences is a network of economic and social players which connect employers and assets. Also, the environmental club of Troyes informs the environment and sustainable development issues in the industries as environmental geography. These structures enrich the skills and performance of industries and local associations. Moreover, UTT (University of Technology of Troyes), IUT

(University Institutes of Technology) and UIMM (Union of Metallurgies Industries) extend the learning through alternate training to enhance the learning for employers in industries. Product service is conducted through the CCI Troyes (Chamber of Commerce and Industry) whose goal is the optimization of the logistics of companies, both in the management of production and the vehicle tour (collection delivery) relying on the skills of Laboratory of Optimization of Industrial Systems(LOSI) at UTT. Thus, these abstract concepts of DOTK ontology of Troyes assist the hierarchical level of industries in this city to integrate these concepts into their activities for sustainability.

Politic, governance, emission, information sharing, management, communication and innovation are the perdurants concepts of DOTK of Troyes which can aide both industries and territory for sustainability. Social in corporate governance is provided by industries with the answer to the concepts of sustainable development by corporate social responsibility through CCI Troyes. It aids the industries for social relation, health, safety and policies implemented in training within industries.

Moreover, the environmental club of Troyes considers the environmental issue in corporate governance in relation to sustainable development, the air quality and waste disposal plans in the industries. The political capital of Troyes investigates the objective of economic activities from local employment in a different section such as agriculture, non-agricultural market, human health. Moreover, reduction of environmental impacts such as energy consumption, rubbish production and climate change, are other politics in this city. Also, wealth creation is another politic that obtains from natural resources,

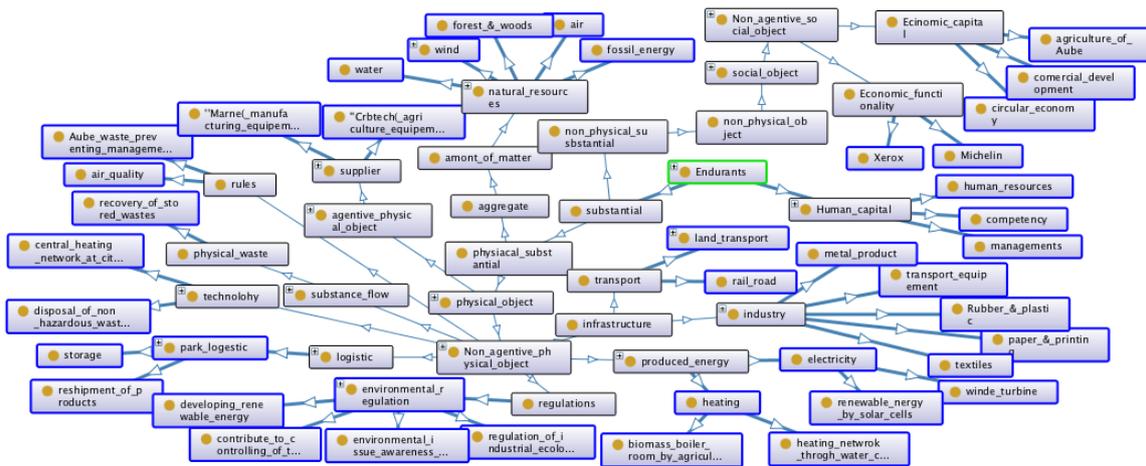


Figure 6: Endurant concepts of DOTK of Troyes.

industries and commune of Troyes. Two main energy productions are electricity and heating energy from the natural resource. Two resources for producing electrical energy are wind turbine and solar cells. Producing of heating is done through the water circuit and biomass boiler room. The central heating network and disposal of non-hazardous waste are the main technology in Troyes.

Also, developing renewable energy, development of recycling sector and environmental issue awareness are some of the regulation are politic in Troyes and helps both industries and territory's ecology. Economic functionality in Xerox corporation which is selling the printer and digital document. This corporation realizes economic functionality based on an integrated management strategy for its products, combined with an offer to sell to its customers and service of their needs.

So, the implementation of concepts of DOTK in this real case allows extracting the territorial resources to present them to enterprises for sustainability goal. Also, lack of resources of Troyes is recognized by DOTK of Troyes such as experience, GIS, culture, etc. So, the responsible of Troyes city should develop these territorial resources for responding to the sustainable objective of industries.

5.2 Semantic Relationships between Concepts of DOTK of Troyes

Ontology can organize semantic information and support to use the inference tool for discovering new knowledge and hierarchical relationships. The aim of this part is to present semantic relationships between

concepts of DOTK of Troyes. In fact, these relationships, show the influence of concepts on each other concepts of DOTK of Troyes. So, it can be useful for the actors of the hierarchical level to understand these influences for sustainability in their production cycle. The methodology used for constructing this graph is Text Mining of concepts of DOTK of Troyes.

Text Mining is the discovery of word and terms by extracting the information from written resources by using linguistics theories (Hearst, 2003). In Text Mining, the goal is to discover unknown information, use the implicit structure of texts and something that no one yet knows. So, Text Mining of DOTK of Troyes is done by Voyant tools¹ as free software usable on the internet. The found websites from concepts of DOTK of Troyes are identified as a corpus for Text Mining. The relationship's graph of analyzing this corpus by Voyant Tools is presented in figure 7.

This graph shows the relationship between management with the organization, social capital, economic capital and logistic. These relationships influence the industries, transports and client satisfaction. Moreover, intellectual capital which supports the management and industry and products. Also, using natural resources by industries and territory and their impact on environmental geography is demonstrated. Details of these relationships with special concepts are shown in the graph that it is understandable for tactical and strategic levels within industries

¹ <https://voyant-tools.org/>

Table 2: Survey of interview with organizations.

Can DOTK ontology help you for sustainable development?	The extracted resources of Troyes by the concepts of DOTK ontology can help and they are confirmed
Do the concepts of DOTK ontology are explicit?	The essence and meaning of these entities guide us to add some other resources to the DOTK ontology of Troyes
Does DOTK ontology help to add other elements to resources of Troyes for sustainable development?	We can find other resources through the essence and meaning of entities
Do the resources of DOTK of Troyes are useable for your works for sustainable development?	We could find the most of entities and resources for sustainable development of enterprise that are extracted by DOTK ontology
DOTK ontology helps to which level of hierarchical level of enterprises?	Aid the strategic and tactic to make a decision for sustainability
Does the semantic graph is usable and applicable for representing the relationships of entities?	It helps the strategic and tactic to make a decision for sustainability. Also, facilitate the presentation of relationship of entities according to the demand of enterprise for their projects

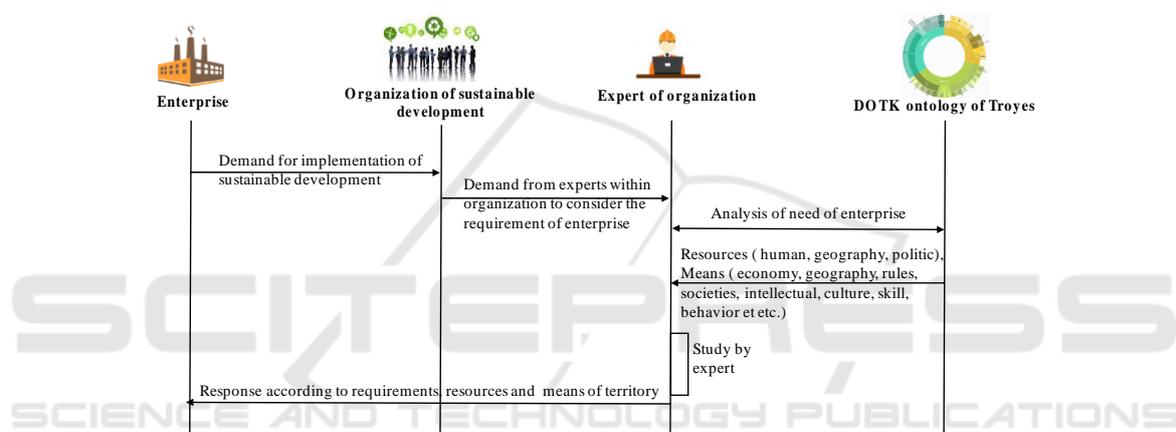


Figure 8: Sequence model of use case 1.

1. At the first step, the organization consider what does the enterprise need. In other words, the first step is the analysis of needs.
2. At the second step, the organization can consider the needs of the enterprise according to the territorial resources of DOTK ontology of Troyes to compare the existence of territorial resources with the needs of the enterprise.
3. So, at the third step, the organization can explore the resources that don't exist in DOTK of Troyes through the essence and meaning of entities of DOTK ontology to answer the needs of the enterprise for sustainable development.

So, in this way, the organizations can find the resources or one alternative solution to respond to the demand for the enterprise. Figure 8 demonstrates the sequence model of use case 1.

6.2 Use Case 2: The Organization That Search the Enterprises to Implement the Sustainable Development

Organizations, also, search the other enterprises in the other geographic territory to install them in Troyes and help them for implementing sustainable development.

1. At first, organizations consider DOTK ontology of Troyes to know about the existing territorial resources.
2. At the second step, the organizations search the enterprises that can be interested in these territorial resources in the particular domain to transfer them to Troyes. For example, park logistic of Troyes is one of the territorial resources which is mentioned in the DOTK of Troyes. There are the sub-resources and clear objectives for the park logistic of Troyes that are clarified by DOTK

ontology of Troyes. Thus, organizations can present the existing resources of logistics to the enterprises that want to install in Troyes in the domain of logistics.

Therefore, DOTK ontology can facilitate the presentation of resources and then, the organizations can prepare the report for the enterprises based on the existing resources to bring the enterprises in Troyes.

7 CONCLUSION

Territorial knowledge as the main concepts for sustainable development within industrial companies is investigated in this research. So, modelling an ontology of territorial knowledge can share the common understanding of this knowledge for actors of hierarchical level within industrial companies to consider this knowledge in their activities. Therefore, following the methodology of modelling of an ontology, a descriptive ontology for territorial knowledge (DOTK) is presented. DOTK ontology represents the essence of entities that actors of industrial companies can follow them for integrating into their works for sustainability and production life cycle. Then, in order to justify that DOTK ontology can be act as a guide to identify the resources of the territory, DOTK is applied in the real case. This application ontology proved which it is possible to extract the resources of territory by this ontology and these resources can be useful for both territory and industrial companies for sustainability. Moreover, a semantic graph is presented that shows the relationships between the concepts of DOTK and it helps to the comprehension of relationships between these concepts at the tactical and strategic level of industries. Finally, the interview with three enterprises in Troyes is done to justify the usability of extracted territorial resources by DOTK ontology. These interviews are confirmed that the extracted resources by DOTK ontology is usable at the strategic and tactic level of enterprises for their decision making for sustainability. Thus, DOTK ontology can help the organizations and enterprises to find the tangible and intangible resources of each geographic territory by the meaning of concepts of DOTK ontology.

In future work, consideration of the visualization of DOTK ontology will be held to investigate that DOTK ontology can be sued in websites. Also, it will be considered that territorial knowledge how can help the operational level of enterprises.

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