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Amer Ezoji

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THÈSE

Pour l'obtention du grade de

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TECHNOLOGIE DE TROYES**

Spécialité: Systèmes Socio Techniques (SST)

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Présentée et soutenue par

Amer EZOJI

le 10 Septembre 2019

**DOTK: territorial ontology as a tool to help the
industries for sustainable development**

JURY

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DOTK: territorial ontology as a tool to help the industries for sustainable development

Abstract : The growing attention given to sustainable development is encouraging companies to integrate sustainability issues into their activities. To increase the performance of this integration, sustainable aspects should be embedded at all corporate hierarchical levels (strategy, tactic & operation). Regarding the increasing role of the territorial resources, lack of knowledge about the territory's feature is a barrier to searching the possible concepts for sustainability's goal. The aim of carried out research in this thesis is to help the hierarchical level in order to increase their knowledge about their territorial resources to integrate this knowledge into their activities for sustainability. For this purpose, territorial ontologies can facilitate territorial knowledge sharing and increase sustainable performances. So, a Descriptive Ontology for Territorial Knowledge (DOTK) is proposed. Then, DOTK ontology is applied in a real case to identify the resources of specific territory. Moreover, it is demonstrated which entities of DOTK can extract the resources of each territory to help sustainable development of industries and territory. We also addressed a semantic graph of the relationship between entities of DOTK ontology. The final contribution of this thesis consists of the validation of application ontology of DOTK via the interview by organizations through the definition of three use cases scenario.

Keywords: ontology, sustainable development, industrial organization, national territory.

Résumé: L'attention croissante accordée au développement durable encourage les entreprises à intégrer les questions de durabilité dans leurs activités. Pour accroître la performance de cette intégration, les aspects durables devraient être intégrés à tous les niveaux hiérarchiques de l'entreprise. En ce qui concerne le rôle croissant des ressources territoriales, le manque de connaissances sur les caractéristiques du territoire constitue un obstacle à la recherche des concepts possibles de durabilité. L'objectif de la recherche réalisé dans cette thèse est d'aider le niveau hiérarchique afin d'augmenter leurs connaissances sur leur ressource territoriale pour intégrer ces connaissances dans leurs activités de durabilité. À cette fin, les ontologies territoriales peuvent faciliter le partage des connaissances territoriales et augmenter les performances durables. Une ontologie descriptive de la connaissance territoriale (DOTK) est donc proposée. Ensuite, l'ontologie DOTK est appliquée dans un cas réel pour identifier les ressources d'un territoire spécifique afin de démontrer quel DOTK peut identifier les ressources de chaque territoire pour aider au développement durable des industries et des territoires. Nous avons également développé un graphe sémantique des relations entre les entités de l'ontologie DOTK. La contribution de cette thèse consiste à la validation de l'ontologie d'application de DOTK Troyes par des interviews avec des organisations de développement territoriaux, permettant de définir des scénarios d'utilisation.

Mots clés : ontologie, développement durable, organisation industrielle, territoire national.

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Abbreviations

AI	Artificial Intelligence
BFO	Basic Formal Ontology
BSC	Business Sud Chamapgne
CAD	Computer Aided Design
CCI	International Chamber of Commerce
DOLCE	Descriptive Ontology for Linguistic and Cognitive Engineering
DOTK	Descriptive Ontology of Territorial Knowledge
GFO	General Formal Ontology
GIS	Geographical Information System
LOSI	Laboratory of Optimization of Industrial Systems
IC	Intellectual capital
ICT	Information and Communication Technology
IE	Industrial Ecology
ISO	International Organization for Standardization
IT	Information Technology
ITE	Industrial and Territorial Ecology
IUT	University Institutes of Technology
LCA	Life Cycle Assessment
NGO	Non Governmental Organization
PLM	Product Lifecycle Management
RLCA	Regionalisation of Life Cycle Assessment
PROTON	PROTo Ontology
SRADDET	Regional Scheme of Planning, Sustainable Development and Territorial Equality
SUMO	Suggested Upper Merged Ontology
TCAT	Public Transport in the Agglomeration of Troyes
TCM	Troyes Champagne Metropole
TM	Text Mining
UIMM	Union of Metallurgies Industries
UTT	University of Technology of Troyes

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Chapter 1

1. INTRODUCTION

1.1 Background

The concept of sustainability is a complex one. However, it is possible to distil some of its most basic and general characteristics by adopting a systemic approach (Gallopín 2003). Sustainability issues affect every component of our society from individuals to regional and global organizations: major ecological or social crises are due to natural resource overconsumption and rising inequality at both local and global scales. Sustainability is not about preserving resources, a product, a company or an organization but rather not systematically degrading the global socio-ecological system. In fact, sustainability is a system property, therefore products, services, technology or organization cannot be sustainable on their own but may be elements of sustainable systems (Allais et al., 2017). Moreover, the growing attention given to sustainable development is encouraging companies to integrate sustainability issues into their activities. To increase the performance of this integration, sustainable aspects should be embedded at all corporate hierarchical levels, from global strategic decisions by top management, through planning and organization by tactical management, to daily engineering and production activities of the operational area (figure 1.1) (Zhang et al., 2013).

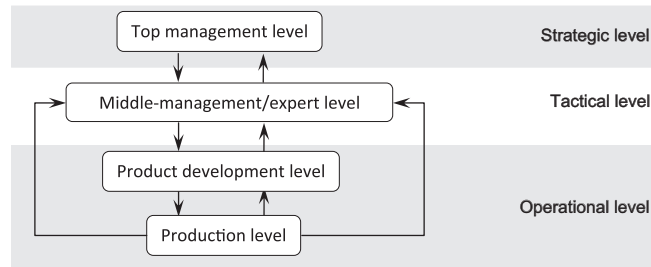


Figure 1.1: Interactivity and coherence between hierarchical corporate levels within companies (Zhang et al., 2013)

The strategic level assists “top managers” who define the corporate strategic goals that will create multi-values for all stakeholders. In order to respond to strategic goals, the tactical level analyzes and organizes the corporate material and immaterial resources (for example cost, knowledge, Human resource, Relationship with stakeholders or organization.) and develops an efficient and implementable roadmap. This matches the strategic goals with specific technological solutions and identifies related “activity tables/chains” to help these goals. Lastly, the operational level supports

the deployment of the process in the company in accordance with the tactics (and tools) chosen (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 and constraints. To do so, the company needs to carefully and reasonably break down “sustainability” into several actions or attributes to help its understanding (Hallstedt et al., 2010). So, an anthropic-centred definition of sustainability with 5 dimensions (5D) has been adopted (Figuiere and Rocca, 2008). 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 a means (not a goal) which enables the realization of social objectives with respect to ecological boundaries. The political sphere has to define development guidelines and must be strong enough to take precedence over economic actors. The political sphere is investigated as the place for public debate and long-term societal orientation and decision making. In fact, public policies are the only legitimate way to define public interest and the common good; consequently, they must coordinate sustainable industrial strategies and expectations from civil society (Allias et al., 2017). The territorial dimension should also be taken into account, adapting global policy to local specificities to develop appropriate solutions. A territory is an evolving and complex combination of a set of actors in which human activities occur and the geographical space that these actors use, landscape and manage (Moine, 2006). It can be compartmentalized into natural, industrial and anthropized ecosystems and the social space (Ibid). So, the territory is considered as a value creation network where tangible and intangible resources flow. Consequently, territorial integration required organizational innovation into company activities (Allais et al., 2015). Thus, it can be concluded that territory consists of all the intangible and tangible dimension of sustainability to help the organizational capability in the company toward sustainability.

In regard to the increasing role of the territorial resources for sustainability and according to the literature review (Allais et al., 2015, Vadoudi et al., 2017, Zhang et al., 2013), some researchers have considered the role of territorial resources on sustainability from different aspects. Allais et al. encourage companies to integrate territorial resources into the product development process to create value for both the company and its territory from a sustainable perspective. Moreover, this research assists industrial companies to both explore the use of latent resources from their territory

and to their responsibility facing their stakeholders in a sustainable perspective (Allais et al., 2015). In other words, this research proposed the importance of the integration of territorial resources in the design process as a sustainability and differentiation strategy for industrial companies.

Better cooperative circulation between the different organizational functions in the company, improve the integration of sustainable issues (Zhang et al., 2013) and studying a product's environmental impact on an interacted territory's environmental statuses can increase decision maker's information when considering design for sustainability (Vadoudi et al., 2017).

1.2 Problem formulation

Allais (2015) extended a method to support the selection of strategic objective toward sustainability by integration of territorial resources in the design process in term of the using of territorial resources for sustainable development goal within industries and assist to the hierarchical levels. Integration of territorial resources into the product development process help the strategic level, the design of the sustainable product and explore the resources from their territory (Allais et al., 2015). Also, better cooperative circulation between hierarchical level for sustainable objective by Zahng (2013), only, is considered from the environmental point of view and other terms of sustainability have not been considered. In addition, territorial resources are not considered (Zhang et al., 2013). Moreover, Vadoudi (2017) demonstrates the interaction between the territory's environmental status and product's environmental impact can assist the considering of design for sustainability (Vadoudi et al., 2017).

However, insufficient attention has been paid to all of the intangible and intangible resources of territory that can help to sustainability within industrial companies. Also, integration of territorial resources (intangible and tangible) into hierarchical level can assist industries for sustainability's goal. Thus, lack of knowledge about the territory's feature and the shortage of knowledge of territory's environment is a barrier to searching the possible concepts for sustainability.

The aim is to influence certain current paradigms to accompany industrial companies towards more sustainability. The aim of carried out research in this thesis is to help the hierarchical level in order to increase their knowledge about their territorial resources to integrate them to their activities for sustainability. Especially, this integration can effect on the decision making for sustainability within enterprise to create the value for human and enterprise in regard to existing territorial knowledge. Thus, it is needed to identify the territorial knowledge for sustainability in the

enterprises. So, the scientific aim is to focus on identifying a way to represent the territorial knowledge and make explicit this knowledge for actors of hierarchical level. Figure 1.2 demonstrates the system of consideration and five dimensions of sustainability.

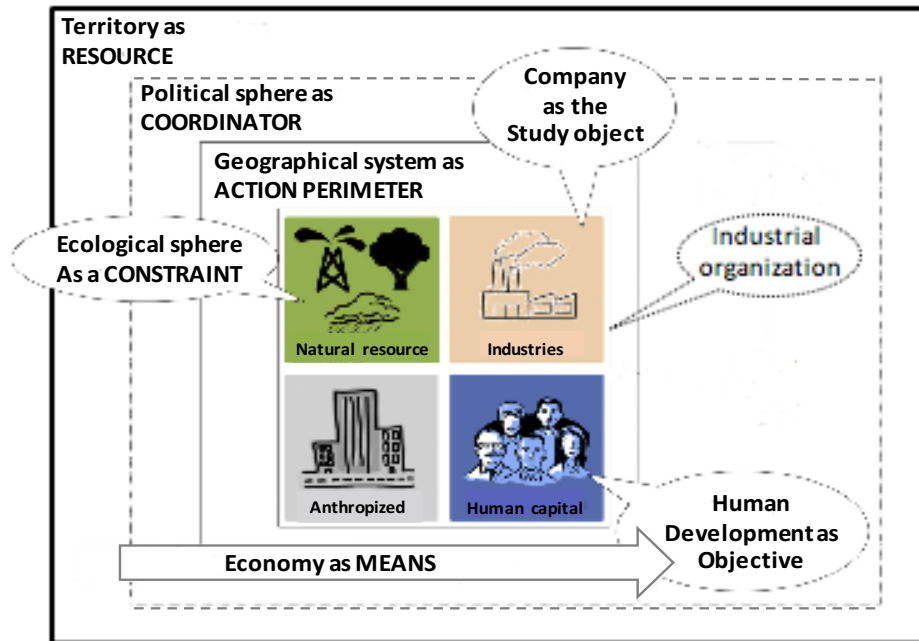


Figure 1.2: System of consideration and five dimensions of sustainability (adapted from work of Romain Allias, 2017)

As it can be seen in this figure, the industrial company is the study object and the aim is to help the industrial organization through the territorial resources.

1.3 Research questions and hypothesis

In previous works, it is clarified that it is necessary to assist the sustainability within industries. But, it wasn't identified, which type of territorial resources affect the sustainable objectives of industrial companies. So two questions can be clarified: Which type of territorial Knowledge affects the sustainable objectives of industrial companies? How to represent and share this knowledge for sustainability's objective within industrial companies?

Moreover, it is need to find a way for understanding, how territorial knowledge can assist the industries. Responding to two first questions, permit to answer to the third emerged question. The third question in this thesis is: Territorial knowledge helps which level of hierarchical corporate level for sustainable development?

We proposed to represent this knowledge by using ontology. Ontology is as a suitable method for representation of dispersed knowledge of tangible and intangible resource of territory (Kumazawa et al., 2014). Ontology enables to meet the purpose of sharing knowledge in relation to defined terms and concepts (Lin et al., 2013). It is a formal, explicit specification of a shared conceptualization and it provides a common understanding of a domain that can be communicated between people and application system (Fensel, 2001). Basically, the role of ontologies is to facilitate the construction of a domain model (Gangemi et al., 2009). Ontology has been used to share a common understanding of the structure of information, make explicit the assumption and analyze the domain knowledge (Noy & McGuinness, 2001).

We assume that the territorial ontology justifies the resource of territory for the sustainability's objective of industrial companies and hierarchical level. In other words, territorial ontologies can facilitate territorial knowledge sharing and exchange in the various hierarchical level of industries to increase the sustainability's performance. This ontology provides concept structure that make explicit the important territorial notions for sustainability.

In order to answer the two first questions, a descriptive ontology of territorial knowledge (DOTK) presents. This ontology (DOTK) can explicit the territorial knowledge for actors of the hierarchical level and help them to understand sustainability and integrate it to their activities.

In order to model DOTK, a methodology based on foundational ontology followed. The conceptual categorization of territorial knowledge is the first step for modelling a domain ontology. Therefore, four categorization of territorial knowledge according to the literature review and adapted with 5 dimensions of sustainability, created. These four types are human, geographical, economic and political capital (Ezoji & Matta, 2018a). Figure 1.3 demonstrates the four conceptual taxonomy of territorial knowledge as a tree flow chart. This taxonomy has done based on the literature review for sustainable objective within industrial companies.

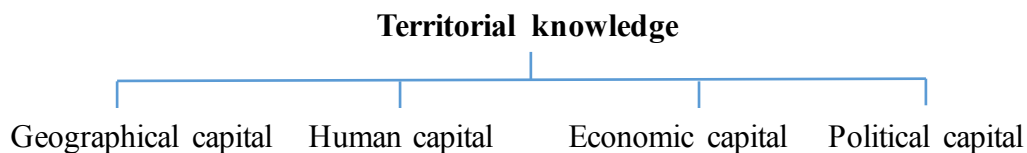


Figure 1.3: Tangible and intangible resource of territory, as territorial knowledge.

Then, DOTK ontology was implemented in a real case to identify the resources of specific territory which resources can help both industries and territory for sustainability's goal. The aim of this

implementation is to demonstrate which DOTK can identify the resource of each territory to help the sustainability within industries.

1.4 Thesis overview

This thesis is organized as follows:

Chapter 1 provides an introduction to the thesis and the problem that is targeted within this research. The important challenge in territorial knowledge for sustainability that this research attempts to address is listed to build up that main problem statement.

Also, a system's consideration of this thesis is provided. The question researches present and explain about the hypothesis to answer these questions by an ontology.

Chapter 2 describes the literature review due to reveal the area of investigation to define the framework of the thesis; Sustainability, sustainable development, territory geography and environmental issue, environmental issue and product, geography and product and other related topics. The results of this literature helped to identify the main research problem and general question researches: How territorial knowledge help the sustainable development within industrial companies?

Then, one part of the first descriptive study explains, where the aim is to gain a sufficient understanding of the current situation through a literature search in relation to different definition territory and all of the element of territory for sustainable development within industries. At the end of this chapter, the specific research questions are proposed: "Which type of territorial Knowledge affects the sustainable objectives of industrial companies?" "How to represent and share this knowledge for sustainability's objective within industrial companies?" "Territorial knowledge helps to which level of hierarchical corporate level for sustainable development?".

Chapter 3 provides further details about the capture of knowledge about the territories' feature for integrating territorial resources into the company's activities for sustainability. The results obtained from this literature review help us to justify the ontology as a tool for knowledge representation. So, as the hypothesis, territorial ontology can help to explicit the territorial knowledge for sustainability. Moreover, details about the principles for modelling an ontology provide in this chapter.

Chapter 4 presents a descriptive ontology for territorial knowledge (DOTK). According to the principles of Bachimont for modelling of ontology, at first, a definition of the taxonomy of

territorial knowledge according to the literature review is presented. Then, the normalization according to the foundational ontology of DOLCE is done to formalize the DOTK. In addition, a semantic graph between concepts of DOTK ontology by Text Mining is provided that shows the relationships between the concepts of DOTK ontology. Finally, a comparison between DOTK ontology and other related ontologies is proposed.

Chapter 5 investigates the implementation of DOTK ontology on a real case (City of Troyes) to justify that DOTK ontology can act as a guide to identify the tangible and intangible resources of territory to assist the enterprises and territory for sustainable development goal. Then, a semantic graph of relationship between concepts of DOTK ontology of Troyes is presented to compare with semantic graph of DOTK ontology. A complete semantic graph is presented from this comparison. Finally, three interviews with three sustainable development organizations are provided to validate the entities of DOTK ontology of Troyes and find the answer for third research question. Moreover, three scenarios of use cases for using of DOTK ontology of Troyes by organizations proposed.

Chapter 6 concludes the thesis by summarizing the findings gained, presenting the areas where future efforts will be devoted, and providing inspirations by means of the benefits that could be attained by successful fulfillment of future research goals.

2. SUSTAINABILITY AND TERRITORY

2.1 Introduction

This first chapter aims at setting the general context of our research. This research is started with consideration of sustainability because the growing attention to sustainable development encourages the industrial companies to integrate this issue to their activities. So, we make the observation in relation to the understanding of sustainability and the field of sustainable development.

Our work aims to support industrial companies towards sustainability. Therefore, it is very important to integrate the sustainable strategy into corporate global development strategy and organizational levels of industries. This integration needs to support sustainable goals to be in line with other existing global corporate tendencies and constraints. So, the company needs to carefully and reasonably break down “sustainability” into several actions or attributes to help its comprehension.

In continuing of this work and in order to understand sustainability dimensions by hierarchical level of industries, an anthropic-centered definition of sustainability with 5 dimensions (5D) has been adopted. Territory as one of these dimensions should also be taken into account, adapting local specificities to develop appropriate solutions for local industrial companies. So, different kinds of literature are considered to investigate the integration of territorial resources (tangible and intangible) in different activities of hierarchical levels for the sustainable development objective. Then, it is found that territory is where all of the tangible and intangible resource flow. So, lack of knowledge about the territory’s feature and its environment is a barrier for searching the possible concepts for sustainability. So, it is needed to organize the territorial knowledge for sustainability within the industrial companies.

2.2 Sustainability

Sustainability¹ as a policy concept has its origin in the Brundtland Report of 1987. That document was concerned with the tension between the aspirations of mankind towards a better life on the one hand and the limitations imposed by nature on the other hand. In the course of time, the concept has been re-interpreted as encompassing three dimensions, namely social, economic and

¹ Dictionary definition: the ability to be maintained at a certain rate or level.

environmental (Kuhlman and Farrington, 2010).

Sustainability has been applied to many fields, including engineering, manufacturing and design. At its core, sustainability is simply the ability to endure or survive, which has significant ramifications (Rosen et al., 2012). The concept of sustainability is a complex one. However, it is possible to distil some of its most basic and general characteristics by adopting a systemic approach (Gallopín 2003). It can be viewed as having three parts: environmental, economic and social (Figure 2.1). As a consequence, achieving sustainability requires an integrated approach and multi-dimensional integrated approach and multi-dimensional indicators that link a community's economy, indicators that link a community's economy, environment and society (Rosen et al., 2012).

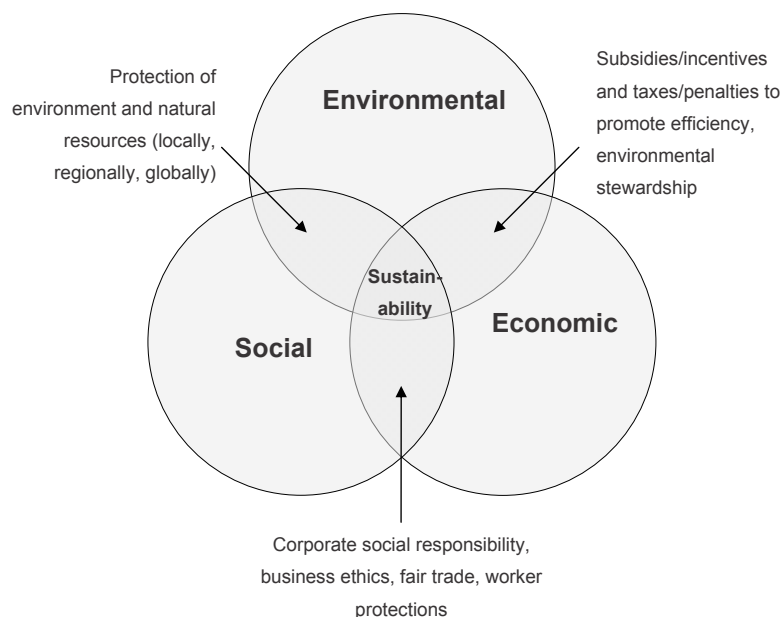


Figure 2.1: Sustainability as the intersection of its three key parts (Rosen et al., 2012)

Sustainability issues affect every component of our society from individuals to regional and global organizations: major ecological or social crises are due to natural resource overconsumption and rising inequality at both local and global scales (Allais et al., 2017).

The mainstream business case of sustainability (i.e. corporate sustainability) does not question the fundamental paradigm of the capitalist market economy (i.e. mass consumption, growth) which is the source of most of the current socio-ecological problems (Buclet, 2011c)

Sustainability is not about preserving resources, a product, a company or an organization but rather not systematically degrading the global socio-ecological system (Allais et al., 2017). In fact, sustainability is a system property, therefore products, services, technology or organization cannot be sustainable on their own but may be elements of sustainable systems (Gaziulusoy et al., 2013). A socio-ecological system is defined as any system composed of a societal subsystem in interaction with an ecological component. It can be either urban or rural, and it may be defined at different scales from local to global (Gallopín 2003). The concept of sustainable development is quite different from that of sustainability in that the word “development” clearly points to the idea of change. Sustainability is an increasingly important requirement for human activity, making sustainable development a key objective in human progress. Sustainable development aims at balancing the economic, social and environmental spheres. This approach is anthropocentric and sets objectives in the social sphere: “the main objective of development is to satisfy the needs and aspirations of the human being” (Allais et al., 2013).

Figuière et al. (Figuière and Rocca, 2008) propose a really sustainable development, refocusing the objectives on the social sphere and using the economy as a means (not as an end) while considering the constraints coming from the environmental sphere. It adds the political sphere, the only legitimate to define development orientations, which must also regain a prominent place and take precedence over the economic actors. The territorial dimension must also be taken into account for the adaptation to local constraints of policies for the development of adapted solutions. It also emphasizes the importance of the temporal dimension. Indeed, sustainable development must ensure dual equity within and between generations.

Our work position itself in this 5-dimensional definition of sustainability: the economic, environmental and social, the political and territorial sphere (adapted from work of Romain Allais, 2015).

Currently, the implementation of sustainability being very largely constrained by the economic sphere, the mechanisms of non-sustainability is reproduced in a logic of the least bad. To overcome this predominance of the economy on the modes of development, it is adopted a definition of the sustainability to 5 dimensions having for end the human development (Allais et al., 2013).

Moreover, 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 and constraints. To do so, the company

needs to carefully and reasonably break down “sustainability” into several actions or attributes to help its comprehension (Hallstedt et al., 2010).

We finally specified our object of study (the industrial enterprise). It is located the heart of the system, at the interface between the economic, social and environmental spheres, it plays a leading role in the structuring of public policies and territories.

2.2.1 How to achieve sustainability?

Many solutions are already being implemented at different systemic level. Several elements are taken into account: human rights, labor, environment or business ... This type of convention aims to give "golden rules" to be respected by all types of organization. Tools based on financial mechanisms have also been proposed (carbon market, environmental tax, etc.) but they are misused and used for speculation purposes or perceived as additional taxes (Allais et al., 2013).

At the corporate level, the international standards on corporate social responsibility such as ISO 26000 or SA8000 are founded that are adapted to their issues (labor law, governance, etc.). However, the normative approach poses a problem of scalability. It is, indeed, fixed in time and will be revised to adapt to the needs and constraints of future generations. "The core issues and areas of action identified in this international standard provide a current view of good practice. There is no doubt that visions of good practice will evolve in the future and in the other areas of action can be considered as key elements of social responsibility "(ISO26000, 2010). In addition, these standards have a high level of ambition but are voluntary and are based on continuous improvement.

There are also many private initiatives of NGOs or companies for the creation of hundreds of labels or brands. The specifications for obtaining these labels are often unclear and ambition levels vary from marketing to a real willingness to act. Eco design tools and methods are also abundant but faced with their number, companies are disoriented (Bovea et al., 2012 & Zhang et al., 2013). Evaluation tools and methods are also very numerous and adapted to different types of audiences and use: LCA is an expert method that quantifies the environmental impacts of a product on its life cycle whereas the concept of Ecological Footprint proposes to quantify the ecosystem resources and services needed for our livelihoods. These tools are essential to support change at different levels through the implementation of targeted action plans to reduce the footprint of individuals, organizations, countries, products etc.

From this quick overview, it can be seen that each element of the system tries individually to integrate certain aspects of sustainability according to its own issues. The different approaches (financial, technical, regulatory ...) depend on the actors involved, their level of ambition and the scope of their action (local, global) or their means of action (political, economic ...).

These approaches propose to influence current trends in order to reduce the negative externalities of our current paradigms in a process of continuous improvement. However, the question very little the results obtained with regard to the real issues of sustainable development.

Thus, faced with the constant degradation of the environment and the living conditions of each, the effectiveness of these approaches, the issues of sustainable development should be questioned.

2.2.2 Definitions the five dimensions of sustainability

In order to clear the definitions and dimensions of sustainability, an anthropic-centered definition of sustainability with 5 dimensions (5D) has been adopted (Figuiere and Rocca, 2008). It focuses on sustainability's objectives on human development (social sphere). The environment is considered as the limiting factor for anthropic activity (ecological sphere). The economic sphere is investigated as a means (not a goal) which enables the realization of social objectives with respect to ecological boundaries. The political sphere has to define development guidelines and must be strong enough to take precedence over economic actors. The political sphere is considered as the place for public debate and long-term societal orientation and decision making. In fact, public policies are the only legitimate way to define public interest and the common good; consequently, they must coordinate sustainable industrial strategies and expectations from civil society (Allais et al., 2017). The political sphere, dedicated in particular to the orientations of the industrial policy. Sustainability is the first case of collective projects of society and Government (Figuiere and Rocca, 2008). Taking the territorial dimension into account is the essential complement to the re-thinking of the political sphere. Whatever level the political decision is concerned and certain objects necessarily require a global vision, the transcription into concrete measures and, consequently, the application of these measures, usually involve very small territorial scales (Figuiere and Rocca, 2008). The territorial dimension should also be considered, adapting global policy to local specificities to develop appropriate solutions. In addition to the administrative boundaries, the territory is an evolving and complex combination of a set of actors and the geographical space that these actors use, landscape and manage (Moine, 2006). 'Territory' is a

polymorphous concept depending on the issues and stakeholders considered (e.g. administrative, ecological...) (Allais et al., 2015).

Figure 2.2 propose a synthetic vision of these first propositions for real sustainability with 5 dimensions.

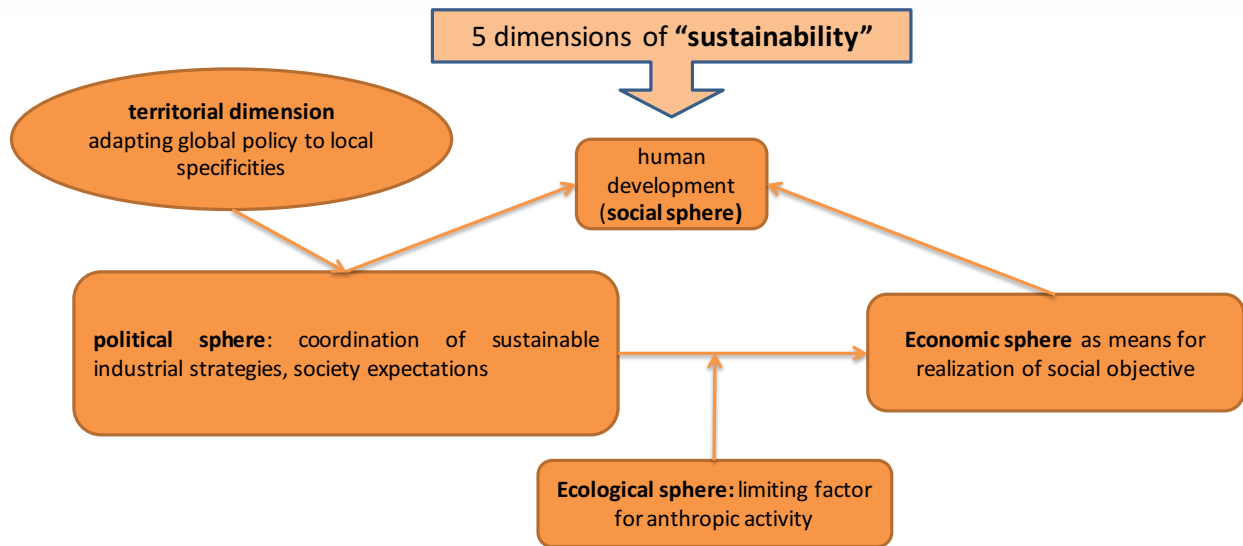


Figure 2.2: Founding principles of real sustainability (adapted from Figuiere and Rocca, 2008 & Allais et al., 2017).

2.2.3 General problem

Industrial enterprise is specified as a study object. In order to integrate the sustainability to their activities, it is needed to the understanding of sustainability. So, in this research five dimensions of real sustainability is adapted and considered. Industrial enterprise is being at heart of the system, at the interface between the economic, social and environmental spheres. They also play a leading role in the structuring of public policies and territories.

Industrial enterprise is a powerful lever that must contribute to sustainability. Figure 2.2 represents the adopted definition of sustainable development in which we have positioned our object of study. So, the general question has emerged.

How to assist the industrial companies toward 5 dimensions of sustainability?

2.3 Industrial enterprise and territorial sphere

Enterprise, the industrial ecosystem and territory are complex systems in that they are a set of elements in dynamic interaction, organized according to a goal (De Rosnay, 1975). Also, the aims of these entities diverge, sustainable development can be a goal shared by these nested systems (Capron and Quairel, 2006).

Moreover, the implementation of sustainability at the level of a company aims to mitigate its negative externalities while working towards its economic viability in the medium and long term. Thus, the ISO 26000 standard invites companies to work towards sustainable development by considering the environment, communities, etc. (ISO26000, 2010). This approach based on the principles of responsibility (accountability, vigilance, ethical behavior, etc.) profoundly changes the scope of the company's responsibility. Indeed, an organization's responsibility is extended to the impacts of its decisions and activities on society and the environment; it is implemented in its sphere of influence (ISO 26000, 2010). Then, stakeholder responsibility has evolved into a broader responsibility to society.

The externalities of a company are spread over a set of actors located throughout the world. However, companies can be local actors by removing intermediaries and dealing directly with customers (Buclet, 2011c). The enterprise as a network of creation/destruction of values embedded in other networks where material and immaterial resources circulate. The value delivered to the stakeholders is produced or destroyed by all the actors in the value constellation (Allais et al., 2015). Moreover, territory is considered as value creation network for human where all of the intangible and tangible resources flow (Allais et al., 2017). Therefore, it can be concluded that there is the direct relation between industrial companies and the territorial sphere as value creation where all intangible and tangible resource flow.

2.4 Territory

The territory² has been the focus of attention for twenty years because it is central to our representations of the complexity that surrounds us. The territory has slowly replaced this term (space) by conferring more thickness on what could also be called environment, that is to say, what surrounds us in a very global sense. That is to say mixing both physical, natural and landscaped

² Dictionary definition: An area of land under the jurisdiction of a ruler or state

environment. But subtly, territory turns out to be much more than space, the environment, or the people who populate it and appropriate it. The definitions eventually overlap, the man is often agent more than actor and most of the time the approaches wisely isolate the organization as the space (geographical space) and the actors (Moine, 2006).

The territory is a promising perimeter to capture specific intangible values but the concept is used in numerous scientific fields and has multiple definitions. It has to be noted that there is a paradox between the globalization of companies' value networks (Buclet, 2011a) and its physical reality in a geographical area (Allais et al., 2015). Therefore, this review focuses on two definitions both from an industrial perspective and geographical science.

2.4.1A definition from geographical science

Territory, geographically, is a contiguous area in which human activities occur that is managed by local stakeholders, whose representations (individual, ideological, and societal) of the territory influence their decisions. The main distinction between “region” and “territory” is the inclusion of the stakeholders in the latter. A territory is, therefore, a place where decisions are made and where stakeholders gather around common questions (Nitschelm et al., 2016).

It can be compartmentalized into four clusters that is adapted from the division proposed by (Moine, 2006) and each of this ecosystems provide specific tangible and intangible resources:

- Natural ecosystems: provides tangible resources (natural resources) such as gas, wood, water... and intangible such as natural amenities, purification.
- An anthropic ecosystem is constituted of the whole anthropic objects such as communication networks, cities. It provides tangible resources such as city garbage or facilities and intangibles such as transport services or human resources.
- The industrial ecosystem is a voluntary disconnect from the previous one, although it is an anthropic construction. It provides tangible resources such as second-hand materials and intangibles such as expertise.
- Finally, human capital is the set of social interactions: networks of relationships, organizations. They are defined as “the set of individual, societal and ideological filters (values) that shapes the understanding an actor has of his territory”. Human capital mainly provides intangible resources such as a common culture, local history or identity.

2.4.2 An administrative definition of territory

The administrative territory is the geographical area managed by a political entity (e.g. country, department, regions, city, etc.) (Allais et al., 2015). Recent French public policies aimed at decentralizing the economy by promoting the attractiveness and empowerment of territories. For the French Economic Analysis Council: “the territory is at the heart of strategies to enhance competitiveness and economic attractiveness” and “can strengthen social cohesion” (Godet et al., 2010). Administrative territories are compatible with the sustainability definition (the i.e. adaptation of public policies to local specificities) but their boundaries are static. Consequently, administrative territories lack the necessary flexibility regarding the nature of a problem and the stakeholders involved. Nevertheless, this lack of flexibility is partly mitigated by coordination between territories but it reduces the reactivity and makes a proactive approach difficult (Allais et al., 2015).

2.4.3 A definition from industry

Anytime, companies selected their location regarding the local specificities without a sustainability perspective. Consequently, if the main factor is the reduction of costs, this leads to the negative aspects of globalization with an incentive for forced work or environmental disasters. To respond to these crimes, numerous regulations and norms exist including the ISO26000 for Corporate Social Responsibility (CSR) (Allais et al., 2015). ISO26000, 2010 defines the sphere of influence of an organization as an “area across which an organization has the ability to affect the decisions or activities of individuals or organizations. The area can be understood in a geographic sense, as well as in a functional sense” (ISO26000, 2010). It appears to define the boundary of the company's sustainability but in the current globalized economy, distance does not exist anymore. Consequently, the company's influence sphere is global and rarely localized in a unique geographical area.

2.4.4 A definition of territory adapting with real sustainability (5-dimensions)

As it is mentioned in Figuière and Rocca's definition of real sustainability, the territory is a relevant perimeter for the implementation of public policies for sustainable development. However, used in many disciplinary fields, the concept of territory must be redefined to serve the purposes and

territorial boundaries depend on the stakeholders and the problem to be solved. The following definition of a territory is provided by (Moine, 2006): the territory is a complex evolutionary system that associates a set of actors on the one hand, and the geographic space that these actors use, develop and manage on the other. The territory thus associates a geographical space and an anthropic space, drawn by history, the modes of organization of the society, the infrastructures, the economic activities. The space becomes a territory built by the contributions of historical facts and ideological, but also by adherence to a project by actors who compose it (Moine, 2006).

Moreover, the notion of territory depends directly on the problem to be solved, the nature of the actors involved and their own objectives and strategies. To make the link with the political sphere, it is focused on public policies (territorial dimension) that act at the macro-economic level with a perspective of sustainability. The territory is at the heart of the strategies aiming at reinforcing the competitiveness and the economic attractiveness. (Godet et al., 2011). All flows of tangible and intangible resources define the identity of a territory.

The area of application of public policies is the administrative territory (country) and its many divisions (region, commune ...). However, this administrative network is fixed and therefore does not meet the needs for flexibility inherent to the changes in strategies or the scope concerned by these strategies. This flexibility is offered by the multiplication of territories with different vocations and missions (country, the community of communes, poles, etc.) and especially the coordination between administrative territories. However, (Allais, 2015) consider the territory as a system of creation/destruction of tangible values (economy, raw materials, products, etc.) and intangibles (culture, knowledge, heritage, etc.). In fact, a territory is a network, where all of the tangible and intangible resources flow. So, the values are created (or destroyed) by the circulation of tangible and intangible resources of territory for both of industries and human (Allais et al., 2015). In the other word, there is a coordination and flow of tangible and intangible resources, between four clusters of natural, industrial, anthropic ecosystem and human capital, and between territories.

So, it can be concluded that territory consists of tangible and intangible resources flow (Allais 2015) which it is a relevant perimeter for the implementation of public policies for sustainability (Figuière and Rocca, 2008). Moreover, industrial companies, as a study object, is located in the territorial scale as one of four clusters that are defined by Moine, 2006. So, investigating these tangible and intangible resources can help the industries companies toward of sustainability to the activities of

industrial companies considering all 5 dimensions (i.e. ecological, social, economic, political and territorial). Moreover, sustainable aspects should be embedded at all corporate hierarchical levels that it is explained in the following section.

2.5 Integration of sustainability into hierarchical corporate levels

The growing attention given to sustainable development is encouraging companies to integrate sustainability issues into their activities. Many authors, therefore, point out the need to establish a systemic perspective in order to improve the integration of sustainability issues into all company activities: from strategic decision-making to the end of the project (Zhang et al., 2013). To increase the performance of this integration, the sustainable aspects should be embedded at all corporate hierarchical levels, from global strategic decisions by top management, through planning and organization by tactical management, to daily engineering and production activities of the operational area (Hallstedt et al., 2010). Figure 2.3 illustrates the interactions of different hierarchic levels.

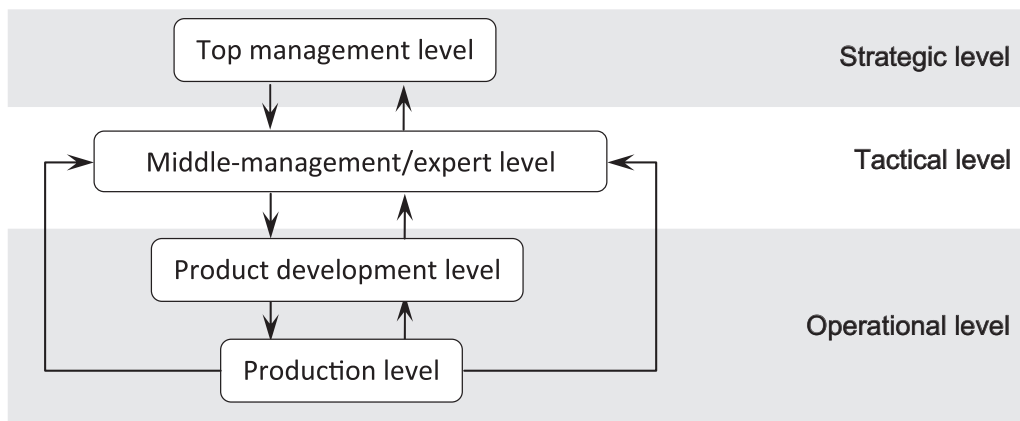


Figure 2.3: Interactivity and coherence between hierarchical corporate levels (Zhang et al., 2013)

Sustainable integration could be improved by better cooperative circulation between the different company levels (strategic, tactical and operational), and to propose a navigation- based approach to support this improvement. The strategic level assists “top managers” who define the corporate strategic goals that will create multi-values for all stakeholders. At the strategic level, the company needs a legible and quantitative method to evaluate its global situation, including material resources

and immaterial capitals. Another issue has been identified regarding the relationship between the global objective of value creation and the sustainable activities carried out in the company (including environmental, social and cost considerations). In order to respond to strategic goals, the tactical level analyzes and organizes the corporate material and immaterial resources (for example: cost, knowledge, Human resource, Relationship with stakeholders or organization.) and develops an efficient and implementable roadmap. This matches the strategic goals with specific technological solutions and identifies related “activity tables/chains” to help meet these goals. At the tactical level, a global approach is necessary to identify a sustainable trajectory (with a series of selected methods) depending on the strategic objectives and the complex and dynamic changeable corporate context. Lastly, the operational level supports the deployment of the process in the company in accordance with the tactics (and tools) chosen. At the operational level, dynamic and flexible information exchanges between product designers and environmental engineering tools are needed to effectively deploy the (eco-) design process as regards the available resources (Zhang et al, 2013).

However, in practice, the integration of sustainable issues faces some difficulties. Some literature suggests that one of the principal barriers is the lack of an existing systemic approach. Zhang et al., provide a global overview in line with the reel structure needed to deal with sustainability; the company should not only focus on the product level, but also on the strategic or tactical level. It is demonstrated that a better circulation among different hierarchical levels (strategic level, tactic level and operational level) and different function presents a positive effect on the integration of "sustainability" (Zhang et al., 2103).

So, it is concluded that the hierarchical levels in industrial companies should understand the concept of sustainability in order to integrate into their activities. Moreover, it is necessary to integrate sustainability into their works for sustainable development goal. Therefore, the analysis turns around of sustainability and territory to help the hierarchical level of industrial companies.

Figure 2.4 shows the system consideration and five dimensions of sustainability. As can be seen in figure 2.4, five dimensions of sustainability is provided. Moreover, 4 clusters of territory, according to (Moine, 2006) are located in the geographical system. These four cluster as mentioned in section 2.4.1, are: Natural, industrial, anthropic ecosystems and human capital. Companies as the study object is located in this ecosystem. Hierarchical level of industrial companies (industrial organization) need to understand this considered system in order to increase of their knowledge

about the territorial resource to integrate this knowledge to their activities for sustainable development objective. Increasing the knowledge of hierarchical level, influence on the decision making of the strategy to create the value for human in regard to existing territorial knowledge.

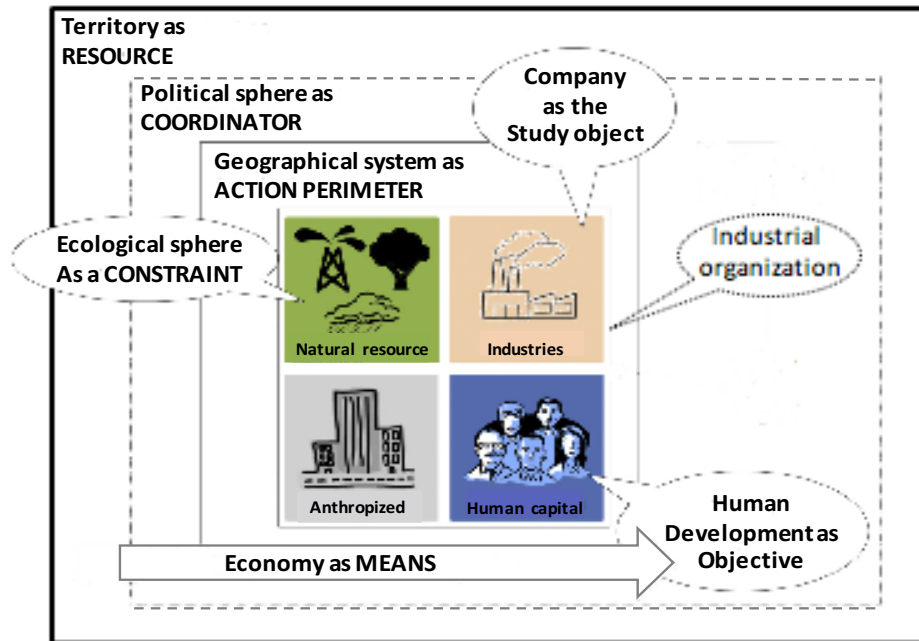


Figure 2.4: System under consideration and five dimensions of sustainability (adapted from work of Allias et al., 2017)

So, the industrial company is the study object in this system consideration and aims is to help the hierarchical level (industrial organization) through the territorial resources.

2.6 Considering of territory for sustainability in different researches

As mentioned, the territory consists of tangible and intangible resource flow that sustainability's policies can implement in this perimeter. Moreover, investigating of territorial resources can assist the industrial companies toward sustainability by integrating to their hierarchical levels. So, the goal in this section is to consider the researches that use the territorial in their work for sustainability from different point of views.

In this research, definitions of the territory consider from different points of geographical science, administrative, industrial aspects and definition adapting with real sustainability (5-dimensions). So, in this section, a review of different works is done which investigate the territory from the

different definition for sustainability. The goal of this literature review is to justify the works that integrate the territory for sustainability and consider their fields.

Nitschem et al. (2016), focus on agricultural territories, which they define as territories in which most land uses or economic activities are based on agriculture. In an agricultural territory, stakeholders focus on questions such as the trade-off between agricultural production and the environment

The relevance of a territorial approach to addressing environmental concerns about agricultural areas is being increasingly recognized. In the scientific community, the definition of “territory” varies among and within scientific communities and countries. The concept of a “territory” was first developed by French scientific communities. The concept of a “territory” as a complex and dynamic system goes beyond that of a “region”. Although the concept of “territory” is still debated, much of the scientific community agrees on a definition based on three main concepts: a geographic space, stakeholders' decision-making processes, and regional identity). Therefore, Nitschem et al. (2016), adopt Moine's (2006) definition of “territory”: a geographically contiguous area in which human activities occur that is managed by local stakeholders, whose representations (individual, ideological, and societal) of the territory influence their decisions. The main distinction between “region” and “territory” is the inclusion of the stakeholders in the latter. A territory is, therefore, a place where decisions are made and where stakeholders gather around common questions (e.g., environmental, economic, societal) or sustainability (Nitschem et al.,2016).

So, Nitschem et al., consider the function of agricultural territory in three categories of environmental, economic and social to assess environmental impacts of an agricultural territory with a higher level of accuracy. This work helps to decrease impacts within a territory by determining which agricultural activities should be developed and where to locate them. It can be concluded that it is considered the territory from the geographical definition for environmental aspects of sustainability to help the stakeholders that make decisions (Nitschem et al.,2016).

Another research by Real & Lizarralde (2017) use a methodology in five regions (hgeographiavm aspect of territory) in order to realize a holistic diagnosis of the territory that analyzed the key features of the territory (geography, urban center, economy, demography and culture), the actual political instruments for circular economy and an input-output characterization for three sectors which the textile industry was one of them. This methodology is followed to manage four regional stakeholder meetings aimed to respectively framing the actual lacks of circular initiatives and

transferring knowledge through good practices around three sectors. The goal of this research was the optimizing of the accessible resource in regional ecosystems(territory) to increase environmental efficiency (Real and Lizarralde, 2017).

Different researches in literature review are considered to investigate the territorial aspect in their work and particularly for sustainability. A review of these researches is presented in table 2.1. In this table is tried to present the main problem of each research, their solution and the concepts of territory which they consider. This consideration is useful to help identify common territorial element is integrated for sustainability in different researches. Moreover, the objective of this table preparation is not to compare the different work, but to introduce them by a short explanation about their objectives and specifications.

Table 2.1: Analyses of literature review about the territories integration for sustainability

Reference	Field	Specification	Objective
Allais et al. 2015	Territorial resource, product design and sustainability in industrial companies	Incorporating territorial resources into design process to increase the environmental, social and economic performance of the company and positive externalities for its territory.	Encourages companies to integrate territorial resources into the product development process to create value for both the company and its territory in a sustainable perspective
Vadoudi & Troussier, 2017	GIS and product with contribution of Design for sustainability	integrate geographical information model(GIS) with product through environmental information model.	Studying a product's environmental impact on an interacted territory's environmental statues can increase decision maker's information when considering design for sustainability
Real & Lizarralde, 2017	Systemic thinking and design and territory (geographical data)	Description of a set of tools for applying systemic design to the development of small-scale territories. (interaction between effective territorial actions and reflexive research design perspectives so to	Selecting design approach in optimizing of the accessible resource in regional ecosystems(territory) to increase the environmental efficiency

		propose operational tools for encouraging systemic design in the development of territorial transition)	
Zhang et al. 2013	Integrating the sustainable development into the companies and framework for hierarchical level	Determine whether sustainable integration could be improved by better cooperative circulation between the different company levels (strategic, tactical and operational), and to propose a navigation-based approach to support this improvement for sustainability	Better circulation between the different functions in company could improve the integration of sustainable issues.
Vadoudi & Troussier, 2015	Geographical information system (GIS) and product	More accurate meaning to sustainability for territorial understanding of the term. designers need to access geographical information that able them to integrate territorial specifications in a proper way. integrated framework (integration of geographic and product data) support designer in decision making, especially in BOL of product life cycle.	Aimed at industrial product service system to improve the design models and importance of geographical information in product-service design.
Shaw & Xin, 2003	GIS and Product and transportation (without contribution to design)	A spatiotemporal GIS design Provides a foundation for the development of spatiotemporal analysis functions to systematically explore land use and transportation interaction.	Exploratory data analysis capabilities to interactively examine land use and transportation interaction at user-specified spatial and temporal scales.
Paola Demartini, 2015	Geography (regional scale) and knowledge of social and economy in	Research on the role of required intangible factors and research on the strategic knowledge	Finding the driver for sustainable territorial (regional scale) governance via

	regional governance	resources that affect a specific regional system's performance and processes of value creation (Social capital, Human capital, structural capital such as ICT)	knowledge and social capital (critical resource that effect the sustainable growth of regional economies)
Lin et Hu, 2017	Geography(regional scale) and knowledge economy in industrial development	knowledge generates a high output, provides opportunities for industry transformation, and decreases resource consumption to achieve environmental sustainability. Also, the ability of industries to acquire, apply and convert knowledge increase product specificity, reduce resource consumption and add value and deference among the products.	changes in industrial development have improved the knowledge innovation, technical level, and productive efficiency of industries in regional scale
Walsund et al., 2013	GIS and Sustainable urban development (product development)	Geographical Information Systems (GIS) and Decision Support Systems (DSS) can be used as tools to help achieve sustainable urban development with focus on the environmental aspect of sustainability. In fact GIS support the knowledge for design makers both sustainable urban and product development	Aimed at detailed common definition of sustainability makes the work for a sustainable urban development difficult.

Belmin et al., 2017	Geographical indication and agriculture (process and Geography)	GIS as governance tools is considered terroirs as sociotechnical niches whose development is influenced by dynamic interactions between specific rules embedded in the biophysical environment and territorial resources, and non-specific rules.	Geographical Indication promote endogenous innovation and sustain the typicality of terroir products
Tingley et al., 2017	Socio – technical factors and Design in a Geographical territory	Interacting factors were identified that guide the process of designing and in the UK. These are: 1) customer preferences; 2) market positioning; 3) techno- economic feasibility; 4) supply chain feasibility; 5) regulation; and 6) organizational attributes.	Identifying of socio-technical element that cause more efficient technologies(product) and design process. Particularly decreasing of material consumption
Peachavanish, 2006	Product and GIS	A query methodology in support of infrastructure management (approach to integrate CAD and GIS).	support different architecture, engineering, construction and infrastructure management related processes
El- Diraby & Osman, 2011	Product process and GIS	Conceptualization of the essence of knowledge that relates to construction products. Product attributes and modalities are also presented to help describe the behavior of these products and support the generation of types or classes of these products.	set of related constraints, mechanisms, actors and processes are identified along with products. (construction concepts in urban structure products)

One of the recent works which is investigated by Allais et al. (2015) to integrate the latent territorial resources into the product development process to create value for both the company and its territory in a sustainable perspective. Allais et al., propose encouraging companies to consider

territory as a value creation network where exploitable resources flow. They proved incorporating of territorial resources into design process has the potential to increase the environmental, social and economic performance of the company and has positive externalities for its territory. This research aims at assisting industrial companies to both explore the use of latent resources from their territory and assuming their responsibility facing their stakeholders in a sustainable perspective (Allais et al., 2015). Sustainability and territorial values are delivered to customers and become differentiators for businesses. So, the proposed method Allais et al. classified: 1- to extend the internal strategic analysis to the all of the value creation factors; 2- to support strategic decisions towards a sustainable strategy; 3- to manage the deployment from strategy to designers and the overall performance assessment of the system (Allais et al., 2015).

The internal value creation aims to increase the body of knowledge relating to value-creating processes inside the business and their interactions. it is a representation of the flow of tangible and intangible resources from one reservoir to another. In order to integrate territorial resources into the company's activity, an important issue is to capture knowledge about its territories (Allais et al., 2015).

Capture of knowledge about the territories is not developed in the different research of literature review. It is an interesting solution already exist for territorial data collection: territorial metabolism (i.e. material flow analysis at the territorial scale), open public data. GIS (Geographic Information System) may be used to represent these data in a multi-layer perspective: tangible resources, skills, human resources, etc.

Promising research is done by Vadoudi & Troussier (2017) on the connection between PLM (Product Lifecycle Management) and GIS to enable territorial data introduction into company's information systems (Vadoudi et al., 2017). There is not significant attention to the relationship between product and geography in the design aspects of the industrial product. But there is still no known method to combine all three pillars of sustainability on a regional scale.

Working on GIS in future research could support knowledge for decision makers both in sustainable urban and product development (Walsund 2013). Design for sustainability is an approach could improve the region's economy and social aspects and while simultaneously improving environmental performance (Crul and Diehl, 2006). So, studying a product's environmental impact on an interacted territory's environmental statues can increase decision maker's information when considering design for sustainability. However, lack of knowledge

about the territory's features and its environmental status, and lack of integrity between that knowledge and the product are barriers to searching for a possible concept for sustainability (Vadoudi et al., 2017).

Moreover, another research is stated that better circulation of information and data flow between the different functions in the company could improve the integration of sustainable issues (Zhang et al., 2013). However, lack of knowledge about the territorial resources and features remain as a problem in order to circulate between the hierarchical level of industrial companies for integrating sustainability. So, few attempts have been made at research in this field to capture the knowledge about the territory's features for sustainability.

2.7 Problem formulation

Contribution of researches in this thesis is to assist the industrial companies based 5-dimension of sustainability. The scientific aim is to focus on identifying a way to consider territorial features as a resources flow and a relevant perimeter for the implementation of public policies for sustainability. Moreover, it is important to understand how these features can assist the sustainable development within industrial companies.

This research is based on a qualitative approach because these question researches of this study could not be answered by applying quantitative methods. There are two reasons for this: (1) It is largely exploratory in nature, and (2) the purpose is to gain general insight into a topic on which little literature exists. The aim is not to quantify or measure something, but to improve our understanding of a phenomenon by obtaining information through existing literature, experts on critical experiences and critical incidents.

At first, an anthropic-centered definition of sustainability with 5 dimensions (5D) has been adopted. Then, it is identified that including territorial features is considering a kind of strategy for sustainability within industrial companies. Therefore, we were looking for a fundamental solution and we identified support of territory as a resource flow for implementation of sustainability within industrial companies. Subsequently, it is reflected to the realized that hierarchical corporate level is the central issue to integrate sustainable issue into industrial companies. Therefore, the analysis is done around of sustainability, territory and assist to the hierarchical level of industrial companies. Thus, the integration of territory for sustainability in different researches is considered. Moreover, it was concluded that intangible and tangible resources of territory are the key factors

in supporting the success of sustainable strategy within industrial companies.

Later, supportive descriptive literature searches about the considering of territory in different works for sustainability were carried out (Table 2.1) to identify the specifications of territory and integration for sustainability. Results obtained from the literature led us to understand which an important issue is capture of knowledge about its territories in order to integrate territorial resources into the company's activity. Moreover, capture of knowledge about the territories is not developed in the different research of literature review. Also, from the state of the art on existing works is understood that the lack of knowledge about the territory's features and its environmental status are barriers to searching for a possible concept for sustainability.

So, the research problem in this thesis is:

**Lack of territorial knowledge and territory's feature to search the possible concepts
for sustainability within industrial companies**

Thus, the main research in this thesis is formulated to consider the capture of knowledge about the territory's resources (tangible and intangible) which influence the sustainable development within industrial companies.

2.8 Research questions

Based on the literature review, it is clarified that identification of territorial resources can assist the sustainability within industries. But which type of territorial resources affect the sustainable objectives of industrial companies, wasn't identified, So, the following research questions are proposed:

1. Which type of territorial Knowledge affects the sustainability's goal of industrial companies?
2. How to represent and share this knowledge for sustainability's objective within industrial companies?

Moreover, finding a method to understand, how territorial resources can assist the industries and respond to two first questions, permit to answer to the third question. The third question in this thesis is:

3. Territorial knowledge helps which level of hierarchical corporate level for sustainable development?

In fact, we assume that territorial resources and sustainability are not independent and the territory's features would influence the sustainable development within industrial companies. But we do not know how these resources would influence sustainability, especially how to represent and share this territorial knowledge.

2.9 Conclusion

Based on the presented literature review in this chapter, the capture of knowledge about its territories for integrating territorial resources into the company's activities for sustainability is not developed in the different researches of literature review. Moreover, there is a lack of knowledge within industrial companies about its territory and environmental status.

In this thesis, we are interested to study this problem. For this purpose, a descriptive study is needed to find the different territorial knowledge which helps the sustainable development within industries. Moreover, it is necessary to represent their influence on the sustainable development of industries. Therefore, finding a method to represent and share of this knowledge is required. So, in order to find the answer for these research questions, the state of the arts is done in the following chapter to detect a method for representing of this knowledge.

Chapter 2: sustainability and territory	
Clarification of research	Part 2.2
	Sustainability: its definition and concepts, how achieve the sustainability?
	Conceptual framework: 5 dimensions of sustainability, Human development objective respecting the environmental limits of the system. Politics is back on the economy. The territory as a perimeter adapting local specification.
	General problem: How to assist the industrial companies toward sustainability in the system of 5 dimensions of sustainability?
	Part 2.3
	Lever for change: Industrial companies and territorial sphere
Descriptive study	Part 2.4
	Territory 's definition, definition from geographical science, administrative definition, industry, definition adapting with 5 dimensions of sustainability
	Part 2.5
Descriptive study	Integration of sustainability into hierarchical levels of industrial companies
	<ul style="list-style-type: none"> • introduction of hierarchical level and their activities • importance of this integration • systems under considering in this research
Perspective study	Part 2.6
	Study of territorial aspects for sustainable objective in different researches:
Perspective study	<ul style="list-style-type: none"> • importance of capture of knowledge about the territory for integrating into company's activity for sustainability.

	<ul style="list-style-type: none"> • studying a product's environmental impact on an interacted territory's environmental for sustainability
	<p>Part 2.7</p>
	<p>Problem formulation: Lack of territorial knowledge and territory's feature to search the possible concepts for sustainability within industrial companies</p>
	<p>Part 2.8</p> <p>Research questions:</p> <ul style="list-style-type: none"> • Which type of territorial Knowledge affects the sustainable objectives of industrial companies? • How to represent and share this knowledge for sustainability's objective within industrial companies? • Territorial knowledge helps to which level of hierarchical corporate level?

3. KNOWLEDGE REPRESENTATION

3.1 Introduction

Literature reviews helped to understand that it is necessary to capture the knowledge about the territories' feature for integrating territorial resources into the company's activities for sustainability. So, it requires to represent this knowledge. This chapter aims at setting the context of knowledge representation. This research is started with historical background about the knowledge and representation. So, I make the observation in the definition of knowledge in context. This work aims to represent territorial knowledge for sustainable development. Therefore, in continuing work, the techniques of knowledge representation are investigated. Knowledge representation is a multidisciplinary subject that applies theories and techniques to develop ontologies. So, ontology as a technique for knowledge representation is considered completely from a different point of view. In this research, it is found that ontology is a tool which can help to explicit the territorial resource for sustainability. Therefore, the principles for modelling an ontology is considered. These principles help us to follow the methodology for modelling a territorial ontology.

3.2 Historical background of knowledge and representation

The words *knowledge* and *representation* have provoked philosophical controversies for over two and half millennia. In the fifth century B. C., Socrates stirred up some of the deepest controversies by claiming to know very little, if anything. By his relentless questioning, he destroyed the smug self- satisfaction of people who claimed to have knowledge of fundamental subjects like Truth, Beauty, Virtue, and Justice. By recreating Socrates 'dialectical process of questioning, his student Plato established the subject of *epistemology*- the study of the nature of knowledge and its justification. Plat's student Aristotle shifted the emphasis of philosophy for the nature of knowledge to the less conversational, but more practical problem of representing knowledge. He established the initial terminology of and defined the scope of logic, physics, metaphysics, biology, psychology, linguistics, politics, ethics and economics. For all of those fields, the terms that he either invented or adopted have become the core of today's international technical vocabulary. Beside his systemic terminology for representing knowledge, Aristotle developed logic as a precise method for reasoning about knowledge. However, the study of logic became unfashionable, and being a logician was no longer a promising career path from a future pope. Besides the linear

notation for logic, researchers in artificial intelligence developed graphic notions called semantic networks. It was a small tree with Aristotle's categories arranged by *genus* (supertypes) and *Species* (subtype). The medieval logicians developed it into a more detailed hierarchy, which they called the *tree of porphyry*. Moreover, logic itself has no vocabulary for describing the thing that exists. Ontology fills that gap: it is the study of existence, of all the kinds of entities that make the world (F. Sowa, J., 2000).

Therefore, it requires to define and consider all of the notions of knowledge representation. So, it is started with the definition of knowledge and its components.

3.3 Knowledge in context

What is knowledge? This a question frequently asked of people in the fields of knowledge engineering (Schreiber, 2001). Knowledge engineering and systems analysis play the role of midwife in bringing knowledge forth and making it explicit (F. Sowa, J., 2000). *Data, information, and knowledge* are three often- encountered words that belong closely together, seem to have slightly different meanings, yet are often used interchangeability as synonyms, and thus lead to continuing confusion. Hence, a frequently asked question is what are the differences are between data, information and knowledge?

Data are the uninterested *signals* that reach our senses every minute. A red, green, or yellow light at an intersection is an example. Computers are full of data: signals consisting of strings of numbers, characters, and other symbols that are blindly and mechanically handled in large quantities.

Information is data equipped with meaning. For a human car driver, a red traffic light is not just a signal of some colored object, rather, it is interpreted as an indication to stop.

Knowledge is the whole body of data and information that people bring to bear to practical use in action, in order to carry out tasks and create new information. Knowledge adds to distinct aspects: first, a sense of purpose, since knowledge is the "intellectual machinery" used to achieve a goal; second, a generative capability, because one of the major functions of knowledge is to produce new information. It is not accidental, therefore, that knowledge is proclaimed to be a new "factor of production".

Table 3.1 summarizes the distinction usually made between data, information, and knowledge.

Table 3.1: Distinctions between data, information, and knowledge (Schreiber, 2001)

	characteristic	example
Data	Un-interpreted raw	— -- —
Information	Meaning attached to data	SOS
Knowledge	<ul style="list-style-type: none"> • attach purpose and competence to information • potential to generate action 	Emergency alert → start rescue operation

An important reason that the question, what is knowledge? is difficult to answer resides in the fact that knowledge very much depends on context. For example, one person's knowledge is another person's data. So, the borderlines between data, information and knowledge are not sharp, because they are relative with respect to the context of use. The observation concerning the context dependence of knowledge is found, in different terminology, across the different study of knowledge. In knowledge engineering, it has become standard to point out that knowledge is to a large extent task- and domain- specific. Knowledge engineering is traditionally concerned with the development of the information system in which knowledge and reasoning play pivotal roles (Schreiber, 2001).

Knowledge engineering has evolved from the late 1970s onward, from the art of building expert systems, knowledge-based systems, and knowledge-intensive information system. Knowledge systems are the single most important industrial and commercial offspring the discipline called artificial intelligence. Also, the use of a knowledge system has the top tree benefits for industries and business:

1. faster decision making
2. increased productivity
3. increased quality of decision- making

Thus, knowledge systems indeed appear to enhance organizational effectiveness. So, knowledge engineering helps, as a result, to build better knowledge systems: systems that are easier to use, have a well-structured architecture and are simple maintain (Schreiber, 2001).

3.4 Knowledge representation

Knowledge representation is a multidisciplinary subject that applies theories and techniques for three others fields:

1. *logic* provide the formal structure and rules of inference
2. *ontology* defines the kind of things that exist in the application domain
3. *Computation* supports the applications that distinguish knowledge representation from pure philosophy.

Without logic, knowledge representation is vague, with no criteria for determining whether statements are redundant or contradictory. Without ontology, the terms and symbols are ill-defined, confused, and confusing. In logic, the existential quantifier is a notation for asserting the something exists. But logic itself has no vocabulary for describing the things that exist. Ontology fills this gap: it is the study of existence, of all the kinds of entities that make up the world. Knowledge representation is the application of logic and ontology to the task of constructing a computable model for some domain (F. Sowa, J., 2000). There are many different ways to approach and study the area of knowledge representation. One might think in terms of a representation language like that of symbolic logic, and concentrate on how logic can be applied to problems in Artificial Intelligence. This has led to courses and research in what is sometimes called “logic-based Artificial Intelligence”. One definition of Artificial Intelligence (AI) is that it is the study of intelligent behavior achieved through computational means. Why is knowledge even relevant at all to AI systems? The first answer that comes to mind is that it is sometimes useful to describe the behavior of sufficiently complex systems (human or otherwise) using a vocabulary involving terms like “beliefs,” “goals,” “intentions,” “hopes,” and so on (Brachman et al., 1991). Identifying such vocabulary, generally requires careful analysis of the kinds of objects and relations that can exist in the domain. Also, the representation vocabulary provides a set of terms with which to describe the facts in some domain, while the body of knowledge using that vocabulary is a collection of facts about a domain (Chandrasekaran et al., 1999). To support the sharing and reuse of formally represented knowledge among AI systems, it is useful to define the common vocabulary in which shared knowledge is represented. A specification of a representational vocabulary for a shared domain of discourse — definitions of classes, relations, functions, and other objects — is called an ontology (Gruber, 1993). Moreover, semantic network in Artificial Intelligence is developed as a graphic notions and the first semantic network was a small tree with categories and their subtypes

(F. Sowa, J., 2000). In a different tendency, it is possible to study Knowledge Representation in terms of the specification and development of large knowledge-based systems (Brachman et al., 1991).

So, ontologies were developed in Artificial Intelligence to facilitate knowledge sharing and reuse. The reason ontologies are becoming so popular is in large part due to what they promise: a shared and common understanding of a domain that can be communicated between people and application systems (Fensel, 2001). A knowledge representation is a set of ontological commitment. For a knowledge base, ontology determines the categories of thing that exist or may exist in an application domain (F. Sowa, J., 2000).

Basically, the role of ontologies in the knowledge engineering process is to facilitate the construction of a domain model. An ontology provides a vocabulary of terms and relations with which to model the domain. Depending on how close the domain at hand is to the ontology, the support is different. However, the nature of an ontology prevents it from being directly applicable to particular domains (Studer et al., 1998). Ontologies are the key enabling technology for the semantic web. They need to interweave human understanding of symbols with their machine processability. Therefore, it seems highly justified to take a closer look at the nature of Ontologies and on whether and how they can actually provide such a service. The reason ontologies are becoming so popular is in large part due to what they promise: a shared and common understanding of a domain that can be communicated between people and application systems (Fensel, 2001).

Because ontologies aim at consensual domain knowledge their development requires a cooperative process. Ontologies are introduced to facilitate knowledge sharing and reuse between various agent, no matter whether they are of human or artificial nature. They should provide this service by providing a consensual and formal conceptualization of a certain area. Therefore, Ontologies glue together two essential aspects that help to bring the web to its full potential (Fensel, 2001):

- Ontologies define a *formal* semantics for information allowing information processing by a computer.
- Ontologies define a *real-world semantics* allowing to link machine processable content with meaning for humans based on *consensual* terminologies.

3.5 Ontology

Since the beginning of the nineties, ontologies have become a popular research topic investigated

by several Artificial Intelligence research communities, including knowledge engineering, natural language processing and knowledge representation. More recently, the notion of ontology is also becoming widespread in fields such as intelligent information integration, information retrieval on the Internet, and knowledge management. The reason for ontologies being so popular is in large part due to what they promise: a shared and common understanding of some domain that can be communicated across people and computers. The main motivation behind ontologies is that they allow for sharing and reuse of knowledge bodies in computational form (Studer et al., 1998). So, at the first step, it is considered the different definition of ontology.

To support the sharing and reuse of formally represented knowledge among AI systems, it is useful to define the common vocabulary in which shared knowledge is represented. A specification of a representational vocabulary for a shared domain of discourse — definitions of classes, relations, functions, and other objects — is called an ontology.

3.5.1 Philosophical definition of Ontology

Originally, the term ontology comes from philosophy- it goes as far back as Aristotle's attempt to classify the things in the world- where it is employed to describe the existence of being in the world (Studer et al., 1998). In philosophy, ontology is the study of the kinds of things that exist. It is often said that ontologies “carve the world at its joints.” (Chandrasekaran et al., 1999). In other words, it is the study of existence, of all the kinds of entities that make up the world (F. Sowa, J., 2000). Ontology is the science of what is, of the kinds and structures of objects, properties, events, processes and relations in every area of reality. ‘Ontology’ is often used by philosophers as a synonym of ‘metaphysics’ (a label meaning literally: ‘what comes after the Physics’), a term used by early students of Aristotle to refer to what Aristotle himself called ‘first philosophy’. Sometimes ‘ontology’ is used in a broader sense, to refer to the study of what might exist; ‘metaphysics’ is then used for the study of which of the various alternative possible ontologies is, in fact, true of reality. Also, Ontology can be expressed in three words: what is there? The answer is everything (Smith, 2003).

Ontology seeks to provide a definitive and exhaustive classification of entities in all spheres of being. The classification should be definitive in the sense that it can serve as an answer to such questions as what classes of entities are needed for a complete description and explanation of all the goings-on in the universe? Or: what classes of entities are needed to give an account of what

makes true all truths? It should be exhaustive in the sense that all types of entities should be included in the classification, including also the types of relations by which entities are tied together to form larger wholes (Smith, 2003).

Unlike the experimental sciences, which aim at discovering and modelling reality under a certain perspective, Ontology focuses on the nature and structure of things per se, independently of any further considerations, and even independently of their actual existence. For example, it makes perfect sense to study the Ontology of unicorns and other fictitious entities: although they do not have actual existence, their nature and structure can be described in terms of general categories and relations (Guarino et al., 2009).

3.5.2 Artificial intelligence's definition of Ontology

Artificial Intelligence (AI) deals with reasoning about models of the world. Therefore, it is not strange that AI researchers adopted the term ontology to describe what can be (computationally) represented the world in a program (Studer et al., 1998). For AI systems, what 'exists' is that which can be represented". The backbone of an ontology consists of a generalization/specialization hierarchy of concepts, i.e., a taxonomy. Also, many definitions of ontologies have been given in the last decade (Guarino et al., 2009).

In 1993, Gruber originally defined the notion of an ontology as an "explicit specification of a conceptualization" (Gruber, 1993). In 1997, Borst defined an ontology as a "formal specification of a shared conceptualization" (Borst, 1997). This definition additionally required that the conceptualization should express a shared view between several parties, a consensus rather than an individual view. Also, such conceptualization should be expressed in a (formal) machine-readable format (Guarino et al., 2009).

In 1998, Studer et al. merged these two definitions stating that (Studer et al., 1998):

An ontology is a formal, explicit specification of a shared conceptualization.

All these definitions were assuming an informal notion of "conceptualization,". In the following, it is focused on the three major aspects of the definition by Studer et al.:

- What is conceptualization?
- What is a proper formal, explicit specification?
- Why is the importance of 'shared'?

3.5.2.1 What is a conceptualization?

Gruber (1993) refers to the notion of a conceptualization according to Genesereth and Nilsson et al. (1987), who claim: “A body of formally represented knowledge is based on a conceptualization: the objects, concepts, and other entities that are assumed to exist in some area of interest and the relationships that hold among them. Conceptualization is an abstract, simplified view of the world that we wish to represent for some purpose. Every knowledge base, knowledge-based system, or knowledge-level agent is committed to some conceptualization, explicitly or implicitly.” Despite the complex mental nature of the notion of “conceptualization,” Genesereth and Nilsson choose to explain it by using a very simple mathematical representation: an extensional relational structure (Guarino et al., 2009).

Briefly, a ‘conceptualization’ refers to an abstract model of some phenomenon in the world by having identified the relevant concepts of that phenomenon (Studer et al., 1998).

3.5.2.2 What is a proper formal, explicit specification?

In practical applications, as well as in human communication, we need to use a language to refer to the elements of a conceptualization: for instance, to express the fact. How can we make sure that such symbols are interpreted according to the conceptualization? For instance, how can we make sure that, for somebody who does not understand English, cooperates-with is not interpreted as corresponding to our conceptualization of reports-to, and vice versa? Technically, the problem is that a logical signature can, of course, be interpreted in arbitrarily many different ways. Even if we fix a priori our interpretation domain (the domain of discourse) to be a subset of our cognitive domain, the possible interpretation functions mapping predicate symbols into proper subsets of the domain of discourse are still unconstrained. In other words, once we commit to a certain conceptualization, we have to make sure to only admit those models which are intended according to the conceptualization. For instance, the intended models of the cooperates-with predicate will be those such that the interpretation of the predicate returns one of the various possible extensions (one for each possible world) of the conceptual relation denoted by the predicate. The problem, however, is that, to specify what such possible extensions are, we need to explicitly specify our conceptualization, while conceptualizations are typically in the mind of people, i.e., implicit. Here emerges the role of ontologies as “explicit specifications of conceptualizations.” In principle, we can explicitly specify a conceptualization in two ways: extensionally and intentionally. In our

example, an extensional specification of our conceptualization would require listing the extensions of every (conceptual) relation for all possible worlds. However, this is impossible in most cases (e.g., if the universe of discourse or the set of possible worlds is infinite) or at least very impractical (Guarino et al., 2009).

Therefore, ‘Explicit’ means that the type of concepts used, and the constraints on their use are explicitly defined. For example, in medical domains, the concepts are diseases and symptoms, the relations between them are causal and a constraint is that a disease cannot cause itself. ‘Formal’ refers to the fact that the ontology should be machine-readable, which excludes natural language. ‘Shared’ reflects the notion that an ontology captures consensual knowledge, that is, it is not private to some individual, but accepted by a group (Studer et al., 1998).

3.5.2.3 Why the ‘shared’ is important?

A formal specification of a conceptualization does not need to be a specification of a shared conceptualization. As outlined above, the first definitions of “ontologies” did not consider the aspect of sharing and only later it was introduced by Borst in 1997. Indeed, one may correctly argue that it is not possible to share whole conceptualizations, which are private to the mind of the individual. What can be shared, are approximations of conceptualizations based on a limited set of examples and showing the actual circumstances where a certain conceptual relation holds (for instance, actual situations showing cases where the cooperates-with relationship occurs). Beyond mere examples, it is also possible to share meaning postulates, i.e., explicit formal constraints. Such definitions, however, presuppose a mutual agreement on the primitive terms used in these definitions. Since however meaning postulates cannot fully characterize the ontological commitment of primitive terms, one may recognize that sharing of conceptualizations is at best partial. For practical usage of ontologies, it turned out very quickly that without at least such minimal shared ontological commitment from ontology stakeholders, the benefits of having an ontology are limited. The reason is that an ontology formally specifies a domain structure under the limitation that its stakeholder understands the primitive terms in the appropriate way. In other words, the ontology may turn out useless if it is used in a way that runs counter to the shared ontological commitment. In conclusion, any ontology will always be less complete and less formal than it would be desirable in theory. This is why it is important, for those ontologies intended to support large-scale interoperability, to be well-founded, in the sense that the basic primitives they

are built on are sufficiently well-chosen and axiomatized to be generally understood (Guarino et al., 2009).

3.5.3 Why are ontologies important?

Almost all ontologies that are nowadays available are concerned with modelling static domain knowledge, as opposed to dynamic reasoning knowledge. In its strongest form, an ontology tries to capture universally valid knowledge, independent of its use, a view closely related to its philosophical origin. However, AI researchers quickly gave up this view, because it turned out that specific use of knowledge influenced its modelling and representation. Other researchers aim at capturing domain knowledge, independent of the task or method that might use the knowledge (Guarino, 1995).

Ontological analysis clarifies the structure of knowledge. Given a domain, its ontology forms the heart of any system of knowledge representation for that domain. Without ontologies or the conceptualizations that underlie knowledge, there cannot be a vocabulary for representing knowledge. Thus, the first step in devising an effective knowledge- representation system, and vocabulary, is to perform an effective ontological analysis of the field or domain. Weak analyses lead to incoherent knowledge bases. Moreover, ontologies enable knowledge sharing. Suppose we perform an analysis and arrive at a satisfactory set of conceptualizations, and their representative terms, for some area of knowledge. In order to build a knowledge representation language based on the analysis, we need to associate terms with the concepts and relations in the ontology and devise a syntax for encoding knowledge in terms of the concepts and relations. We can share this knowledge representation language with others who have similar needs for knowledge representation in that domain, thereby eliminating the need for replicating the knowledge-analysis process. Shared ontologies can thus form the basis for domain-specific knowledge-representation languages. Shared ontologies let us build specific knowledge bases that describe specific situations. For example, different electronic- devices manufacturers can use a common vocabulary and syntax to build catalogues that describe their products. Then the manufacturers could share the catalogues and use them in automated design systems. This kind of sharing vastly increases the potential for knowledge reuse (Chandrasekaran et al., 1999).

3.5.4 Types of ontologies

There are several types of ontologies, and each type fulfils a different role in the process of building a domain model. They all share- to some extent- the underlying idea of the most researchers agree that it is useful to distinguish between different generality levels of ontologies (Borst 1997, Van Heijst 1997):

- *Generic ontologies*: are valid across several domains. Generic ontologies are also referred to as *super theories* and as *core ontologies* (Van Heijst, 1997). It is related to the philosophical definition of entities and things (Guarino, 1995).
- *Domain ontologies*: capture the knowledge valid for a particular type of domain (e.g. electronic, medical, mechanic, digital domain) (Studer et al.,1998).
- *Application ontologies*: contain all the necessary knowledge for modelling a particular domain (usually a combination of domain and method ontologies) (Fensel, 2001).
- *Representational ontologies*: do not commit to any particular domain. Such ontologies provide representational entities without stating what should be represented. A well-known representational ontology is the *Frame Ontology* (Gruber, 1993), which defines concepts such as frames, slots and slot constraints allowing to express knowledge in an object-oriented or frame-based way.

The ontologies mentioned above all capture static knowledge in a problem-solving independent way. Knowledge Engineering, however, is also concerned with problem-solving knowledge, therefore another useful type of ontology are so-called *method* and *task ontologies*. Task and method ontologies provide a reasoning point of view on domain knowledge. In this way, these ontologies help to solve the ‘interaction problem’, which states that domain knowledge cannot be independently represented from how it will be used in problem solving, and vice versa. Method and task ontologies enable to make explicit the interaction between problem-solving and domain knowledge through assumptions (Studer et al.,1998).

3.6 Hypothesis and principles for structure of an ontology

The ontology is the heart of any knowledge description: knowledge is intimately related to the ontology since it is necessarily expressed in terms of ontology. Therefore, designing the ontology of a domain is a key issue for knowledge representation (Gruber, 1993).

In fact, we assume that ontology can facilitate territorial knowledge sharing and exchange in the various hierarchical level of industries to increase sustainable performances. So, a domain ontology provides the concept's structures and clarification that make explicit the important territorial notions for sustainability.

So, the hypothesis of this thesis can be expressed:

Territorial ontology can facilitate territorial knowledge sharing and justify the resources of territory for sustainable development objective of industries

So, modelling of the territorial ontology is considers. At the first step, it is important to understand the principles and method for modelling an ontology. So, the principles for structuring an 'ontology' is followed.

Designing an ontology corresponds to conceptual modelling, the categories of objects that reconsider the existences. These categories are structured by a subsumption's relation and constitute a taxonomic hierarchy (Bouaud et al., 1995). In the following part, the principles present for modelling and using an ontology in the context of knowledge-based systems.

3.6.1 Principles for modelling an ontology

When building knowledge-based systems, the most important point is to ensure that the formal exploitation of the knowledge representation conforms to its meaning in the domain. On the other hand, the issue of knowledge representation is designing of formal representation system for the cognitive aspect of knowledge (Bouaud et al., 1995). Moreover, designing an ontology corresponds to the conceptual modelling of categories of objects that are considered in a domain (Bachimont et al., 2002). An ontology is the result of modelling that focuses on the characterization of primitives for the formal representation of knowledge. So, these principles are:

3.6.1.1 Foundational issue of knowledge representation

Generally, Artificial Intelligence consists of the solving problem using of human knowledge that is usually expressed in natural language. Since there is no other operational expression of this knowledge, it needs to consider the semantic richness of language and its multiple potential interpretations. Knowledge of people about the object in a domain is mainly descriptive. It relies on the notion of the prototype; whose logical status is not clear enough to be usable. Knowledge

must be considered as an objective notion, shared by people. Basically, it is necessary to fix the meaning of terms. Knowledge will be adequately described if it is provided for explicitly rendering of its objective and shared aspect (Bouaud et al., 1995).

Briefly, in non-formal domains, there are not complete definitions for the categories of objects by descriptive knowledge. So, normalizing help the agreement of use of notions and it consists of an agreement on the meaning of domain notions by the manipulation of their explicit descriptions (Bouaud et al., 1995).

3.6.1.2 Normalizing by necessary conditions

A usual way of normalizing of the descriptive knowledge consists in stating the necessary relations between domain notions. The distinction between intension and extension is a necessary condition. The denotation of a type is its extension and objects characterized by the type. Basically, there is no explicit relation between the intension of a type, its meaning and its extension. Its extension is not a characterization of the type. Moreover, there is no means to yield the extension from intension in non-formal domains, although this is not the case in the artificial domain. Because of the lack of an explicit relation between the intentional definition of a type and its extension, it must be careful to not confuse the properties that characterize extensions with those that concern intensions. So, the normalizing condition makes an explicit distance between the intentional definition of a type and its extension (Bouaud et al., 1995).

3.6.1.3 Normalizing by necessary and sufficient conditions

Subsumption by the using of necessary conditions is the basis of all taxonomic organizations. The laws that rule intentional subsumption are compatible with the minimal logical interpretation of a taxonomic link in case of such a partial definition. Such, taxonomies, based on necessary conditions, are used for property inheritance. There is no equivalence between the type and its definition. Partial definitions are not enough to be sure that we talk about the same notions. It needs sufficient conditions in order to agree that a notion corresponds to the same knowledge.

Building taxonomies from the necessary condition cannot allow the classification. The differences between a type and its genus are only necessary conditions for building a taxonomy and sufficient conditions need to the notion corresponds to the same knowledge (Bouaud et al., 1995).

The knowledge normalization must be carried out in order to assign complete definitions of types. Also, normalizing by complete definitions is the essence of notions which are used their basic meaning (Bachimont, 2000).

3.6.1.4 Characterizing the essential properties

By assigning the complete definition to the notions, the aim is capturing the essence of notions and determining the essential properties. Capturing the essence of an object, typically, falls within the ontology. An ontology may be defined as the set of objects that exist in a domain (Bouaud et al., 1995). The essence of notions should be captured by assigning complete definitions of notions and their essential properties. So, building an ontology is to decide which object retain the studied domain. The notion of object is intentional and corresponds to the ontology of the domain. Thus, defining the types is by deciding the essential characteristics to build the ontology of the domain. Moreover, a careful distinction must be made between essential and incidental, non-essential and properties (Bachimont et al., 2002). The distinction is important to clarify what must be considered as the basic meaning of a type: its essence. Also, the properties must be clarified by intension of the existed object. The non-essential properties of types are not part of the ontology. Knowledge associated with them must be declared separately in a knowledge base (Bouaud et al., 1995).

3.6.1.5 Essence and taxonomy

Types are defined in terms of necessary and sufficient conditions when the normalization process is completed. An essence is unique, and a type has a unique definition. The notion has two essences that there are two different sets of necessary and sufficient conditions to determine it. Therefore, these two definitions determine two different notions. Types are defined by necessary and sufficient conditions that the relationships between types replicate the formal properties of subsumption hierarchically (Bouaud et al., 1995).

A type consists of its properties. Moreover, the meaning of properties must be understood through its positions in the ontology. So, the same property in different positions does not have the same meaning. This fact comes from the natural language in which concepts in an informal domain are expressed at the knowledge level: natural language semantics is not compositional (Bachimont et al., 2002).

So, respect to these rules, a taxonomic structure of an ontology, as a tree, composes. Each concept

in the taxonomy of ontology has the meaning and it can clarify the meaning of notions for the domain-specific application.

As mentioned, we assume that ontology can facilitate territorial knowledge sharing and exchange in the various hierarchical level of industries to increase sustainable performance. So, at the following chapter, modelling an ontology of territorial resources, in respect to the principles for modelling an ontology, is pursued.

3.7 Conclusion

In this chapter, a perspective study about the capture of knowledge and representation of knowledge is considered. At first, it is tried to consider knowledge in context. Then, the importance of knowledge representation is presented. It is found that ontology, as one the tools of knowledge representation, can share the common understanding of a domain that can be communicated between people and application systems. Therefore, it is focused on the ontology as a tool for representing territorial knowledge and sharing of this knowledge. Modelling a territorial ontology as hypothesis of this thesis can help to answer the research questions. So, in order to model a territorial ontology, the principles for modelling of ontology are followed. Therefore, in the following chapter, an ontology for territorial knowledge proposes.

Chapter 3: Knowledge representation	
Perspective study	Part 3.2: historical background of knowledge and representation
	Part 3.3
	Knowledge in context: What is the knowledge? Data, information and knowledge
	Part 3.4
	Knowledge representation <ul style="list-style-type: none"> • Knowledge representation is a multidisciplinary subject that applies theories and techniques for three other fields: logic, ontology computation. • A specification of a representational vocabulary for a shared domain of discourse — definitions of classes, relations, functions, and other objects — is called an ontology. • the role of ontologies in the knowledge engineering process is to facilitate the construction of a domain model.
	Part 3.5
	Ontology: <ul style="list-style-type: none"> • definition from philosophical point of view • definition in domain of artificial intelligence <ul style="list-style-type: none"> ○ An ontology is a formal, explicit specification of a shared conceptualization.
	Importance of ontology: <ul style="list-style-type: none"> • Ontological analysis clarifies the structure of knowledge • ontologies enable knowledge sharing • Shared ontologies can thus form the basis for domain-specific knowledge-representation languages. • The kind of sharing vastly increases the potential for knowledge reuse
	Types of ontology: <ul style="list-style-type: none"> • Generic ontology • Domain ontologies • Application ontology • Representational ontology
	Part 3.6
Hypothesis: Territorial ontology can facilitate territorial knowledge sharing and justify the resource of territory for sustainable development objective of Industries	
Principles for modelling an ontology: <ul style="list-style-type: none"> • Fundamental issues of knowledge representation • Normalizing by necessary conditions • Normalizing by necessary and sufficient conditions 	

	<ul style="list-style-type: none">• Characterizing the essential• Essence and taxonomy
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**4. DESCRIPTIVE ONTOLOGY FOR
TERRITORIAL KNOWLEDGE (DOTK)**

4.1 Introduction

This chapter aim is, modelling a territorial ontology in order to represent the territory's features for a possible concept for sustainability. This chapter starts with the methodology for modelling of territorial ontology and its implementation. According to the methodology in this research, the first step is creating a taxonomy of territorial knowledge which affects the sustainability within companies. So, the state of the art in this chapter is focused on the elements of territory that affect the sustainability within industrial companies. Therefore, a taxonomy with four main aspects of territory is proposed and other found elements are categorized as sub-elements of these four capitals. So, the taxonomy of territorial knowledge is proposed according to four categories of geographical, human, economic and political capital.

Then, consideration of general ontologies is investigated. General ontology can help the normalizing of elements of territorial taxonomy for modelling of ontology. After normalization, a Descriptive Ontology for Territorial Knowledge (DOTK) and its notions are presented.

In order to show the relationships between the concepts of DOTK ontology, a semantic graph is investigated. This graph is developed based on Text Mining and it is modelled by Voyant-tools. Voyant-tools is one of the free Text Mining software that is usable in the internet. Finally, the comparison between DOTK ontology with other ontology of sustainability and territory is illustrated. The goal of this comparison is to show the lack of concepts that have not considered in other researches.

4.2 Research approach and methodology

This chapter starts with the research clarification phase. During this step, an exploratory review of the literature is implemented to clarify the current understanding and expectations, by identifying the extent to which the problems are solved in practice and what still remains to be solved.

The next step is the literature review due to obtaining a sufficient understanding of the current situation. The result of this literature helped to identify the research problem and questions which mentioned in chapter 2.

Then, according to state of the art, ontology is identified as an important tool for knowledge representation. Studying this perspective study help us to identify the hypothesis of this research and principles for modelling an ontology (mentioned in chapter 3).

Initial steps of the methodology are inspired by principles of modelling an ontology as mentioned in section 3.6.1. These principles guide this research to define a methodology for modelling of territorial knowledge for sustainable objective within companies.

According to these principles, the first step of methodology for modelling a territorial ontology is a conceptual categorization of territorial knowledge. This categorization is done by searching the keywords such as territorial resource, territorial knowledge, sustainability and sustainable development within industries, sustainable strategy. This analysis helps us for extracting of intangible and tangible notions of territory for the sustainable objective in industrial companies. The result of this step was four main taxonomies of territorial knowledge and their sub-elements. Analysis of these categorizations as territorial knowledge and adapting with 5 dimensions of sustainability are human capital, geographical capital, economic capital and political capital. The taxonomies of domain concepts are key components of the building of ontology.

Normalizing by the generic (foundational) ontology is second step of methodology for modelling a territorial ontology. In this step different generic ontologies are considered. Finally, through the comparison of foundational ontologies, DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering) ontology is selected for normalizing of the element of territorial knowledge. Entities of DOLCE were adequate with elements of a territorial resources for normalizing that its detail explains in section 4.4.

Finally, specialization of conceptual taxonomy of territorial knowledge is made by the ontology of DOLCE. In fact, in this specialization, differentiate between the concepts of territory and their genus are normalized by DOLCE ontology. The result of this specialization is a Descriptive Ontology for Territorial Knowledge (DOTK). DOTK is an ontology of domain that shows the why reasoning and nature of territorial resources and can explicit the territorial knowledge for the hierarchical level of companies. Moreover, DOTK ontology helps the communication between actors of companies for integrating of sustainable development in their activities.

In summary, the methodology for modelling of territorial ontology can be explained in these steps:

1. Identification of conceptual categorization of territorial knowledge
2. Consideration of foundational ontology for normalization (principle base of ontology)
3. Specialization of top-level ontology (DOLCE) according to conceptual taxonomies of territorial knowledge for modelling an ontology in the domain of territory for sustainability.
4. Modelling of DOTK ontology

In the following sections, different steps of the methodology are explained in details with their logic and objectives.

4.3 Conceptual categorization of territorial knowledge

The territory is largely impacted by the activities of companies and the company can be largely impacted by its territory. So, it is needed to define the notions of the intangible and tangible resources of territory as territorial knowledge which supports the integration of sustainable development into companies. The territorial dimension should be taken into account, adapting global policy to local specificities to develop an appropriate solution for the industries (Moine, 2006). In the state of the art, is tried to find the territorial knowledge that influences the sustainable development within industrial companies. In order to describe territorial knowledge, it is required to justify the main elements of territorial knowledge and their sub-elements. These main elements should be defined by adapting with 5 dimensions of sustainability (figure 2.4). So, the main elements of territorial knowledge which are extracted from literatures, are: Human, geographical, economic and political capital which is adapted with 5 dimensions of sustainability (e.g. Nitschelmet al., 2016; Gobert and Allais, 2016; Allais et al., 2015; Zhang et al., 2013; Petty, R., 2000; Franzato et al, 2013). In fact, the high level of territorial knowledge selected according to 5 dimension of sustainability. As explained in this figure 2.4, 5 dimensions of sustainability exist in the territory that these dimensions cover the geographical system as action perimeter. Moreover, there are 4 cluster in the geographical system to describe the system under consideration. Also, a list of territorial element provided according to literature review and then four main elements are made by existing territorial element and 5 dimensions of sustainability.

Figure 4.1 shows the four main tangible and intangible resources of territory as territorial knowledge.

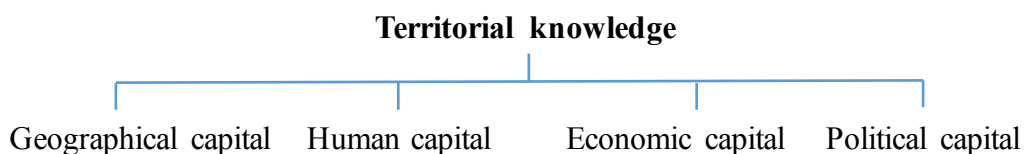


Figure 4.1: Tangible and intangible resource of territory, as territorial knowledge.

Human capital is valued as a key-value provider by integrating individual, social and organizational

capital as one of the main capitals of territory (Gobert and Allais, 2016). Organizational capital within the company ensures the efficient use of resources. Individual and social groups identify the interaction with their environment within a geographical system (Barreteau et al., 2016). Human activities occur in the geographical system that is managed by stakeholders (Nitschelm et al., 2016) and infrastructural capital in geographical system's use for specific projects and facilities to improve the productivity (Gobert and Allais., 2016). The management of geographical capital is made by political entities (Barreteau et al., 2016). Moreover, economic capital creates the value for human and industry through the product for human consumption and provide the resource for industrial activity (Nitschel at al, 2016).

In summary, it is tried to show the relationships between these four main elements of territorial knowledge. As it can be explained, there is a link between them and each element cover another element for sustainability. In the following sections, different elements of territorial knowledge are explained in details.

4.3.1 Economic capital

As mentioned, there is a mutual influence between the territory and the activities of companies. Moreover, intangible capitals of territory are disciplines that create the value and the structure and organization of the enterprise to support the integration of sustainable development (Allais et al., 2015). Also, the economic capital creates the value for human and industry through the product for human consumption and provide the resource for industrial activity (Nitschel at al, 2016). Value is defined as the relationship between the satisfaction of the need and the resources used to achieve this satisfaction (Habib et al., 2011). Moreover, the value is not absolute but relative and can be perceived differently by different parties involved who are in different situations. The standard differentiates the need for use (a function of the product measured by material indicators) and the need for consideration (subjective, measurable by intangible indicators) (Allais et al., 2015). Elhamdi (2005) broadens this definition by opening it up to the beneficiary parties and not just the consumers (Elhamdi, 2005) value-creating networks, focusing on stakeholders and the resources of the extended business and its territory. The value concerned is the value that is incorporated into the product/service by its design and by the network that has made that process of design possible (e.g. respect for ethical values, respect for the environment, identity-related aspects of the product) (Allais et al., 2012).

A differentiating factor for the future of the company is the reduction of physical and symbolic distance with its stakeholders, especially its customers. The sustainability of the company is supported by the proximity to the intangibles carried by brands (luxury, high-tech), culture (and culture Quicksilver slides). These values are built throughout the history of the company and can be intimately linked to the territory. In fact, the territory supports many interconnected value chains in a complex network that is combined in a "basket of goods" (Pecqueur, 2001).

The main challenge for a company's survival is to differentiate itself by demonstrating a set of alternative values to low cost. Economic models have evolved from the linear value creation chain (supplier-business-client) to network models, also referred to as "value constellation" models (Normann, & Ramirez, 1994). Evolution of economic models increases the complexity of a company's value creation network knowledge and its performance management. Moreover, territorial resources carry business and sustainable values but remain under-exploited by companies and strategic involvement and support is essential for their integration into companies (Allais et al, 2015).

Neely (2007) defined business performance as the process of value creation that satisfy stakeholders' needs and expectations even though these may not be of equal importance (Neely et al., 2007). In fact, Wheeler, Colbert and Freeman (2003) argue that a business model based on value creation is capable of accommodating the notion of corporate social responsibility, sustainability and stakeholder involvement at different levels within the business (i.e. strategic and managerial) (Wheeler et al., 2003).

The dominance of cost as a factor in decision making together with the globalization of markets has impelled businesses to relocate production to low-cost countries, sometimes to the detriment of quality and timing. The countries concerned have, however, responded to the challenge and are now able to offer products in line with the market's expectations (Allais et al., 2013).

Environmental and societal criteria are becoming factors creating value for businesses and one of the drivers of their current and future performance. Proximity as a component of the response to customer demand is becoming another important differentiator for business. Proximity as a response to the demand for a specific product may include mass customization, the proximity of brand values (e.g. protecting biodiversity, fair trade) or cultural proximity (e.g. tradition, ties to the territory) (Allais et al., 2015).

Strategic processes are creators of value and are intended to modify the way the business adapts

itself to its environment by exploiting resources which, in the right circumstances, have the potential to generate sustainable competitive advantage (Allais et al., 2012).

Even if economic growth is no longer a target of sustainability, the economic dimension has to be considered as a major lever for system change and the main incentive for sustainability transition in companies. In fact, companies integrate sustainability into their activities with a utilitarian perspective (Capron and Quairel, 2006). Sustainability creates a competitive advantage for proactive companies both from the possibility of being rewarded by the market and from avoiding risks (Holmberg and Robert, 2000). The economic community agrees, from 50 to 90% of the value of companies depends on intangible assets (i.e. brand, organization...) (Allais et al, 2015).

The 5 dimensions of sustainability, as well as current unsustainable paradigms, are elements of the socio-ecological system. The focus is put on the evolution of value creation factors to understand their dynamic using a historical and forecasting study on economic models.

The early **industrial economy** was based on mass production supported by the organization of work and the development of machine tools. Value is created for customers by the possession and the use of an artifact. Strategic positioning on the value chain and optimization of production costs create value for the industry. The **market economy** is based on mass consumption of goods. Customer value is created by the possession of a recognizable and rewarding object (**brand**). Business value is created by reducing the costs of production (**outsourcing** to low cost countries), the desirability of products (**marketing**) and the planned obsolescence of products (race for “**innovation**”). The **service economy** creates value by adding services to very low-cost products. Customer value is created by the multiplicity of services associated with low cost artifact. Business value is created by the proliferation of service offers and low production costs. The artifacts become secondary or even disappear in this economic model. The cell phone is a perfect illustration of the infinite addition of service to an artifact (Allais et al, 2017). The **functional economy** is a major change compared with previous models. The value no longer depends on possession of the product but on the satisfaction of a need. Value is created for the customer by providing a level of performance supported by a product-service. The physical support that enables the function remains the property of the seller. This change involves improving the durability of the object and can lead to a reduction of the ecological impact of mass consumption. There are plenty of examples in mobility services (shared bicycles or cars ...) (Bourg and Buclet, 2005). **The Quaternary economy** creates value for the customer by customizing the answer to his specific request. The

company creates value by a tailor-made arrangement of products and services as a response to customer expectations. The company is not necessarily the creator of these goods and services. **Customer satisfaction** is the main issue of this economic model (Debonneuil, 2007). The change of thinking caused by these new models of consumption (use rather than possession) and the development of communication networks allow the emergence of “**collaborative consumption**” (Botsman and Rogers, 2010). This model is based on the empowerment of the consumer, who is alternately seller or buyer and joins a community of interests: traveling, self-constructing, reusing, cooking, gardening etc. Through dedicated social networks, actors exchange intangible assets (i.e. knowledge, know-how, time, space, money). Transactions can be free (donations), based on barter (objects of the same value), and paid by non-monetary transaction (e.g. points system to acquire another property) or a monetary transaction. If there is a company, it creates value by networking sellers and buyers. The core values for this model are reputation and membership value (Allais et al, 2017).

Table 4.1 shows the value creation factors to understand their dynamic using and forecasting study on economic model.

These evolutions of economic models have had profound consequences on the methods of value creation of the company and its organization. We are particularly interested in intangible capital, an economic discipline based on this observation: “**finance** is not the source of wealth creation but it’s results and generate by operation and investments ” (Fustec et Al., 2011).

Table 4.1: Evolutionary perspective on economic models adapted from Habib (2012), Bourg and Buclet (2005), Botsman and Rogers (2010)

Economic Model	Value creation factors
Industrial	Production system optimization of cost
Market	Minimization of production costs for clients and company and marketing
Service	Combination of services with low cost goods
Functional	Satisfaction of a performance level thanks to the product/service couple
Quaternary	Customizing the response by an array of products, services
Collaborative	Services reciprocity, reputation social networking

Figure 4.2 shows the details of economic elements, as territorial knowledge, to create value for human and companies. Moreover, these intangible elements of economic capital can help the sustainable development of companies through the value creation for both companies and society in the territory.

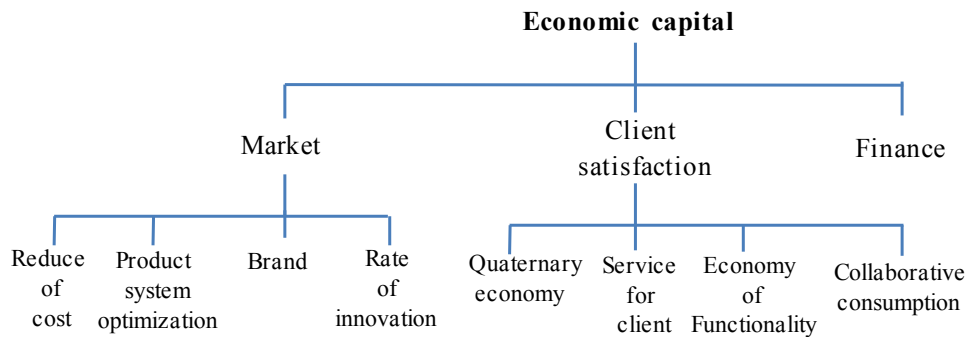


Figure 4.2: Economic capital to create value for human and companies.

The universality of these socio-ecological principles for sustainability is accepted. In order to give the political sphere precedence over the economy, Renault (2011) proposes the principle of the relocation of the economy that emerged from the shared observation of negative impacts of

globalization both on the economy of older industrialized countries and the environment of new industrial centers. This political principle aims at relocating both positive and negative externalities of the economic activities (i.e. local employment and wealth creation, ecological impacts but stricter environmental regulation). It may be applied equally to the political, territorial and company level. So, in the following section, the coordination between political, territorial and company spheres is investigated.

4.3.2 Political capital

As it is seen in Figuière and Rocca's definition of real sustainable development, the territory is a relevant perimeter for the implementation of public politic for sustainable development (Figuière and Rocca, 2008). The political dimension must return to its central place because it is the only legitimate for defining the orientations of development and the common good. The application of political decisions must be adapted to local specificities at the territorial level (Allais et al., 2015). At a political level, the main challenge is to prevent the company relocating and, in doing so destroying local employment and associated economic activities. Current policies tend to increase territorial competitiveness thanks to, for example, the creation of clusters or industrial ecology strategies. A cluster is a “geographic concentration of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g. universities, standards agencies, trade associations) in a particular field that compete but also cooperate”. Cluster policy can increase the competitiveness and this policy enables knowledge and skill exchanges between actors in a local network perspective. Industrial Ecology (IE) or Industrial and Territorial Ecology (ITE) are regional planning strategies that propose a systematic search for physical or organizational symbiosis at a local scale (e.g. port or industrial area) implementing both physical accounting and social research methods (Schiller et al., 2014).

Industrial Ecology (IE) can be defined as seeking synergies between stakeholders to reduce the environmental impacts of human activities on ecosystems (Buclet, 2011b). Industrial and Territorial Ecology (ITE) is a strategy of land management and planning to create economic, societal, social and environmental shared value for the stakeholders of a territory. ITE is a systemic approach that repositions mankind as an element of the biosphere and proposes making human actions compatible with biosphere capacities in a resource scarcity perspective (Buclet, 2011b). The underlying paradigm is that a society has to balance its needs regarding the availability of local

resources. IE and ITE provide innovative solutions to help managers reduce costs and add value to products while coupling territorial economic development and environmental constraints (Buclet, 2011b). Both these strategies aim at facilitating exchanges of tangible or intangible resources between actors of a local network in order to create value for both the companies and the territory (Allais et al, 2015) and these strategies can be implemented by political principles.

Moreover, as mentioned, the political principle aims at relocating both positive and negative externalities of the economic activities (i.e. local employment and wealth creation, ecological impacts but stricter environmental regulation). It may be applied equally to the political, territorial and company level. In order to facilitate coordination between political, territorial and company spheres, governance principles are added (Allais et al, 2017). **Corporate governance** is defined “as the full set of relationships between a company's management, its board and its stakeholders, including but not exclusively shareholders” in the “power to change” (Nelson et al., 2001). Also, this strengthening of a company's intangible assets is overlooked when only economic factors are discussed (Holmberg and Robert, 2000). The necessary coordination between these three organizational levels (political, territorial and company level) and individuals may be supported by the three principles for sustainable governance proposed by Buclet (2011b): **capability**, proximity and participatory **democracy**.

Participatory Democracy aims to build a balance between individual preferences and the common interest in meeting the challenges of sustainable development. This reconciles company and social expectations. This governance principle facilitates the influence principle.

Capability/empowerment aims to maintain and develop the capacity of organizations/individuals to meet their own expectations. This governance principle enables the competences principle achievement. Proximity aims to bring together the decision-making level and the level impacted by the decision. At an individual level, this proximity principle facilitates the influence principles. At a company level, it implies that a governance instance (e.g. board of directors, etc.) considers and integrates internal and external stakeholders in the decision process. Boschma (2004) defined 5 types of proximities: cognitive, organizational, social, institutional and geographical. When applied to business, the proximity principle also considers organizational proximity (e.g. cooperation within the value constellation, co-design of solutions, territorial interactions, etc.) and geographical proximity (e.g. local supply chain, local resource exploitation, local markets, etc.). Applied to the relation between customers and company, social proximity (e.g. tradition, ties to the

territory, protecting biodiversity, fair trade) may result in mass customization or a decentralized product lifecycle and become an economic advantage (Allais et al., 2015; Gobert and Allais, 2016; Tyl et al., 2015).

In the other words, the principle of governance such as **capability, democracy, council and administration** in different **scales (local, regional, national and international)** support the industrial organization for sustainable development. The elements of political capital that can help the sustainable development of companies are shown in figure 4.3 (Allais et al., 2015; Gobert and Allais, 2016; Tyl et al., 2015; Francesconi et al, 2015; Buclet, 2011; Pecqueur, 2006).

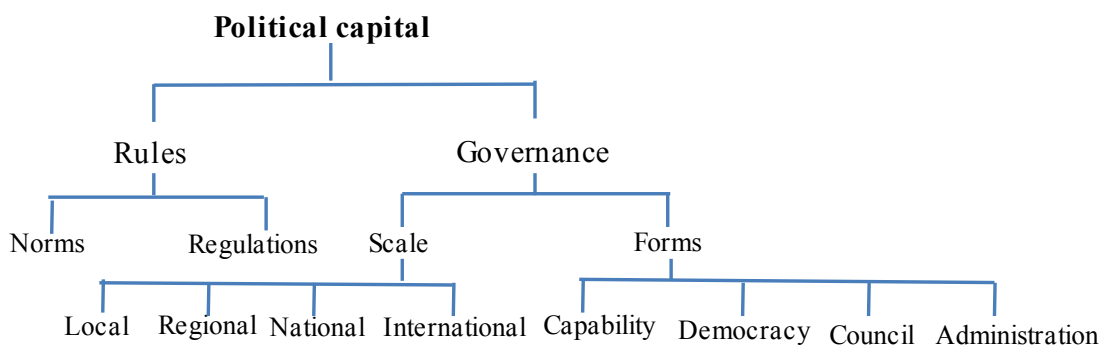


Figure 4.3: Political capitals that help the corporate governance.

In accordance with the 5D of sustainability’s definition, the economy, as a mean of transition, must be considered. A competitiveness principle is proposed at the micro-level (company) is proposed in addition to the previous principles for sustainability transition. It consists of the systematic adoption of intangible capital in both strategic and operational governance. In fact, intangible assets can be considered as strategic, and, with appropriate tools, can be analyzed and managed in the decision-making bodies. Consequently, governance tools and methods have to be adapted to the evolution of economic models (i.e. dematerialization of value creation factors; growing complexity and collaboration in value network); growing importance of stakeholders in business (value co-creation and value networking); growing demand for responsible solutions (i.e. eco, local, responsible products); expansion of the number of stakeholders (environmental and social)) (Allais et al., 2017). Moreover, Allais et al. (2017) show the integration of intangible capital of territorial knowledge, such as human (stakeholders) and ecological aspects into the strategic decision process of industrial organization at local scale. Strategic governance concerns decisions help to top managers and giving the value to the initiatives at the strategic level that come from the operational level (Allais et al., 2017). In other words, senior management improves their practices regarding to

the integration of intangible assets into strategic and operational governance and 5D-sustainability's integration within the company's value constellation.

4.3.3 Geographical capital

Geography is the base system including physical features of the earth, atmosphere, the population distribution, resources and political and economic activities (Dahlman et al., 2011). The **techno-sphere** system refers to the global technology systems integrating all **human activities** and the ecosphere system refers to the human-environmental system. Input flows that directly enter the techno-sphere directly come from the ecosphere (relating to natural resources), and all the output flows [which generally cause the environmental impacts (Kougoulis, 2009)] that directly exit the techno-sphere to the ecosphere all belong to a specific geography. The relation between geographical and environmental information is addressed by regionalisation of life cycle assessment (RLCA) as a solution to improve the accuracy of life cycle assessment, which is coupled with a geographical information system (GIS) (Vadoudi et al., 2017).

GIS, by accessing different sources of information (biological resources, pollution sources and affected areas, land cover and use, water availability and quality and energy sources and use), enables the use of a set of simple operations such as overlay, classification, interpolation and aggregation of spatial information (Rodríguez et al., 2014) to generate useful information for decision-makers in support of sustainability (Vadoudi et al., 2017).

As mentioned, **ecosphere** refers to the human-environmental systems. So, **environmental geography** is the interaction of humanity and the environment (Vadoudi et al., 2017) and define as space for the **circulation flow** (Cerceanu et al., 2018). Moreover, industrial and territorial ecology is the strategy of natural resource management and planning to create the economic, social and environmental value for stakeholders of geography toward sustainability. So in this regard, coordination between actors can help to the implementation of this synergy (Buclet, 2011b).

Natural resources as the main element of geography are used to describe all of the input flow from ecosphere that enter to the techno-sphere (Zhang et al., 2015, Vadoudi et al., 2017).

Substance-flows are a key factor to assess the resource consumption and environmental impacts. Moreover, substance-flows can flow within the techno-sphere, and between techno-sphere and ecosphere and their environmental impact should be considered by industrial companies through the product life cycle in the geographical system. In other words, substance-flows link the **product**

with the territory.

Elementary flows, product flows and waste flow as subparts of substance flows have the environmental impact within ecosphere and techno-sphere (Zhang et al, 2015).

Elementary flows are the foundation for calculating environmental impacts of a product life cycle, which can be classified into two subclasses: resources class and emissions class.

- **Resources class** is used to describe all of the input flows that enter the techno-sphere directly from the ecosphere, which relate to natural resources, such as crude oils, ores, and water.
- **Emissions class** is used to describe all the output flows that exit the techno-sphere directly to the ecosphere, which generally causes environmental impacts. The emissions class itself has three subclasses: Emissions air class, Emissions soil class, and Emissions water class.

The **product flows** class is used to describe all the valuable output substances produced from a process. According to the process producing product flows, the product flows can be classified into five subclasses: Part class, Assembly class, Energy Product class, and Material Product class.

- **Energy product** class is used to describe all of the product flows that come from the energy processes which consume natural energy resources. According to the properties of resources, the energy product class itself also derives subclasses: **Electricity** class, **Fuel** class, **Mechanical** energy class, etc.
- **Material product** class is used to describe all of the product flows that come from the material processes which consume natural material resources, such as **ores**, **forest**.
- A **functional product** is usually an assembly that consists of multiple parts. The **Assembly** class is used to describe the product flows with assembly structure.
- **Part class** is used to describe the product flows of all the single part that is made of engineering materials within the techno-sphere. Part class can further derive the recycling part class, reuse a part class, etc.

Waste Flow class is used to describe all undesired substances produced from a **process**. The waste flow class further derives two subclasses: **waste product** class and **waste class**. In general, the waste products are not directly discharged to the environment but enter into the disposal phase. In the disposal phase, the waste products are disassembled and are screened. As a result, some waste products are converted into new product flows such as reuse parts and recycled materials; some are converted into wastes and then enter waste treatment processes such as incinerator, landfill, and

some are directly discharged into the environment (Zhang et al, 2015).

Moreover, the **infrastructure** sector supports vital activity in the territory and comprises the entities and services responsible. Also, infrastructures act as fundamental facilities to improve the productivity of existing resources. (Ivanov et al., 2016). **Technology** as one of the subclasses of infrastructure that increase productivity and great flexibility with **supplier** and **customers**. In addition, the environmental impact of a product can be abstracted as four types: **production phase**, **transport phase**, use phase and disposal phase by human or industry (Gobert and Allais, 2017; Francesconi, 2015; Parente et al, 2015; Franzato et al., 2013). Figure 4.4 demonstrates the elements of geographical capital as tree flowchart.

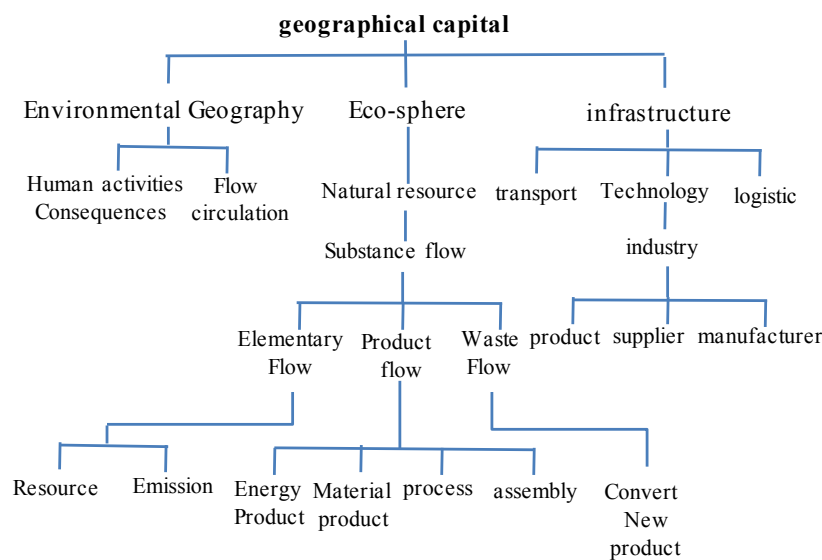


Figure 4.4: Elements of geographical capital as territorial knowledge.

4.3.4 Human capital

Human capital is as the first driver of growth of a geographical area in the territory (Jordao et al., 2017) and elements of human capital help the hierarchical level of companies to create the **value** for stakeholders (individual and social) through the management of human capital. Moreover, human activities occur in the geographical system that is managed by stakeholders (Nitschelm et al., 2016). **Individual**, **social** and **organization** are the main territorial knowledge of human capital which help the hierarchical levels of companies and territory (Gobert and Allais, 2016; Barreteau 2016; Parente, et al, 2015; Francesconi, 2015; Allias et al., 2013; Fustec et Al., 2011; Krucken 2008; Pecqueur 2006; Petty 2000).

Individuals and **groups** place on their connections understand and relationships between societies and their environment. In fact, it is the interaction of individuals and groups with their environment and geography (Barreteau 2016). The organization has the ability to affect the decision or activity of individuals or organization (Allais et al., 2013). Organization in the company ensures the efficient use of productive resources (human or IT) (Fustec et al., 2011).

Intellectual capital (IC) as a cluster of individual, is used to create and use **knowledge** to enhance the industrial value (petty et al., 2000). This knowledge founded in the organization that add value to the products/ services through the application of intelligence to the industry (Jordao et al., 2017). This knowledge emerges from interactions with other individuals which can enable individuals to become aware of the resources present on an area and of the way of exploiting them (Gobert and Allais, 2017). IC links to the **knowledge management** in the organization of the company through the knowledge, **competencies** to improve the organization process and ability to innovate. **Sharing of knowledge** in network help to the **learning** process within companies and between them (Jordao et al., 2017).

Increasing the body of knowledge relating to the links between value-creating processes inside the business (e.g. HR, logistics) help to the industry and increase the knowledge of decision makers (Allais et al., 2013). In other words, **human resources** are evaluated as the main provider of value (work). The managers on the one hand (competent, strategist, leader ...) and employees (serene, committed, stable ...). This evaluation gives a prominent place to the company's human resources department with a focus on the forward-looking management of resources and **skills** (Fustec et al., 2011). Moreover, a combination of knowledge and competencies influence the organizational selection of environmental strategies on sustainability efforts and a relentless search for a greener business model (Rousseau, 2017). Also, **innovation** as a skill of intellectual capital not sufficiently valued in the strategic level because don't inform the strategic decision making that must be considered through knowledge management and governance in the company (Allais et al., 2017, Jordao et al., 2017).

Individual and groups as a stakeholder can affect or affected by the organization and they need in the strategic help to sustainability in different company's level such as product designer, environmental engineer, supplier, etc., and their expectation should take into account in decision making. So, some of the **behavior** and values the organization, such as change of mind and evolution of company culture, must be recognized. Changes should be anchored in the **culture** to

deploy a sustainable strategy. Middle manager have the most important role in the culture of the organization to speared sustainability by managing people to influence their behavior (Zhang et al., 2013).

Identification of the organizational filed should be taken into account to create the commitment to the desired change for sustainability. **Sharing of value** for customers is created by the network that supports the design activity (e.g. local sourcing, identity-related aspects of the product/service) (Allais et al., 2015). Creating of multi-value for stakeholders analyze by the management of corporate human resource and knowledge to help to the strategic goals (Petty et al., 2000, Zhang et al., 2013). In addition, **Exchange of information** between actors of networks is necessary for **communicating** with internal and external actors to optimize the circulation of decision and data flow in the different level of industry. The industrial organization has emphasized that when decision making and information are not equally shared, different activities become unbalanced in the company and stop allocating and distributing resources efficiently (Rio et al, 2013). Another main important element for the company is **geographical information system(GIS)** which can help product designers to analyze the environmental impacts before and after design, which change design characteristics and product specifications based on the environmental status of each geography (Vadoudi et al., 2017).

Moreover, the process of the organization and **coordination** of actors improve territorial cohesion at different levels and support the different structure of territorial knowledge (Toth et al, 2015).

Details of human capital can be seen in figure 4.4 as tree flowchart.

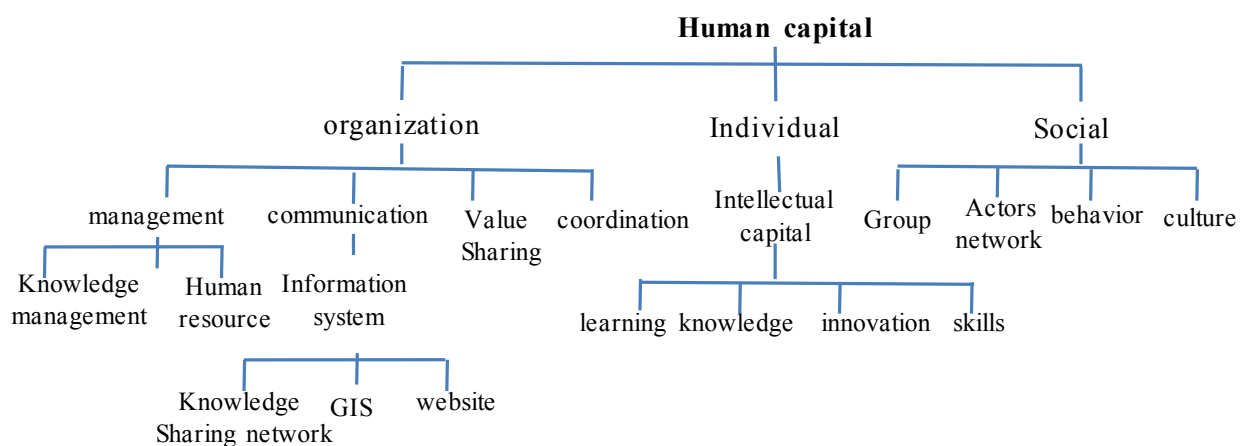


Figure 4.5: Details of elements of human capital capital as territorial knowledge.

4.4 Foundational ontology for normalizing of conceptual categorization of territorial knowledge

The first step for modelling of territorial ontology is the identification of conceptual categorization of territorial knowledge which is presented in the previous section (section 4.3). The aim of categorization is identifying the elements of territory which help the sustainable development of companies according to 5 dimensions of sustainability. Figure 4.6 shows all of the elements of territorial knowledge for modelling an ontology.

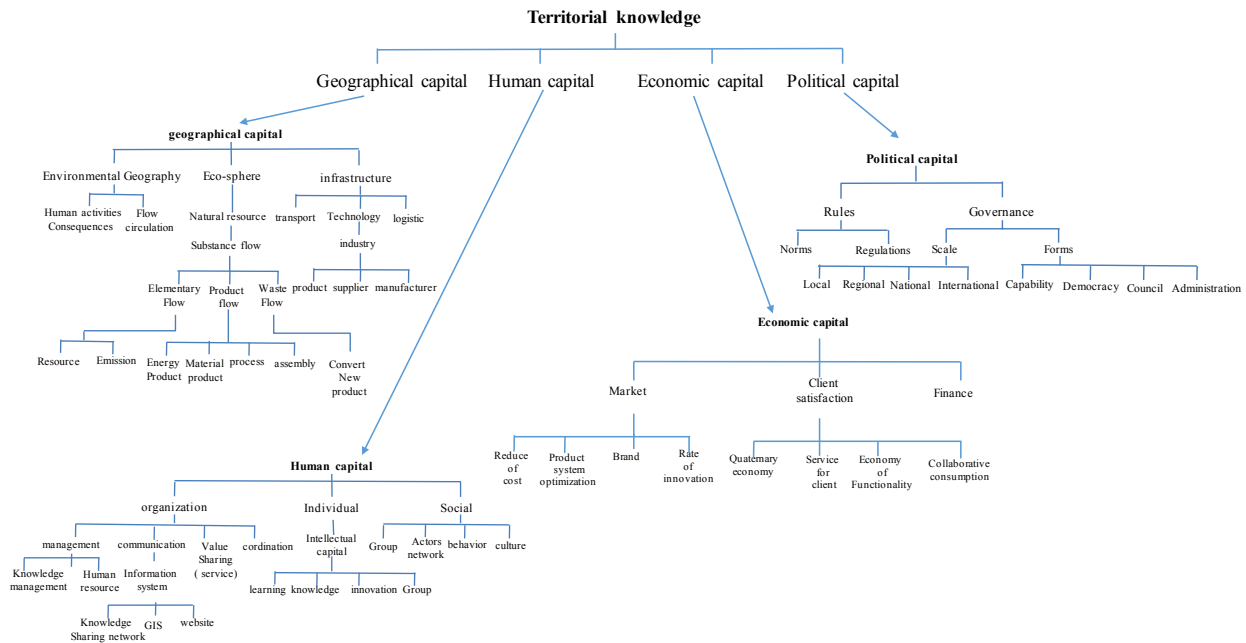


Figure 4.6: Conceptual categorization of elements of territorial knowledge.

So, it is needed to normalize these elements for modelling a territorial ontology. Also, normalizing by complete definitions is the essence of notions which are used their basic meaning. So, foundational ontologies can help the normalization of these elements. As mentioned, generic ontologies: are valid across several domains. Foundational ontologies are also referred to as super theories and as core ontologies (Van Heijst, 1997) and provide conceptualizations of general notions, such as time, space, events and processes (Oberle et al., 2006). In fact, foundational ontologies can act as a reference for agents to commit to certain theories, as a set of formal guidelines for domain modelling, and as a tool for making heterogeneous ontologies interoperate or merge (Gangemi et al., 2003).

Foundational ontologies 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 and richly axiomatized (Borgo and Masolo, 2009). Moreover, foundation ontologies focus on concepts (like the concepts of object, event, quality, role) and relations (like constituency, participation, dependence), that are not specific to particular domains but can be suitably refined to match application requirements. It provides a starting point for building new ontologies and supply a reference point for rigorous comparison among different possible ontological approaches (Oberle, et al., 2006). In addition, foundational ontologies are used in applications only in approximated forms via partial translations into the different application-oriented languages. Thus, the relevance of foundational ontologies does not rely in their direct impact on applications but in their ability to providing conceptual handles with which to carry out a coherent and structured analysis of the domains of interest (Borgo and Masolo, 2009).

So, in the following sub-section, types of foundational ontologies are investigated. The aim at this step is, selecting of foundational ontology which is adapted with the essence of elements of territorial knowledge for normalizing.

4.4.1 Types of foundational ontologies

Foundational (Upper) Ontologies are quickly becoming a key technology for integrating heterogeneous knowledge coming from different sources. Moreover, there are different types of foundational ontology, namely BFO, Cyc, DOLCE, GFO, PROTON, Sowa's ontology, and SUMO, that are based on how much, to the best of our knowledge, they are visible and used inside the research community (Mascardi et al., 2007). DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering) and SUMO (Suggested Upper Merged Ontology) are the most prominent and advanced example of foundational ontologies (Eisemann, 2009). Moreover, DOLCE and SUMO are in the categories as a resource for designing knowledge system belong ontologies and formal description of the structure of knowledge bases (Schreiber, 2008). Therefore, in this research, it is focused on two foundational ontologies of DOLCE and SUMO. The aim is their comparison and selecting one of them for normalizing of territorial knowledge.

4.4.1.1 DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering)

DOLCE is the first module of a library of foundational ontologies and idea is to make the rationales and alternatives underlying such choices as explicit as possible, as a result of careful isolation of the fundamental ontological options and their formal relationships. This ontology has a cognitive bias and aims to capture ontological categories underlying natural language and common sense. As reflected by its acronym, DOLCE has a clear cognitive bias, in the sense that it aims at capturing the ontological categories underlying natural language and human commonsense (Gangemi et al., 2003).

It is intended to act as a starting point for comparing and elucidating the relationships with other ontologies of the library and also for clarifying the hidden assumptions underlying existing ontologies or linguistic resources (Oberle et al., 2006).

According to DOLCE, different entities can be co-located in the same space-time. DOLCE is described as an “ontology of particulars”, rather than an ontology of universals or properties (Mascardi et al, 2007). Particulars are entities which have no instances; universals are entities that do have instances. Properties and relations (corresponding to predicates in a logical language) are usually considered as universals. We take the ontology of universals as formally separated from that of particulars. Of course, universals do appear in an ontology of particulars, insofar they are used to organize and characterize them: simply, since they are not in the domain of discourse, they are not themselves subject to being organized and characterized (Gangemi et al., 2003).

DOLCE is based on a fundamental distinction between enduring and perduring entities and abstract. The difference between enduring and perduring entities is related to their behavior in time. Endurants are wholly present (i.e., all their proper parts are present) at any time they are present. Perdurants, on the other hand, just extend in time by accumulating different temporal parts, so that, at any time they are present, they are only partially present, in the sense that some of their proper temporal parts (e.g., their previous or future phases) may be not present. 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. In other word, perdurants are extended in time such as event and process. The main relation between endurants and perdurants is that of participation: an endurant “lives” in time by participating in a perdurant. For example, a person, which is endurant, may participate in a discussion, which is a perdurant. A person’s life is also a perdurant, in which a person participates

throughout its all duration (Gangemi et al., 2003).

Briefly, the distinction between endurant and perdurant, as top-level classes of DOLCE, can be summarized:

Endurants (also referred to as continuants)

- Are wholly present at any time at which they exist
- Can change in time
- E.g. physical objects

Perdurants (or occurrents, occurrence)

- Are extended in time
- Only partially present at any time at which they exist
- E.g. events and processes

Endurants and perdurants are related by participation:

- An endurant ‘lives’ by participating in a perdurant, e.g. a person participates in a discussion, a violinist performs in a concert

Abstract, also, is one of the main entities of DOLCE ontology. The most common definition of abstracts is that these are entities that exist neither in space nor in time (Eisemann, 2009). Abstract includes both object-level concepts, such as set, time, and space, and meta-level concepts such as attribute and relation. From the corresponding gloss, abstract “is a general concept formed by extracting common features from specific examples”. Moreover, it is quite natural to consider attributes and relations as meta-level concepts, while set, time, and space, seem to belong to the object domain (Gangemi et al., 2003). Abstracts do not have spatial or temporal qualities and they are not qualities themselves. An example is regions used to encode the measurement of qualities as conventionalized in some metric or conceptual space (Oberle et al., 2006).

The taxonomy of the most basic categories of particulars assumed in DOLCE is depicted in Figure 4.7.

The taxonomy of the most basic categories of particulars assumed in DOLCE includes, for example, abstract quality, abstract region, agentive physical object, amount of matter, non-agentive physical object, physical quality, physical region, process, temporal quality, temporal region (Mascardi et al, 2007). So, it is very important to understand the concept of these entities for normalizing. Therefore, there are explained in detail in below:

Qualities and quality regions: qualities can be seen as the basic entities we can perceive or

measure: shapes, colors, sizes, sounds, smells, as well as masses, lengths, electrical charges... The term ‘Quality’ is often used as a synonym of ‘property’, but this is not the case in DOLCE: qualities are particulars, properties are universals. Qualities *inhere* to entities: every entity (including qualities themselves) comes with certain qualities, which exist exactly as long as the entity exists. Within a certain ontology, we assume that these qualities belong to a finite set of *quality types* (like color, size, smell, etc.), and are characteristic for (*inhere in*) specific individuals: no two particulars can have the same quality, and each quality is *specifically constantly dependent* on the entity it inheres in: at any time, a quality can’t be present unless the entity it inheres in is also present (Gangami et al, 2003).

Substantials: roughly, it sees substantials as stable aggregates of qualities: they are endurants that can have qualities but are not themselves qualities. It is distinguished between *physical* and *non-physical substantials*, according to whether they have direct spatial qualities. Within physical substantials, it is distinguished between *aggregates*, *objects*, and *features* (Gangami et al, 2003).

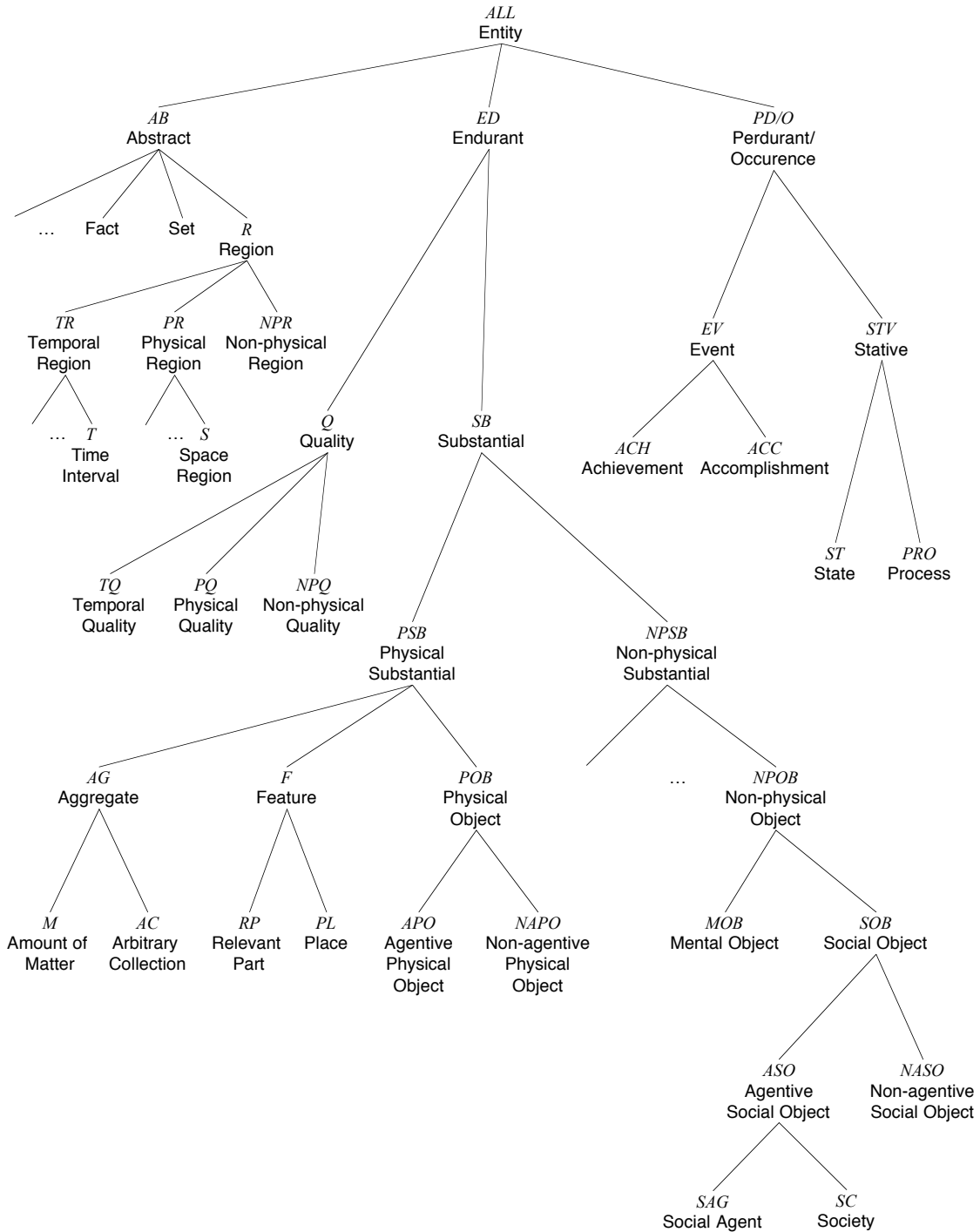


Figure 4.7: Taxonomy of DOLCE basic categories (Gangemi et al., 2003).

Aggregates: it is considering two kinds of aggregates: amounts of matter (example: some air) and arbitrary collections (example: my foot+ my car) (Gangami et al, 2003).

Objects: are endurants with unity, different types of object have different unity criteria. Objects

can change their parts over time (they can have temporary parts). Objects do not depend on other objects for their existence (Borgo and Masolo, 2009).

Feature: typical examples of features are “parasitic entities” which are specifically constantly dependent on physical objects. On the other words, Features are dependent on other entities for their existence (Borgo and Masolo, 2009).

Non-physical substantials and the agentive/non-agentive distinction: physical objects that have intentionality are called Agentive, those which do not are called Non-agentive. In general, the former is constituted by the latter: human persons are constituted by organisms, robots are constituted by types of machinery, and so on (Masolo et al., 2002). Among non-agentive physical objects, we have ordinary objects like houses, organs, pieces of wood, etc. Non-physical Objects are divided into Mental and Social according to whether they are “produced” by a single agent or recognized by a community of agents. In the first case, we say that mental objects (like an idea) are specifically dependent on agentive physical objects, while in the second case we need to further distinguish between Agentive and Non-agentive social objects (Gangami et al, 2003).

4.4.1.2 SUMO (Suggested Upper Merged Ontology)

Concepts in SUMO are organized into a single hierarchy rooted at the entity, representing the most general concept. The first two levels of the hierarchy are depicted in Figure 4.8.

It can be seen that entities are divided into physically existent stuff (Physical), and abstract, mentally represented stuff (Abstract). Physical things are further distinguished as objects and processes, etc. (Sevcenko, 2003). Abstracts are entities that exist neither in time nor in space (Eisemann, 2009).

Subclasses of a class are usually mutually exclusive, i.e. they do not share common instances. For example, nothing can be both an abstract and a physical, neither both an object and a process. This property is explicitly specified in SUMO. However, some classes can have multiple super-classes. For example, a Human is both Hominid (a member of a certain class of animals) and a Cognitive Agent (an entity with the ability to reason) (Sevcenko, 2003).

Physical entities are further divided into Objects and Processes. Other general topics, which are not shown in figure 4.8, include: structural concepts (instance, sub-concept), general types of objects and processes, abstractions (including set theory, attributes, and relations, number, measures, temporal concepts, such as duration and parts and wholes) (Oberle et al., 2006).

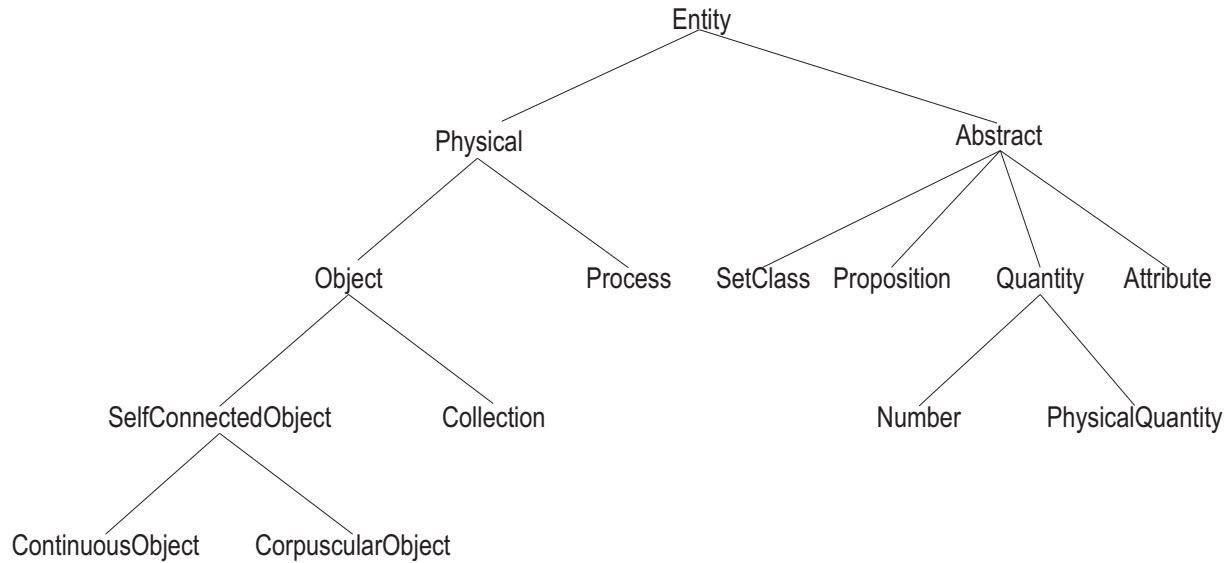


Figure 4.8: Taxonomy of SUMO basic categories (Oberle et al., 2006).

4.4.1.3 Comparison between DOLCE and SUMO ontology

Foundational ontology such as DOLCE and SUMO are quickly becoming a key technology for integration heterogeneous knowledge coming from different sources. It needs to choose one of these ontologies for normalizing of conceptual categorization of territorial knowledge. DOLCE has a similar purpose and business process to SUMO in that it is a free research project in inference but DOLCE is methodologically and fundamentally conceptualist (Mascardi et al, 2007) and it allows to different entities to be co-located in the same space-time (Eisemann, 2009) while SUMO is its relatively low coverage that does not allow for open-domain applications. It also lacks a connection between its concepts (Sevcenko, 2003). Moreover, DOLCE use the simplest quantified model logic and it is modelled very carefully according to a certain world- view and it serves as a foundation for a driver range of ontologies in different subject areas (Eisemann, 2009).

Another fundamental ontological distinction can be drawn between a 3D and 4D view of the world. When adopting the 3D view, objects are claimed to extend in three-dimensional space and to be wholly present at each instant of their being. From a 4D point of view, objects are extended into space and time, and only partially present at each instant (Eisemann, 2009). Put simply, endurants correspond to 3D objects and perdurants correspond to 4D objects (Niles & Pease, 2001). Table 4.2 shows the comparison between SUMO and DOLCE ontological choices.

Table 4.2: Comparison of SUMO and DOLCE ontological choices (Eisemann, 2009).

	SUMO	DOLCE
descriptive / revisionist	unclear (tends towards descriptism)	descriptive
reductionist / multiplicative	unclear (tends towards multiplicativism)	multiplicative
actualism / possibilism	unclear (tends towards actualism)	possibilism
universals included?	yes	only particulars
endurantism (3D) / perdurantism (4D)	3D	3D / 4D

As can be seen in table 4.2, DOLCE has clear typical ontological choices in comparison with SUMO. For example, descriptive vs. revisionist impose that only entities extended in space and time exist and it is clear property in DOLCE while this trend is not clear in SUMO. Also, a multiplicative vs. reduction that allow different entities to be co-localized in the same space-time and using a modal logic coincides with possibilism vs. Actualism.

Multiplicative vs. reductionist A multiplicative ontology aims at giving a reliable account of reality as it allows different entities to be co-localized in the same space-time. These co-localized entities are assumed to be different because they have incompatible essential properties. A reductionist ontology postulates that each space-time location contains at most one object: incompatible essential properties are regarded as being linked to different points of view from which one can look at the same spatiotemporal entity.

Possibilism vs. Actualism the fundamental thesis of actualism is: “Everything that exists is actual.” Possibilism is the denial of this thesis and there are various forms of possibilism that correspond to the various ways in which one can deny this thesis. Many of our reflective and creative thoughts seem to be about possibilities and much of our logical reasoning involves drawing conclusions which, in some sense, necessarily follow from premises that we already believe. When committing to possibilism, we are able to represent possibilism, i.e., possible entities, in our domain (Oberle et al., 2006). Table 4.3 summarizes the differences between different ontology orientation.

Thus, it can be understood from these comparisons that DOLCE ontology is adapted with elements of territorial knowledge. Particularly, there are so many physical and non-physical elements in the conceptual categorization of territorial knowledge which are compatible with endurants (3-Dimensions) and perdurants (4-Dimensions) in DOLCE ontology. So, DOLCE can help the

normalization of elements of territorial knowledge. In this way, it is possible to specialize in the position of each element according to its essence and meaning. Finally, a territorial ontology as an ontology of domain is modelled that is explained about its detail in the following section. This ontology is named: Descriptive Ontology for Territorial Knowledge (DOTK).

Table 4.3: summary of ontology orientation (Magee, 2011).

Ontology	Orientation
<i>BFO</i>	Minimalist; supports mutually exclusive 3D/4D physical perspectives; continuant/occurrent distinction fundamental; scientific naturalist epistemology
<i>DOLCE</i>	Constructivist; scientific; theoretical; functional/attributional
<i>GFO</i>	Naturalist epistemology; uses scientific over 'folk' terms
<i>PROTON</i>	Focus on commercial/industrial terms; pragmatic
<i>SUMO</i>	Intentional; constructivist epistemology; pragmatic

4.5 Descriptive Ontology for Territorial Knowledge (DOTK)

As mentioned, DOLCE ontology can help the normalizing of the elements of conceptual categorization of territorial knowledge for specializing of them according to their essence and meaning. Descriptive Ontology for Territorial Knowledge (DOTK) is come out of this specialization. DOTK clarify the “nature” and “why reasoning” of elements of territorial knowledge.

In this step for modelling of DOTK ontology, the elements of conceptual categorization of territorial knowledge are normalized by meaning of abstract, endurant and perdurant and their sub-notions. The differences between these notions and their genus are only necessary conditions for building a taxonomy of ontology.

The essence of notions should be captured by assigning complete definitions of notions and their essential properties. So, building an ontology is to decide which object retain the studied domain. Moreover, the notion of the object corresponds to the ontology of the domain. Thus, defining of sub-notions by deciding the essential characteristics build the ontology of the domain. Each sub-notion consists of its properties. Moreover, the notion of the object corresponds to the ontology of the domain. Thus, defining of sub-notions by deciding the essential characteristics build the ontology of the domain. Each sub-notion consists of its properties. Moreover, the meaning of

properties must be understood through its positions in the ontology. In other words, there is the complete definition for notions of abstracts, endurant and perdurant and their essential properties as defined in section 4.4.1.1(Ontology DOLCE). So, foundational ontology of DOLCE is selected which is adapted with the essence of elements of territorial knowledge for normalizing.

Approach of normalizing is according to concept of entities of DOLCE which explained in details in section 4.4.1.1. Therefore, the elements of territorial taxonomy positioned at DOLCE ontology according to their meaning to build DOTK ontology. In other words, meaning of elements of territorial taxonomy adjust with the essence and concepts of entities of DOLCE ontology. Therefore, according to definitions of these notions, the elements of territorial knowledge are normalized to construct DOTK ontology as an ontology of domain. Figure 4.9 shows the class hierarchy of DOTK ontology that is done by protégé³.

In fact, DOTK makes explicit territorial knowledge for the hierarchical level of the company and can help them about the common understanding of different notions. In other words, it can help the communication between different actors with different vision about sustainable development. So, the hierarchical level of the company has a common understanding of the different concepts of territorial knowledge that aid them to use this knowledge in these activities and the implementation of sustainability.

³ Protégé is a free, open source ontology editor and a knowledge management system.
<https://protege.stanford.edu/products.php>

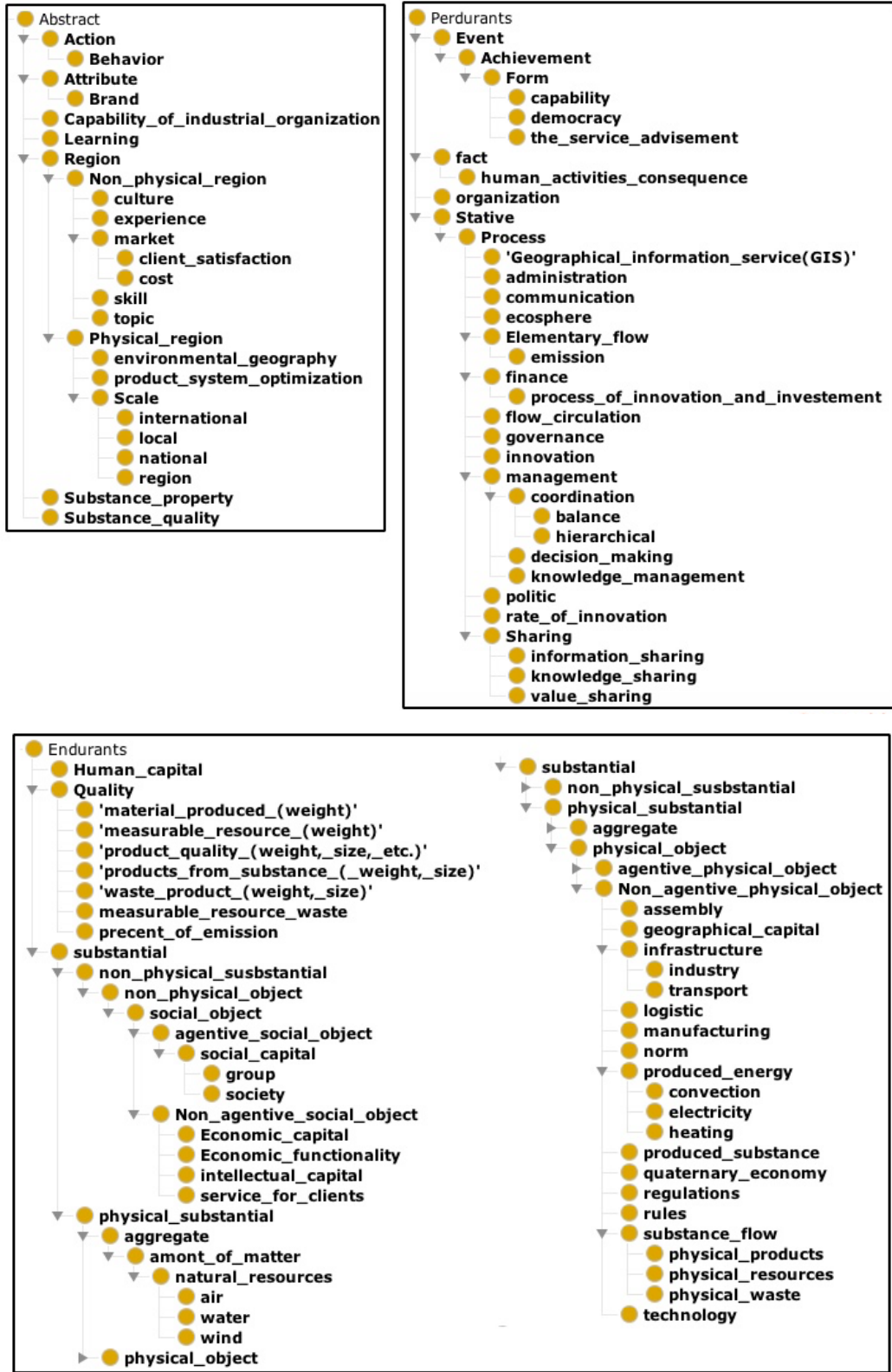


Figure 4.9: Hierarchy class of DOTK ontology.

4.5.1 Notions of abstract in DOTK ontology

There are different elements in the territorial knowledge taxonomy which can categorize in different classes of abstract in DOTK ontology. In this normalization, the elements of territorial knowledge which mentally represented stuff, are specialized as abstract. In fact, they are the entities that exist neither in time nor in space.

This categorization, identifies the place of territorial knowledge elements, such as geographical (environmental geography, substance quality and property, capability of industrial organization) human (behavior, skill, culture, learning, topic), economic (brand, market, product system optimization and political capital (local and regional scale), and their sub-class in abstract's entity. The notions of DOTK as abstract, is demonstrated in figure 4.10.

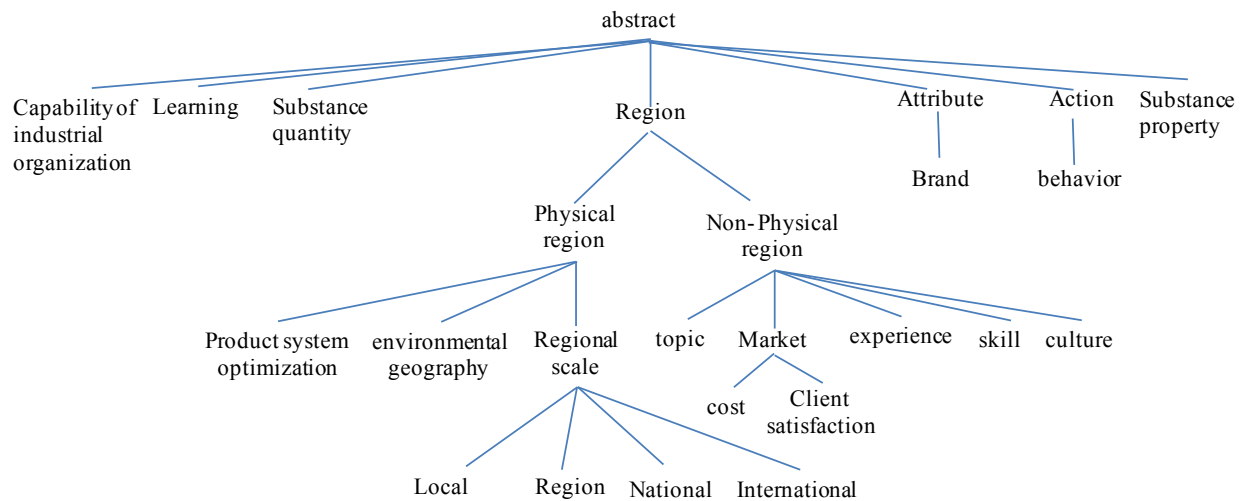


Figure 4.10: Notions of abstract in DOTK ontology.

So, this ontology assists to understand the meaning of different territorial knowledge elements according to their definition and position in DOTK ontology. Moreover, it is useful in industrial companies to understand the notions of territorial knowledge which assist sustainable development. Because categorizing of territorial knowledge in DOTK help actors to understand the nature of this knowledge in abstract's notions. So, the inference of relationship of territorial knowledge together is powerful due to the projection of the links by using of heritage in the tree. So, actors can easily understand how different territorial knowledge are linked together by showing the nature of these

links and not only toward the process. Semantic representation aims to show the role and nature of objects in reasoning (the “why” of reasoning), while a process shows the “how” of reasoning.

4.5.2 Notions of endurant in DOTK ontology

Endurants are wholly present at any time at which they exist and mainly as physical objects. There are many elements of the taxonomy of territorial knowledge which coincident to endurant’s notions. Especially, most of the sub-classes of geographical and human capitals are adapt with meaning of quality and substantial entities according to their definitions and essence. These elements consist of: geographical capital (logistic, manufacturing, assembly, infrastructure, technology, substance flow, produced substance, energy product, natural resource, supplier and quality of product, quality material and resource), human capital (group, society, intellectual capital, human resource), economic capital (service for client, quaternary, functionality) and political capital (rule, regulation, physical scale, norm). Figure 4.11 demnstrates the notions of endurant of DOTK as tree taxonomy.

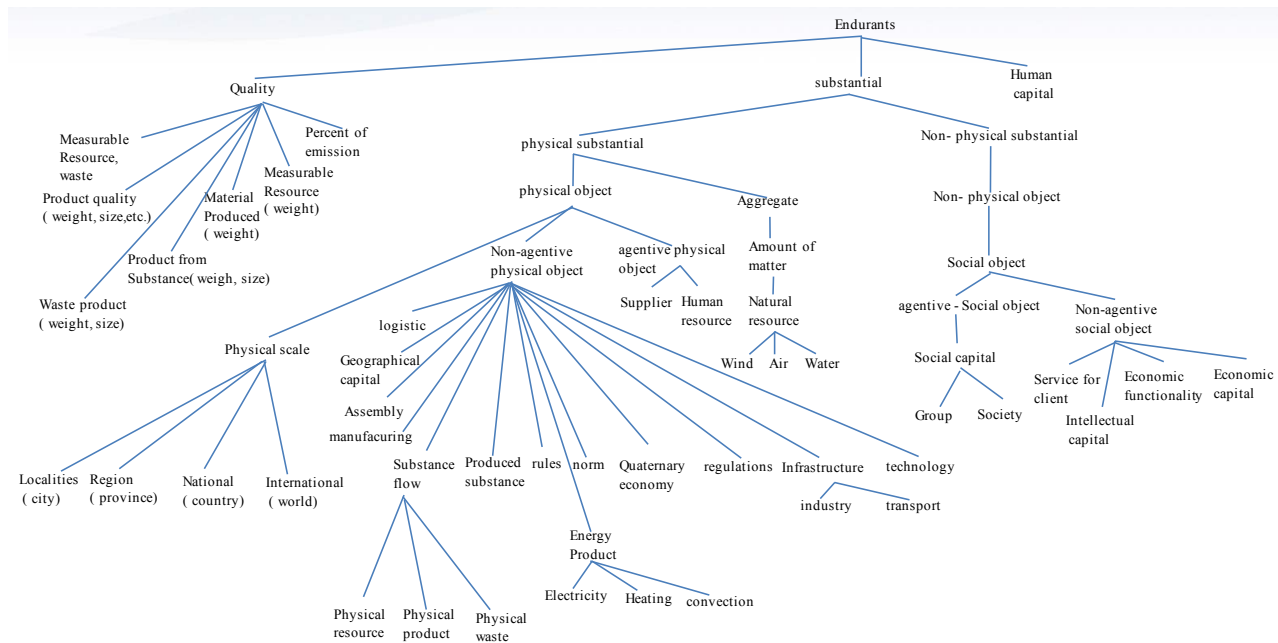


Figure 4.11: Notions of endurant in DOTK ontology.

4.5.3 Notions of perdurant in DOTK ontology

This categorization in perdurants seeks to identify territorial knowledge as event, stative, phenomena, internal change, intentional process. In fact, it clarifies temporal parts or spatial parts

of territorial knowledge. Most of the territorial knowledge is placed in stative as a process and some of the sub-classes of political capital adapt event entities. GIS, flow circulation, eco-sphere, emission, management, knowledge, administration, governance, innovation, finance and communication are sub-notation of the process. Moreover, capability, democracy and council advisement are sun-notation of the event. Figure 4.12 shows the notions of perdurant in DOTK ontology.

DOTK represents the role of ontology as a meaning of vocabulary. This vocabulary can account for the necessary semantics in order to establish seamless, unambiguous information sharing from territorial knowledge within hierarchical levels of industrial companies. DOTK provides more details about the notion and intention of territorial knowledge taxonomy for sustainable development objective.

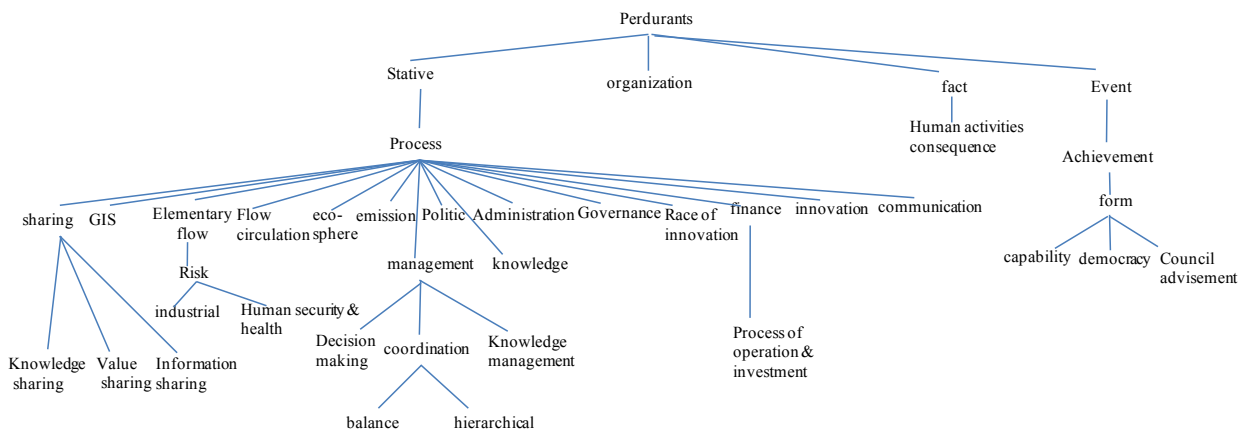


Figure 4.12: Notions of perdurant in DOTK ontology.

4.6 Semantic graph of DOTK ontology by Text Mining

One of the applications of ontology is the organization of semantic information and support the using inference tool to discover new knowledge and hierarchical relationship (Zhan et al., 2010). The semantic graph shows the relationship between different concepts of DOTK ontology. This semantic representation demonstrates the "why" reasoning of the territorial concepts of DOTK ontology to help the actors of the hierarchical level. So, actors of hierarchical level within industries can understand the relationship between these concepts and their influence on each other concepts. The methodology for constructing this graph at first step is Text Mining of related terms of DOTK ontology. Text mining is the discovery of word and terms by extracting the information from written resources by using linguistics theories (Hearst et al., 2003). So, the corresponded texts of concepts

of DOTK ontology are put in the “Voyant-tools⁴”. Voyant-tools is one of the free Text mining software usable in the internet. Moreover, the corresponded texts of concepts of DOTK are the conceptual categorization of territorial knowledge that is explained in section 4.3.

The texts of different territorial knowledge from scientific sciences in this domain, such as political, economic, geographical and human capital, are put in Voyant-tools. The output of Text Mining of texts of territorial knowledge by Voyant-tools is four semantic graphs. Each graph shows the relationships between the main concepts of each territorial capital. Then, these four graphs are mixed together to demonstrate the relationships between all of the concepts of territorial knowledge. Finally, a complete graph of DOTK ontology is achieved. But, before detailing the semantic graph, it is necessary to know about Text Mining and their principles.

4.6.1 What is Text Mining?

Text Mining (TM) is the discovery by computer of new, previously unknown information, by automatically extracting information from different written resources. A key element is the linking together of the extracted information together to form new facts or new hypotheses to be explored further by more conventional means of experimentation. In Text Mining, the goal is to discover heretofore unknown information, something that no one yet knows and so could not have yet written down (Hearst et al., 2003).

Thus, Text Mining is defined as: “The knowledge- discovery process which looks for identifying and analyzing useful information on data which is interesting to users from big amounts of textual data” (Atkinson Abutridy, 2000). From this perspective, Information Extraction (IE) and Text Mining may be complementary tasks but they differ in many ways. While IE relies in matching some fixed patterns to get the required information from the text and then translate it into a structured media (ie. database, templates, etc), Text Mining or Information Analysis relies in the fact that the value of the raw information comes from the competence can be got to analyze and to produce “elaborated” information. This is, both a high-level information/knowledge which could be implicit but not present on data and a potentially useful information/knowledge for the decision-making process in a certain activity domain (Atkinson Abutridy, 2000).

Therefore, the tasks of Text Mining on textbases could include the following:

⁴ <https://voyant-tools.org/>

- To cluster knowledge/information into charts/maps.
- To summarize information.
- To identify hidden structures between groups of objects.
- To extract hidden associations between elements on the texts.
- To provide an overview of the contents of a large document collection.
- To categorize texts by discovering relevant groupings.

4.6.1.1 Text Mining techniques

There are different techniques and methods for Text Mining in order to find new structures, patterns, or associations. Some Text Mining has involved the assumption of an a priori categorization (preprocessing) into attributes and then proceeded via “classical” Data Mining methods, i.e. statistical analysis, associations, etc. (Rajman et al., 1997). Others, investigate the full text of document collection, e.g. categorization used above, or purely analytical results.

A common end-goal of much Text Mining is a more efficient, complete, and/or specific way to browse and search large collections of documents. Thus, the main techniques in Text Mining can be divided according to the tasks they perform in the discovery process: the kind of information they extract and the kind of analysis/association done with them. So, kinds of extracted information in Text Mining are:

1. **Labels:** it has been assumed that associated with each document is a set of labels and knowledge- discovery operations are performed on the labels of each document. In general, it can be assumed that labels correspond to keywords, each of which represents that a given document is about a topic associated with that keyword (Manning et al., 1997).
2. **Words:** in which a document is assumed to be labelled with each of the words that occur within it (Atkinson Abutridy, 2000).
3. **Terms:** in which for each document are found word sequences that are likely to have meaning in the domain, and then mining is performed on the extracted terms labelling each document. The advantage of this method is that the extracted terms are fewer in number and tend to represent the important information on the text than the previous approaches (Feldman et al, 1998).

4.6.2 Semantic graph of concepts of DOTK ontology

As explained, this semantic graph is made by the method of Text Mining via Voyant-tools. The aim is consideration of the relationship between concepts of DOTK ontology. The entities of this graph are extracted by Text Mining of conceptual categorization of territorial knowledge (section 4.3) and their sub-categories (sub-sections: 4.3.1, 4.3.2, 4.3.3 and 4.3.4) by Voyant-tools. 35 articles about territorial knowledge for sustainability are analyzed by Text Mining via the Voyant-tools. The goal is to show the relationships between entities of DOTK ontology and their impact on each other entities. Moreover, because the main entities of DOTK ontology are modelled from the conceptual categorization of territorial knowledge, it is necessary to model the semantic graph from these conceptual categorizations (section 4.3).

The methodology for constructing of semantic graph explain in following steps:

- 1- At fist, the text of each main element of territorial taxonomy and its sub- elements put in Voyant-tools
- 2- The output was several graph from Voyant-tools for each main element and its sub-elements and these graph show the relationships between the elements.
- 3- After comparison of these graphs together, all of these graphs re-grouped to one graph (relationships between main elements of these graphs that influence on sustainable development, re-grouped)
- 4- The mentioned steps are done by Voyant-tools for other main elements of territorial taxonomy and their sub-elements. So, it gained four regrouped - graphs
- 5- Finally, these four re-grouped graphs of element of territorial knowledge re-grouped to one semantic graph that it is shown in figure 4.13.

Figure 4.13 demonstrates the semantic graph of “DOTK” ontology which is made by Porotégé.

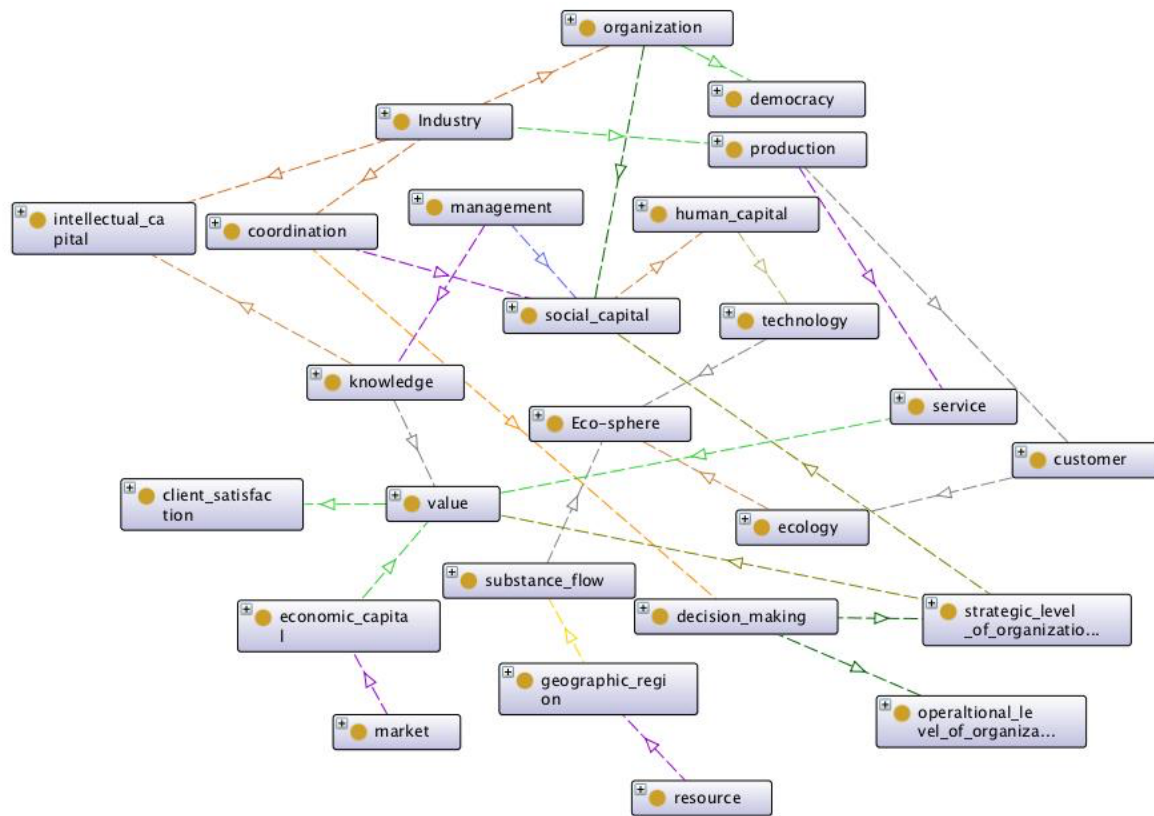


Figure 4.13: Semantic graph of relationship between concept of DOTK ontology via protégé.

Analysis of this semantic graph is started with democracy. Democracy as a class of political capital build a balance between individual preference and the challenge of sustainability in industrial companies and this balance is made by governance. Industries use governance to facilitate coordination between territory and companies through the organization.

Communication in the organization, coordination between politic and company, innovation and integration of stakeholders (individual/ social capital) assist to the governance in strategic and operational level of the company. So, knowledge management uses the knowledge of the social capital of industries to create value for clients and industries. Communication between different level of industry help to strategic level to give the value to the innovations that come from operational level within industries.

Political sub-classes are considered for long-term social orientation and decision making in companies and the realization of the social objective is possible by economic capital as a means. Service and logistic foster the market as economic capital to share the value for social capital by

governance decision making. In this regards, intellectual capital is used and coordinated the organization of industries for governance decision making.

Industries for the objective of human development need to use the natural resource with respect to the ecological sphere. Natural resource come from eco-sphere and industrial activity have the ecological influence, such as emission and disposal waste, on the ecosphere. Moreover, a flow is a kind of substance that enters or leave from a process an environment and this substance has the property and quantity. Also, substance flow has ecological influence.

This graph considers the property between concepts which located in the physical and non-physical region, aggregate, agentive physical and non-agentive physical object, non-physical object, agentive and non-agentive social object, process and achievement. This graph is shown in figure 5.

This graph can be understandable for actors of tactical and strategic level within industrial companies in order to better realizing of impacts between concepts and rule of relationships through the attribute between them. So, it is useful for the integration of concepts of territorial knowledge to their activities for the objective of sustainable developments.

Figure 4.14, shows the semantic graph of DOTK ontology as like as figure 4.13 by the attribute between the concepts. These attributes are extracted from the texts of conceptual categorization of territorial knowledge. Voyant-tools doesn't have the ability to extract the attributes between entities from the texts. So, these attributes are extracted according to my personal interpretation from the texts of scientific articles of conceptual categorization of territorial knowledge. Thus, these attributes can aid to better understanding of the relationship between entities and show how the entities influence each other entities.

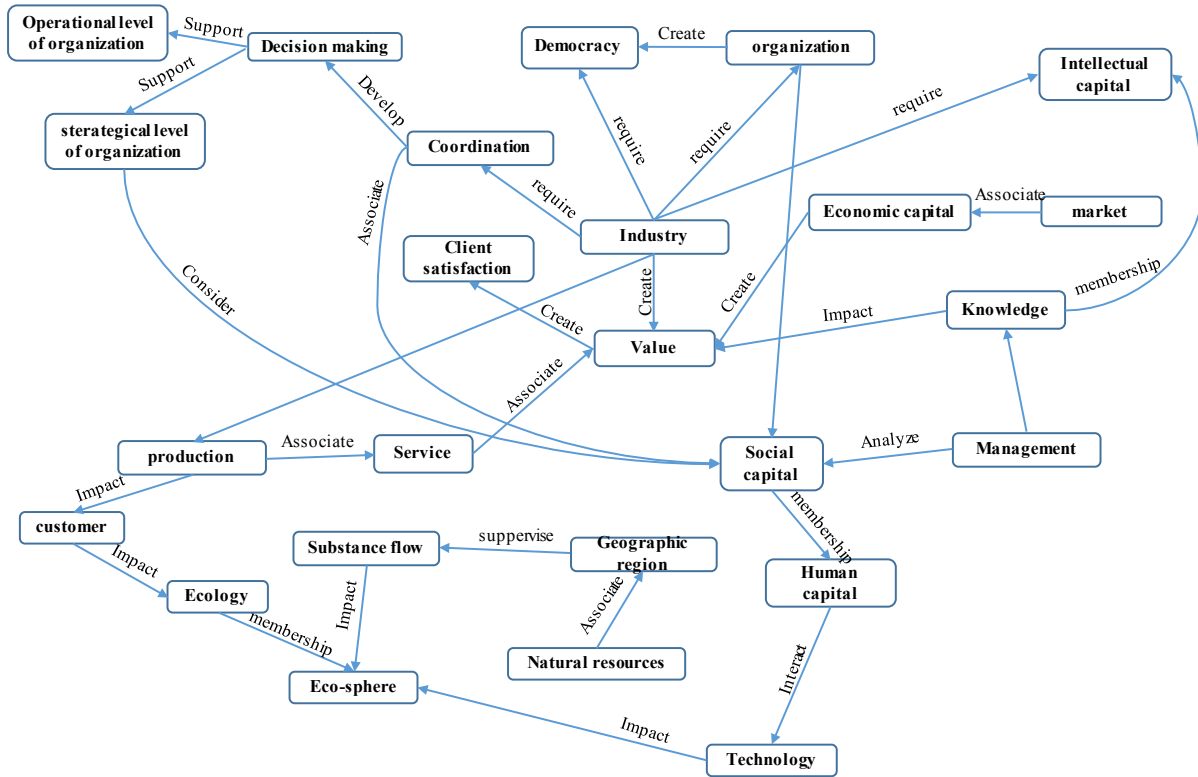


Figure 4.14: Semantic graph of relationship between concept of DOTK with attribute between them.

The advantages of the semantic are:

- showing the relationships between concepts of DOTK ontology
- showing the influence between the concepts of DOTK ontology by attribute between them
- help the actors of industrial companies (tactical and strategic level) to realize impact between concepts and rule of these relationships

4.7 Comparison of DOTK ontology with other ontologies of sustainability

Sustainability assessment has received more and more attention to measure and evaluate the level of its accomplishment. The efficiency of sustainability assessment depends on the available knowledge of the ongoing capabilities and there is not knowledge systematization in the sustainability assessment domain. Ontology as a form of knowledge conceptualization, assess and

support the level of sustainability. So, some researches consider ontology-based knowledge modelling for sustainability. The aim in this section is to compare DOTK ontology, as an ontology-based knowledge for sustainability, with other research of ontology for sustainability to identify the intention of each ontology and lack of concepts that other researches are not considered in their ontology. Moreover, it will be considered the objective, construction and level of each ontology comparing with our territorial knowledge for sustainability. This comparison assists to understand, how other ontologies for sustainability are constructed. Also, it is useful for understanding whether other researches clarify the entities of sustainability in different ontologies to improve knowledge of actores about the sustainability within industrial companies or not.

For example, Konys (2018), is provided formal, practical and technological guidance to a knowledge management-based approach to sustainability assessment (Konys, 2018). The aim of Konys is the improvement of understanding of interactions between natural and social systems to guide these interactions toward more sustainable trajectories. During of this interaction, sub-classes of ontology for sustainability is presented such as: community, innovation, policies organization and management system, natural resource, organization context, competitive advantage, environmental impact, economic impact, stakeholder relationships, supplier and customer relations, company strategy, resource utilization, social impact, sustainable consumption, quality of service, supplier performance, flexibility. The base of this sustainability assessment ontology is on the related set of presented criteria and specified relation. It provides complete domain knowledge of sustainable assessment solutions which can be directly applied by the experts in the process of sustainable assessment evaluation (Konys, 2018). This ontology by Kony (2018) is constructed by specification includes the criteria and sub-criteria such as the domain of usage: production and manufacturing sector, issues: environmental impact, scope: assessment, receivers: company, sustainability dimension: environmental dimension. But, several missing can be seen in this research in comparison with DOTK ontology. Firstly, the subclasses of ontology for sustainability are not categorized. So, it is not cleared to understand the categorization of the subclass of sustainability (environmental, social or economic) and political capitals are not considered. Secondly, the entity of sub-classes of this ontology is not identified from particular or universal point of view (Konys, 2018).

Another research has 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 expectations, satisfaction and capability are taken into account to construct this ontology but there are missing of further elements in comparison with DOTK ontology. Moreover, it cannot be seen how the available element link to other elements of sustainability. The proposed ontology by Upward (2016) is valued, not only to the groups of stakeholders (leader and manager in the company), but also to those outside the realm of business, such as public policy analysts and educators. It is based for the stirringly sustainable business model and it is present some of the elements related to the sustainable business model. it is not considered all of the aspects of sustainability such as social, environmental and political and place of each entity in the ontology. The aim of this section is considering of multidimensional views for sustainability as an ontological approach that it can be seen their intention for the ontology of sustainability in table 4.3. It has been prepared by literature review and this table shows some of the main ontological based knowledge for sustainability. Also, analyzing in table 4.3 represents the construction of each ontology and it is clarified the level of entities of its ontology and in this table, some of the important ontology for sustainability is considered.

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 and some parameter of economic and social in their ontologies. For example, Lin et al. (2013), provide an ontology-based process-oriented framework to support the product development with the environmental concept and make balance between the economic benefits and environmental protection. In other words, it presents the ontology-based of product development from an environmental point of view (Lin et al, 2013). All aspects of political capital, almost, are not taken into account in most of the researches about the ontology for sustainability. Moreover, most of the parameters of sustainability are extracted generally and some works such as Borsato (2014) propose an ontological based that it is related to specific terms of sustainability (Borsato, 2014). Borsato (2014) suggest an ontology through sustainability term of product and process data entities as explained in table 4.4.

Table 4.4: Concept and level of other ontological researches for sustainability.

Reference	objective	Main concept	Level of ontology
Wijesooriya et al, 2015	develops ontology-based multi-dimensional view to <i>environmental management</i> by focusing on sustainability	social aspect of environmental management (Individual, group and organization), optimizing resource, social knowledge	Taxonomy for ontological views generally
Konys, 2018	understanding of interactions between natural and social systems and to guide toward more sustainable trajectories	production, manufacturing, environmental impact and environmental dimension for process of sustainable assessment	Formal description: query mechanism
Borsato, 2014	Relates sustainability terms to product and process data entities through semantic ties and facilitate the use of sustainability throughout product's life cycle	product, process, material and property, activity, Data, Organization, Place to fill the gap between product life cycle management and sustainability	Ontology: class process
Lin et al, 2013	Balance between the economic benefits and the environmental protection by providing a ontology based process oriented to support the product development within environmental concept.	product, organization and process area in companies (environmental and economic)	Ontology based on design chain operational reference model
Upward et al., 2016	ontology based on sustainable business models (Economic), as validate by ecological economics and derived from natural, social, and system sciences	Product and development, Stakeholder (manager), governance and industrial ecology to assist the designing sustainable business	Relationship diagram generally

Also, other researches didn't consider whether it is possible to integrate these sustainable ontologies to industrial activities or not. In addition, if this integration is possible, how can assist the hierarchical level in industrial companies. Moreover, level of entities is not identified in the other ontologies of domain

This comparison assists to compare different notions which other works investigated in comparison with the notions of territorial knowledge. Moreover, another goal of this comparison is to understand which types of these ontologies can be useful for semantic web and specific application within industrial companies. It can be concluded that other researches consider some aspects of sustainability or only consider the environmental aspects in their ontology and there is lack of political and geographical elements in their taxonomy obviously.

4.8 Conclusion

Sustainability requires a semantic approach in order to understand the relation of concepts of territorial knowledge for local and regional territory. So, as mentioned, it needs to present a territorial ontology. In this chapter, a methodology for modelling a territorial ontology is followed. Thus, at the first step, elements of territorial knowledge and sub-elements based on 5 dimensions of sustainability are categorized as tree flowchart. Foundation ontology can facilitate comprehension of territorial knowledge concepts and nature of this knowledge for actors of hierarchical levels for implementation of sustainability via ontology. So, DOLCE ontology is selected as a foundational ontology for normalizing of elements of territorial knowledge. Therefore, a descriptive ontology for territorial knowledge (DOTK), as an ontology of territorial domain, is proposed through the following of methodology for modelling an ontology. DOTK ontology represents the "why reasoning" of each entity of territorial knowledge as a guide to help the actors of hierarchical level within companies. Moreover, the semantic graph demonstrates the attribute between concepts of DOTK ontology for the understanding of their relationships and rules between concepts. Also, the semantic graph as a guide helps the comprehension of semantic describing. In addition, DOTK ontology is compared with other ontologies of sustainability theoretically. It proves that there is the lack of some concepts of sustainability in the other ontologies.

In summary, this chapter answer to the two first questions:

1. Which type of territorial Knowledge affects the sustainable objectives of industrial companies?

2. How to represent and share this knowledge for sustainability's objective within industrial companies?

In fact, with modelling of DOTK ontology, the types of territorial knowledge that effect on the sustainability within industrial companies are represented. As motioned, taxonomy of territorial knowledge consists the elements in the territory that influence on the sustainability of industry and there is not enough knowledge about this territory's feature in the companies to integrate this knowledge to their work for sustainability. Moreover, another problem is communication for implementation of sustainability. Implementation of the sustainability science approach is often difficult because of poor communication between experts from different academic fields. DOTK ontology can facilitate information sharing and exchange in the various engineering domains of industries by providing concept structures and clarifications that make explicit and precise important notions of territorial knowledge for sustainability.

The advantage of DOTK is that can be completed via other concepts through other researches in this domain in future. In other words, DOTK ontology can be a guide to identifying the resources of territory and for this reason, it is very useful in sustainable development. So, the usability of DOTK ontology for identifying the resources a territory for sustainable development objective explains in the following chapter.

Chapter 4: Descriptive Ontology for Territorial Knowledge (DOTK)	
Perspective study (development of proposition and method)	Part 4.2
	Research approach and methodology: <ol style="list-style-type: none"> 1. Identifying of conceptual categorization of territorial knowledge 2. Consideration of foundational ontology for normalization 3. specialization of top level ontology (DOLCE) according to conceptual taxonomies of territorial knowledge for modeling an ontology in the domain of territory for sustainability. 4. Modelling of DOTK ontology
	Part 4.3
	Conceptual categorization of territorial knowledge: <ul style="list-style-type: none"> • Four categorizations of economic, political, geographical and human capital • Sub- elements of these categorizations
	Part 4.4
	Foundational ontology: <ul style="list-style-type: none"> • have a large scope • can be highly reusable in different modeling scenarios • are conceptually well founded • are semantically transparent and richly axiomatized • provides a starting point for building new ontologies
	Ontology DOLCE & SUMO: <ul style="list-style-type: none"> • definition of their concepts • comparison of them
	Part 4.5
	Descriptive Ontology for Territorial Knowledge (DOTK): <ul style="list-style-type: none"> • Notions of abstract DOTK • Notions of endurant DOTK • Notions of perdurant DOTK
	Part 4.6
Semantic graph of DOTK ontology by Text Mining: <ul style="list-style-type: none"> • Text Mining (TM) is the discovery by computer of new, previously unknown information, by automatically extracting information from different written resources 	
Semantic graph of concepts of DOTK ontology <ul style="list-style-type: none"> • showing the relationships between concepts of DOTK ontology • showing the influence between the concepts of DOTK ontology by attribute between them • helping the actors of industrial companies (tactical and strategic level) to realize impact between concepts and rule of these relationships 	

	Part 4.7
	Comparison of DOTK ontology with other ontologies of sustainability <ul style="list-style-type: none">• This comparison assists to compare different notions which other researches investigated in comparison with the notions of territorial knowledge.• understanding which of these ontologies will be useful for semantic web and specific application whining industrial companies• other researches consider some aspects of sustainability or only consider the environmental aspects in their ontology and there are lack of political and geographical elements in their taxonomy obviously.

**5. VALIDATION OF DOTK: BUILDING AN
APPLICATION ONTOLOGY OF TROYES**

5.1 Introduction

In the previous chapter of this thesis, modelling a DOTK ontology in order to represent the territory's features is addressed to help the industrial companies. In fact, DOTK is an ontology of domain that represent the “why reasoning” of concepts of territorial knowledge which share the common understanding of these concepts and help the better communication between actors of hierarchical levels. This chapter aim at implementing of DOTK ontology on the real case of geographical territory to show that DOTK can act as a guide to extract the tangible and intangible resources of territory to assist the industrial companies. In other words, we want to validate the concepts of DOTK ontology and for this reason, a real case (Troyes city) is selected to implement DOTK ontology for extracting of its resources. In fact, DOTK ontology is very useful for sustainable development because it can be a guide to identify the resource of a geographical territory.

This chapter starts with the introduction of real case and then, the methodology of this implementation explains. The result of this application ontology is DOTK ontology of Troyes.

In order to demonstrate the relationship between the concepts of DOTK ontology of Troyes, a semantic graph is investigated by Voyant-tools based on Text Mining. Finally, a comparison between the semantic graph of concepts of DOTK ontology with the semantic graph of concepts of DOTK ontology of Troyes is done. The goal of this comparison is to present a complete semantic graph that shows the relationship between all of the concepts of territorial knowledge. Finally, another validation of DOTK ontology through the presentation of DOTK ontology of Troyes and interview with top-managers of three organizations in Troyes present. These validations have shown the usability of DOTK ontology and semantic graphs for the objective of sustainable development of enterprises.

5.2 Case 1: Troyes city in Champagne Ardennes

Troyes is a city of France and the capital of the department of Aube, located in the Champagne-Ardenne region in the northeast of the country. Its geographical features are:

- Surface area: 13.2 sq. km
- Population: 60,009
- Climate Type: Oceanic

- Average temperature: Summer 15.8°C, Winter 5.8°C
- Average sunshine 1,816.4 hours per year
- Average rainfall: 644.8 mm per year

Textile companies' production is a popular clothing brand as the economy of this city. Moreover, this city is rich in water resources due to the high amounts of rainfall. In terms of geographical resources, the agro-food industry is the central driver of regional economic activities. Newer industries are automobile components, plastics, and food and beverage processing. The city's chemical, glass, packaging, and printing industries are directly related to the needs of the champagne producers (www.champagne-ardenne.cci.fr).

So, DOTK ontology is applied in Troyes to guide the identification of resources of this geographical territory. So, a new application ontology is constructed by DOTK ontology. Each concept of DOTK ontology conduct to find the corresponded concepts for modelling of the application ontology of Troyes. Thus, DOTK ontology is applied for identifying of territorial resource of Troyes to model the DOTK ontology of Troyes. This Ontology presents the territorial resources (tangible and intangible) of Troyes according to their essence, position and meaning in DOTK ontology. The concepts of this ontology can help the governmental organization and industrial companies toward sustainability by presenting the tangible and intangible resources which locate in the territory of Troyes.

Moreover, Troyes is selected as a case study to show the methodology of implementation of DOTK ontology. In other words, this methodology demonstrates how DOTK ontology can be used for every geographical territory to identify its territorial resource for the sustainable development goal of industrial companies.

5.3 Methodology for modelling of DOTK Ontology of Troyes

Searching on the internet website according to the concepts of DOTK ontology is the methodology for identifying territorial resources of Troyes. So, each concept of DOTK ontology according to its essence is searched in the websites of intangible and tangible resources of Troyes. Therefore, the concepts of DOTK ontology assist to find the corresponded territorial resources in Troyes for sustainability. In other words, each concept of DOTK act as well as a guide to search the corresponded resources in regards to its meaning. Therefore, DOTK ontology of Troyes is completed by this methodology. So, consideration of each concept of DOTK ontology and

searching in websites help us to identify its territorial resources for sustainable development.

The aim of this implementation is to show that DOTK ontology can guide for modelling an application ontology and can identify the tangible and intangible resources of each geographical territory. So, this application ontology can represent for the hierarchical levels of industry for sustainable development objective. Moreover, construction of DOTK ontology has this possibility to add other new elements of territorial knowledge which will be found by other researchers in future to complete the element of DOTK ontology for sustainability.

According to entities of DOTK ontology, the resources in DOTK ontology of Troyes are presented in three types of entities of abstract, enduring and perdurant. In the following sub-sections, the details about the resources of Troyes are explained.

5.3.1 Entities of abstract in DOTK ontology of Troyes

Entities of DOTK ontology as Abstract, are learning, client satisfaction, skill, product system optimization and environmental geographical concepts. So, these entities are searched in the website to find the resources in relation to their essence and meaning in Troyes. 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 which are found in websites. 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.

The objective of different **brands** in this city is **creating value for their clients** and helping the economic capital. **Different association** the **sustainable mobilization** and population mobilizing to develop the **culture**. Sustainable mobilization is made by means of urban displacement's plan and **clean vehicles** to improve this culture. Moreover, political organization, **workshops** events and communication develop the population mobilizing to exchange the culture for sustainable development objective.

University of Technology of Troyes (UTT) 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 of Troyes)

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.

The concepts of these resources as the entities of abstract in DOTK ontology of Troyes are shown by red entities in figure 5.1. Thus, these abstract's entities as resources of Troyes assist the hierarchical level of industries in this city to integrate these resource to their activities for sustainable development. Moreover, it can help the better communication between experts from different academic fields to facilitate information sharing and exchange in the various hierarchical levels by providing concept structures and clarifications that make explicit and precise the important notions and resources. In other words, by pursuing each resource, it can be understood the essence and meaning of its type. Therefore, the meaning of types can support the evaluation and share the understanding of these entities between actors of the hierarchical level.

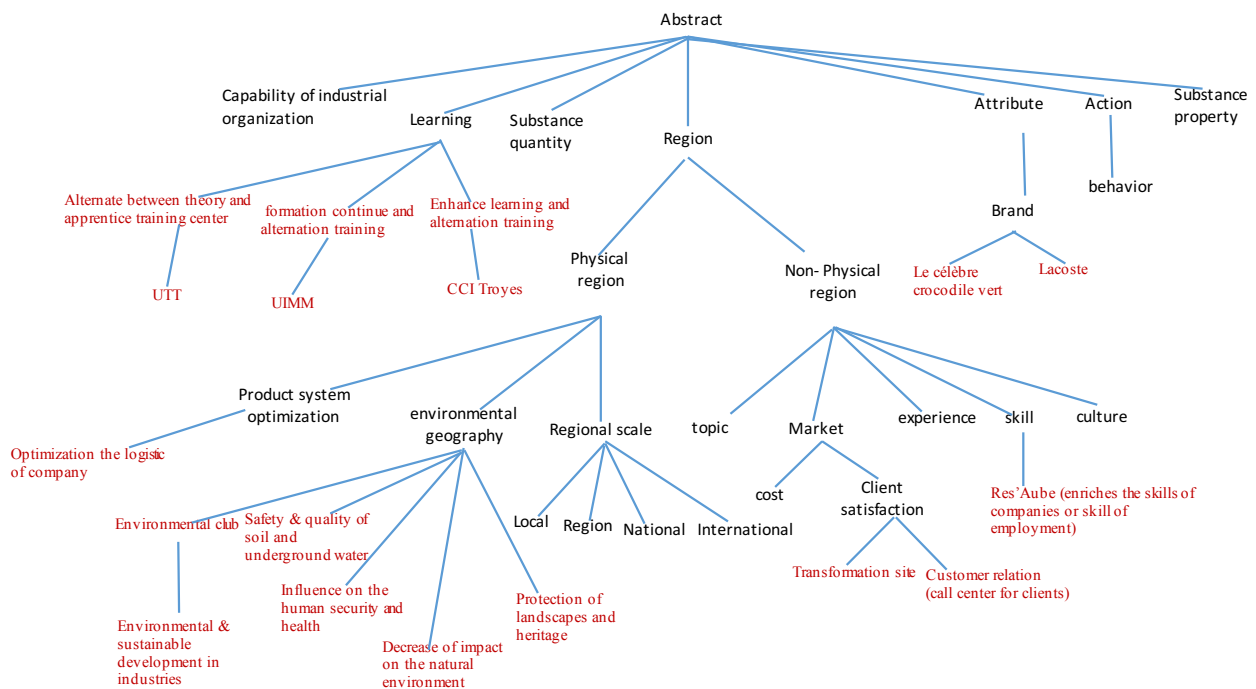


Figure 5.1: Entities of abstract in DOTK ontology of Troyes.

5.3.2 Entities of endurant in DOTK ontology of Troyes

Most of the endurant concepts of DOTK ontology are located in the agentive and non-agentive physical object of substantial entities. Regulation, energy product, infrastructure, physical waste and logistic, economic capital are the main concepts of substantial in DOTK ontology. The

political rules in Troyes are concentrated to integrate environmental issues into public policies. One of this rule is the environmental assessment describes and **evaluates the significant effects that the waste management system** may have on the environment of the territory. It thus makes it possible to integrate or reinforce the consideration of environmental considerations in the planning of public waste management policies. Another main rule is air quality through the **reducing of greenhouse gas emissions and energy consumption in the territory by at least 20% by 2020, increased the production of renewable energy and recovery up to 45% by 2020**, the adaptation of the regional territory to climate change, improving air quality by **reducing pollutant emissions atmospheric and reduction of the harmful effects** of the degradation of the quality of the air on the environment.

Two main **energy production** are **electricity** and **heating** energy produces through **water circuit a biomass boiler room**. The main resources for electrical energy are **wind turbine, solar cells and hydraulic energy**. Moreover, the heating energy produces from the urban heating network through **water circuit and biomass boiler room by agriculture resources**. These pure energies can help the environment and climate change. Also, developing the renewable energy, development of recycling sector and environmental issue awareness are some of the regulation which helps both industries and territory's ecology.

Industries of Troyes produce the **textile, metal products, rubber, plastic, paper and transport equipment**. **Park of logistic** help to industries for reshipment of products, storage through the transport by **railroad** and **land transport**. Also, the **supplier** provides the products and raw material for the industries that they need for their project or production. There are different suppliers in Troyes which supply different materials such as: **Aub'protect** (Work clothes, Safety shoes, Protective glasses, Safety gloves etc.), **Comptoir** dry at industrial (welding equipment), **Crbttech**(agricultural material), **Marne industrial service** (Cutting tools, Metrology tools, Machine tools, carbides, Fast steels, etc.).

In addition, the **natural resource** such as **wind, water, forest and woods, fossil energy** provide the resources for industry and territory of Troyes. The **central heating network and disposal of non-hazardous waste** are the main **technology** in Troyes that assist this territory.

Also, the **circular economy** is one of the main capital of the economy in Troyes. The circular economy is a system of production, exchange and sharing allowing social progress, preservation of natural capital and economic development. **The concretization of the new value buckets**

promoted by the circular economy aims to respond to all social, economic and environmental issues related to our current production and consumption patterns, optimize the material and energy. **Cooperative agriculture** through the agriculture product store is one of the systems of the circular economy of this geographical territory and agriculture companies. In fact, agriculture is one the main economic capital in Troyes and there are the different association that work on the sustainable development in agriculture. Moreover, **foyer aubois** by social redistribution and integration of social economy through resold is another system of circular economy in this city.

Another concept of this ontology for **economic functionality** is Xerox corporation which sells the print 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 satisfaction of their needs.

Moreover, different groups and societies act as **social capital** in Troyes. For example, some association such as **E-grin, Petit débrouillards**, assist the education movement for individual and collective behavior of sustainable development and global citizenship. In other words, these associations do the organization of an educational and cultural nature for both Troyes and local companies of Troyes.

Moreover, an association such as **health environment** as social capital, aid the society for buildings isolation and rehabilitation of buildings through the energy and material consumption. In addition, some **energy mediator** association, **economize the energy consumption** for the society via the giving of counsel to them. So, these associations support social capital and economic capital for sustainable development.

So, according to essences of these concepts, the territorial resources are searched in websites to discover the territorial resources of Troyes which aid the industries for sustainable development adapted to 5 dimensions of sustainability. Figure 5.2 demonstrates the endurant's territorial resources of Troyes as red entities extracted by implementing DOTK ontology. Endurants of DOTK of Troyes identify the most tangible resources of Troyes. In addition, there are some intangible concepts in the DOTK ontology which the corresponded resource in Troyes for them are not found. So, there are the lack of resources of Troyes which are identified by DOTK ontology of Troyes and these resources should develop in the geographical territory for responding to improvement of sustainability.

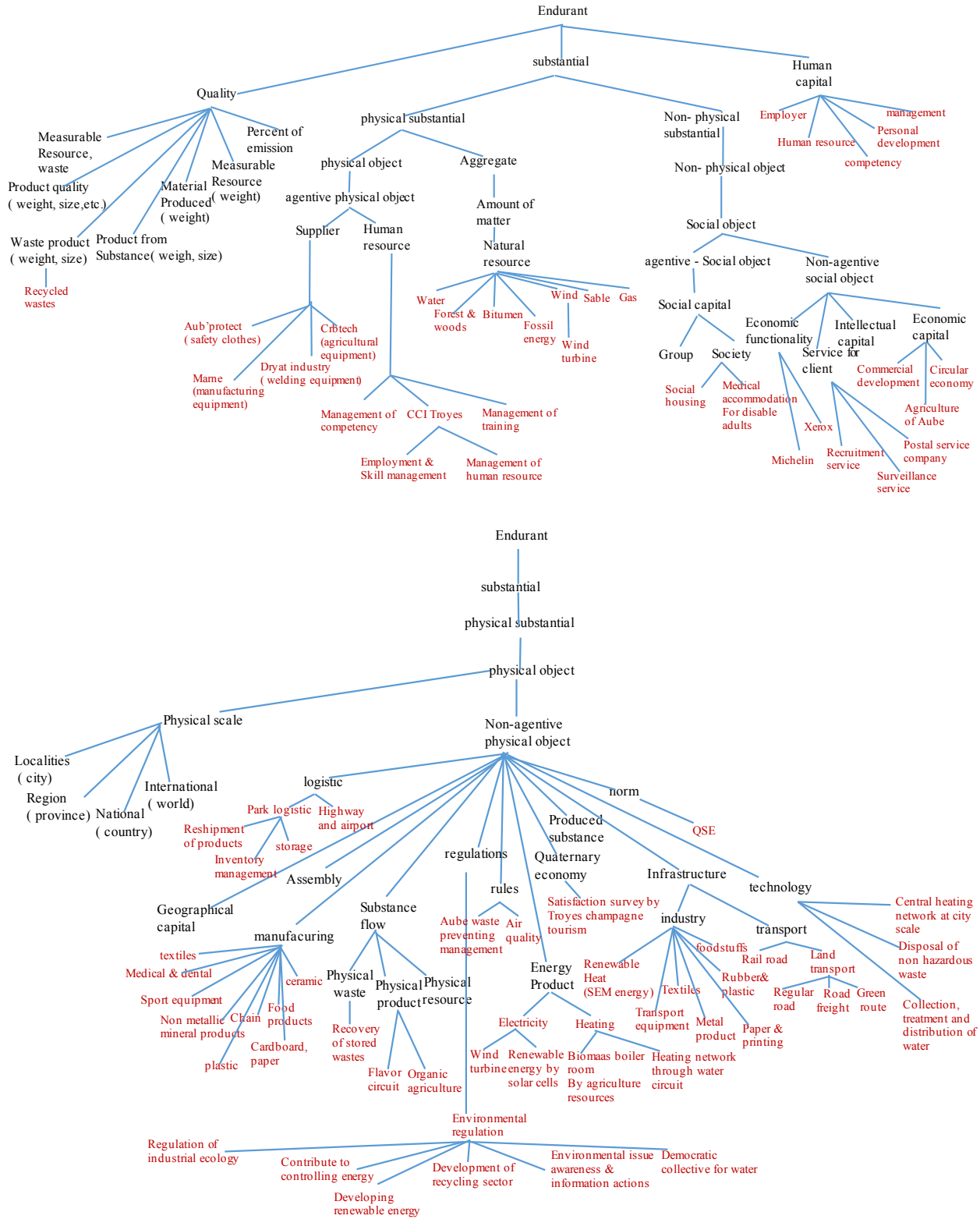


Figure 5.2: Entities of enduring in DOTK ontology of Troyes.

5.3.3 Entities of perdurant in DOTK ontology of Troyes

The perdurants concepts of DOTK ontology are politic, governance, emission, information sharing, management, communication, innovation, human activities consequence and organization which can find their corresponded resources in Troyes. The **political capital** of Troyes as a process of perdurant demonstrate the objective of economic activities from local employment in the different section such as agriculture, non-agricultural market, human health (**2% employment in the agriculture section, 28% employment in the public administration, education, human health and social action, 2% in particular employment, 58% salaried jobs in non-agricultural market sectors**).

Wealth creation is one of the politics in Troyes which obtains from **work** and **capital factor** and **natural capital**. They explain in below:

- The **work factor** includes all human activities, intellectual or manual, whose objective is to produce a good or value-added service. It gives rise to the perception of remuneration.
- The **capital factors** are: 1-circulating technical capital, usable in the short term (less than one year). It will be destroyed or transformed as part of the production of wealth 2- the fixed technical capital, which is used in the long term. This capital consists of real estate used for the production of wealth.
- **Natural capital** (generally known as "land capital"). It groups together all the natural resources that constitute means of producing ecological goods and services. In this context, natural resources represent opportunities for creating "clean" wealth.

Moreover, **reduction of the environmental impact** such as environmental labelling: water consumption, energy consumption, rubbish production, climate change such as CO₂, NO₂ and CO, ecological and biological products are other **politics** that follow for sustainable development in the companies of Troyes and in this city. In addition, industries increase the types of **risk** in this city. In fact, the risks that increase the emission to water, air and sol and human security and health within industries.

Social aspects in corporate governance are provided industries with the answer to the concepts and challenges of sustainable development by the corporate social responsibility through CCI of Troyes. It aids the industries for **social relation** within industries, **health, safety and employment policies** implemented in **training**. Moreover, consideration of **the environmental issue in corporate governance** is related to the sustainable development that considers the **air quality** and

waste disposal plans in the industries and environmental club of Troyes. Organization of training is another subject in the organizational level of industries of this commune which **UIMM** and **UTT** assist the industries by alternate training. **UTT, technopole of Aube and park of technology** have the cooperation with industries to innovate in the domain of sustainable development for territory. Also, **the club of industrial ecology of Aube** acts as a network of exchange of information for industrial ecology between industries to **share the information** of this domain through the internet site and information service.

In addition, **social network** helps communication and **marketing** is one of the tools for communication that help the economic capital for sustainable development of industries and Troyes.

Human activities, as a cause of environmental degradation, can easily be divided into five main activities: the collection of resources, manufacturing of goods, transportation of goods and people, urbanization, production and energy consumption. Thus, the direct effects of these activities on the environment can be grouped into three main types: resource depletion, habitat destruction and pollution.

The main missions of the **services of the department council** for territorial development and community life are: 1- management of aid to municipalities for school, sports and socio-cultural facilities, 2- subsidies to sports, cultural and leisure associations, 3- financial support for higher education, departmental scholarships and 4- support for economic development infrastructure, collective action and innovation.

So, each concept of DOTK guides to search the suitable resource of Troyes for modelling an application ontology for industries in Troyes. In other words, DOTK ontology is very useful for sustainable development because it can be a guide to identify the territorial resources for industries and geographical territory. Figure 5.3 demonstrates the perdurant's entities of DOTK ontology of Troyes that are shown as red entities.

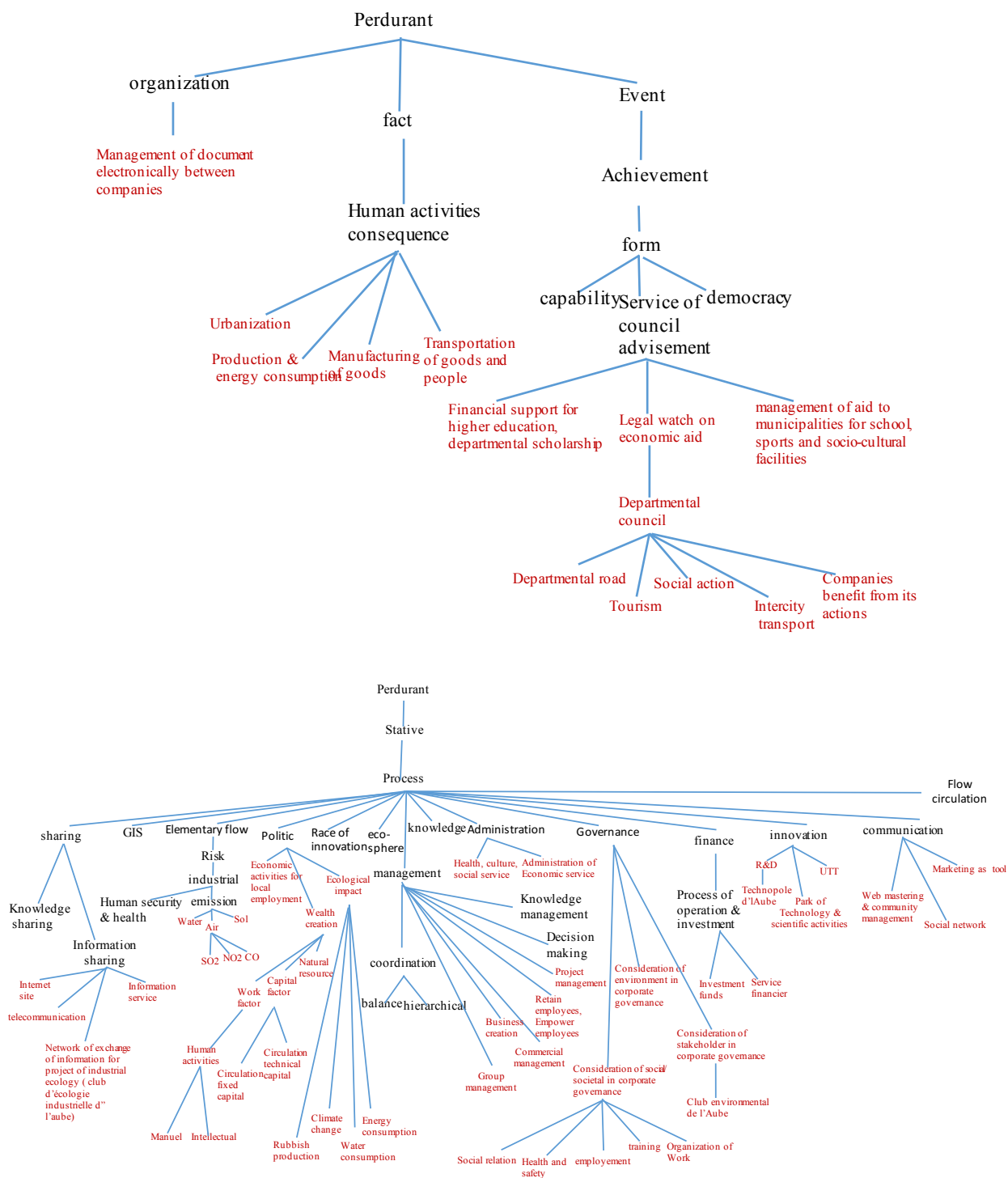


Figure 5.3: Entities of perdurant in DOTK ontology of Troyes.

5.3.4 Semantic graph of DOTK ontology of Troyes by Text Mining

As explained in section 4.6, the semantic graph shows the relationship between different concepts of DOTK ontology. In this part, the semantic relationships between entities of DOTK ontology of Troyes is demonstrated. The aims are, at first, help the actors of the hierarchical levels of companies by the relationship and attribute between the entities and secondly, the comparison between the graph of DOTK of Troyes with the graph of DOTK ontology. The comparison aid to have a complete graph which shows all of the relationship between all of the entities. In other words, semantic graph of DOTK ontology of Troyes complete the relationships between semantic graph of DOTK ontology.

Semantic graph of DOTK ontology of Troyes is made by Text Mining method via Voyant-tools. Key terms of DOTK ontology of Troyes are extracted by Voyant-tools. In other words, different founded links in relation to the resources of Troyes from the internet website, are put in the Voyant-tools. Then, key terms of DOTK ontology of Troyes and their relationship are created by Voyant-tools. So, according to each resource of Troyes, one graph is created. Finally, through the mixing of these graphs together, one complete graph of DOTK ontology of Troyes is presented. Semantic graph of DOTK ontology of Troyes is shown in figure 5.4.

This graph shows the widespread relationship between entities of DOTK ontology of Troyes which assist actors of local companies in Troyes in order to better realizing of impacts between entities. So, it is useful for integration to the activities of local companies.

This semantic graph shows more detail about the relationship and effect of entities of DOTK ontology of Troyes. So, in order to compare the graph of DOTK ontology of Troyes and DOTK ontology, it needs to generalize the semantic graph of DOTK of Troyes. Because the relationship between entities of the graph of DOTK ontology consists of the concepts in the level of the domain ontology. While entities of the graph of DOTK ontology of Troyes are categorized in specialized level. So, it needs to generalize the relation between concepts.

DOTK of Troyes, but the relationships are retained according to the relationships between entities of the graph of DOTK of Troyes.

Following these steps, generalized semantic graph of DOTK of Troyes is constructed. Figure 5.5 shows the generalized graph of DOTK of Troyes. This semantic graph (figure 5.5) can compare with the graph of DOTK ontology and complete it.

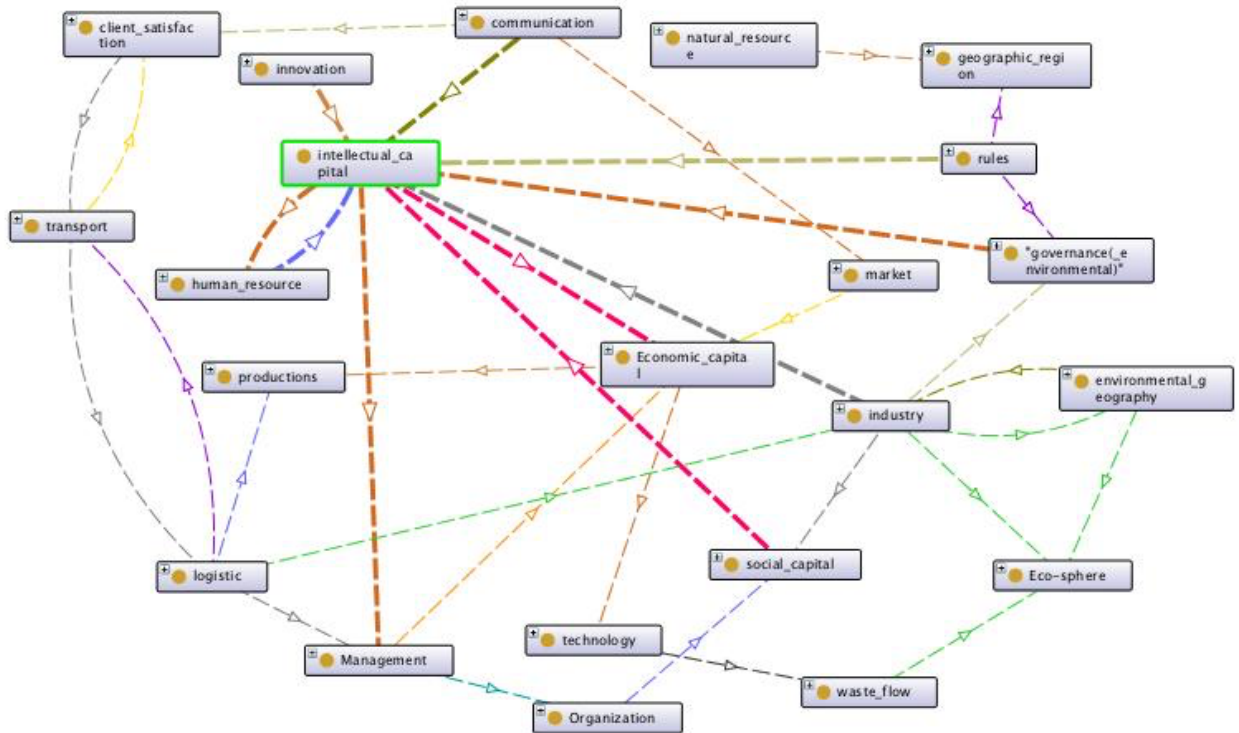


Figure 5.5: Generalized semantic graph of DOTK ontology of Troyes.

Attributes between these entities can help the better understanding the relationships. In fact, these attributes show how these entities influence other entities. Moreover, Voyant-tools can not extract the attribute between the entities from the texts. The attributes for showing the influence between the entities are extracted from the text through the interpretation. Therefore, the best attribute according to the reasoning and interpretation are found from the texts of DOTK ontology of Troyes (internet websites that resource of Troyes is found from them). Figure 5.6, shows another form of generalized semantic graph of DOTK ontology of Troyes as like as figure 5.5 by the attribute between the entities.

Analysis of this semantic graph is started with democracy. Democracy as a class of political capital build a balance between individual preference and the challenge of sustainability in industrial companies and this balance is made by governance. Industries use governance to facilitate the

coordination between intellectual capital and give the value to the initiatives at the strategic level that come from the operational level.

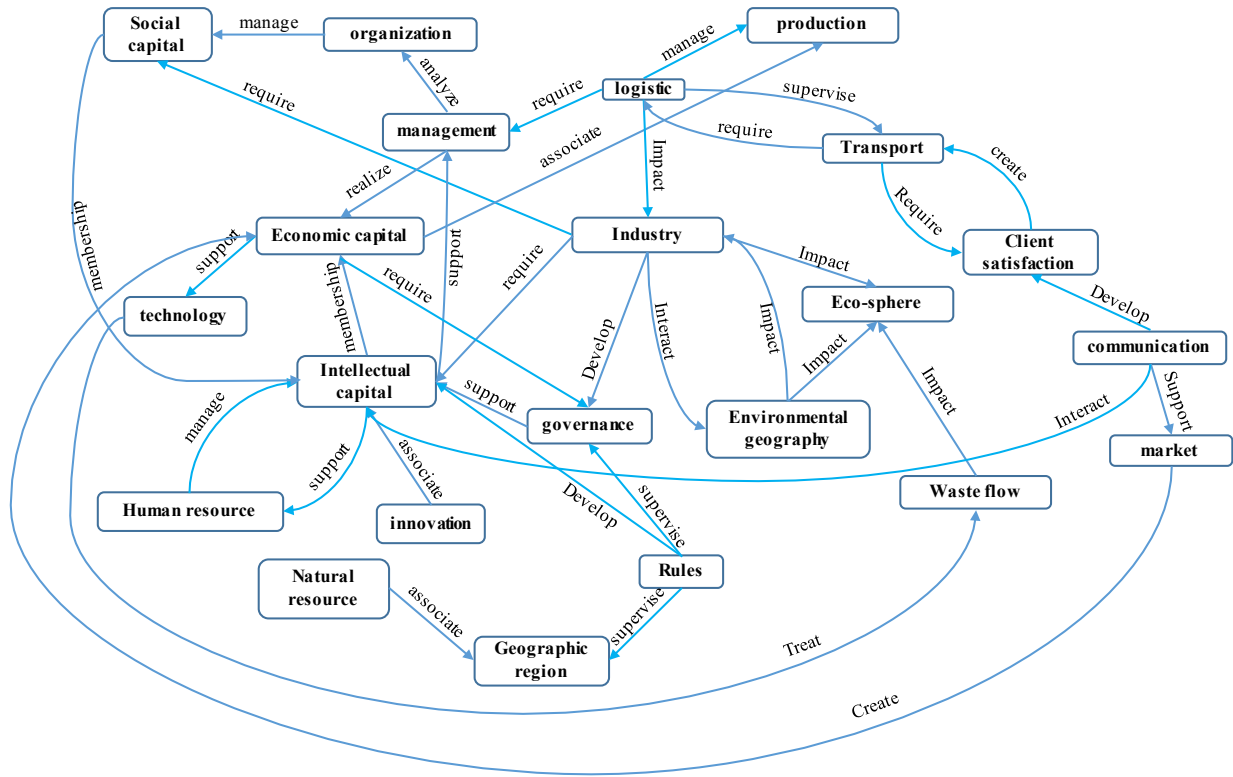


Figure 5.6: Generalized semantic graph of DOTK ontology of Troyes with attribute between them.

Moreover, intellectual capital supports the management through the using of knowledge of the social capital within industries to create value for territory and industries.

Political sub-classes are considered for long-term social orientation and decision making in companies and the realization of the social objective is possible by economic capital as a means. Communication and logistic support the market to share the value for social capital by governance decision making through the production.

Industries for the objective of human development has the interact with environmental geography. Moreover, environmental geography impact on the industries and ecosphere. Also, Natural resources are associated with the geographic region that the political rules supervise the geographic region. These rules assist the governance strategic decision within companies to reduce the ecological influence on the ecosphere. For example, waste flow is treated to decline the environmental impact on the ecosphere.

5.3.5 Comparison of the graph of DOTK of Troyes with the generalized graph of DOTK of Troyes

As mentioned, the goal of this comparison is to have a complete graph which shows all of the relationships between all of the entities. In order to have a complete semantic graph, the relationships add to the semantic graph of DOTK ontology by the additional relationship which exist in the graph of DOTK of Troyes. The graph of DOTK of Troyes is built by specialization of entities while the graph of DOTK is constructed by entities in the domain ontology. In fact, the graph of DOTK of Troyes can complete the graph of DOTK because the graph of DOTK of Troyes has more relationships between concepts because of specialization of its entities. Finally, a complete semantic complete graph of DOTK ontology is presented which is shown in figure 5.7. The red arrows show the added relation which is completed through the comparison.

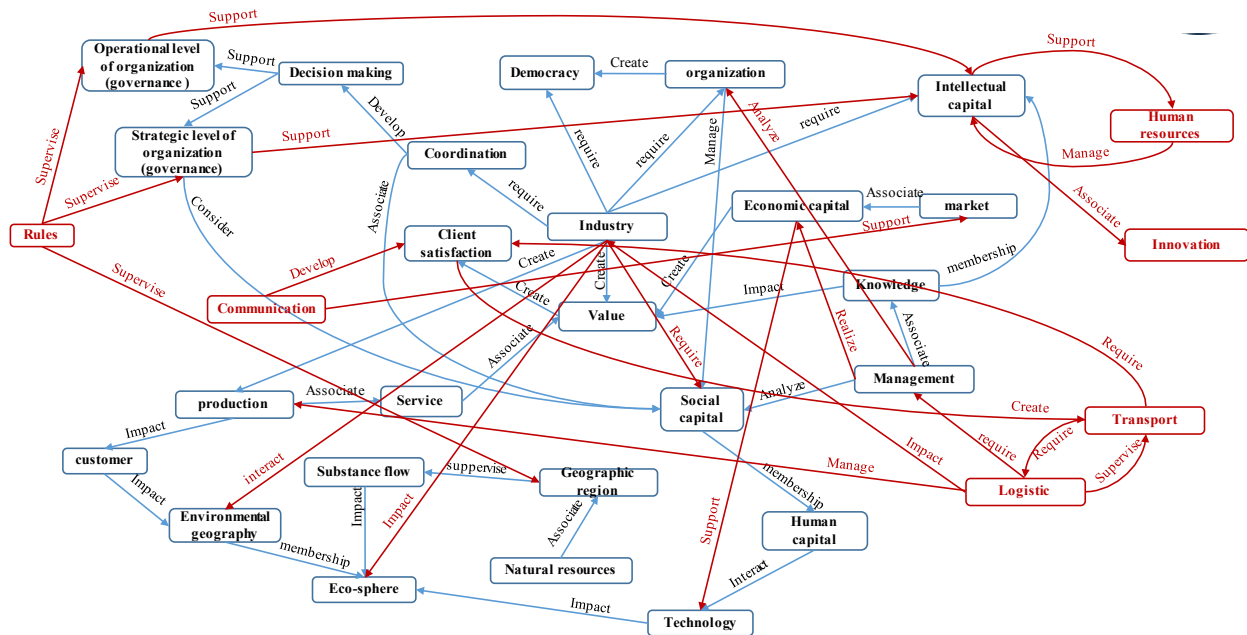


Figure 5.7: Complete semantic graph of DOTK ontology.

As can be seen in figure 5.7, the relationships between the intellectual capital and human resources and innovation were missed in the semantic graph of DOTK ontology. While these relationships were in the semantic graph of DOTK of Troyes and they add to the complete semantic graph of DOTK ontology. In fact, intellectual capital supports human resources and it is managed by human resources.

Another missing relationship in the graph of DOTK ontology is the influence between the intellectual capital and operational and strategic level of organizational governance which is demonstrated in the complete semantic graph. In fact, the operational and strategic level of organizational governance is supported by intellectual capital. Moreover, political rule supervises the operational and strategic level of organizational governance within companies and geographic region for sustainable development.

Communication develops client satisfaction. Also, it can support the marketing which is associated with economic capital. Management realizes the economic capital for supporting technology. In addition, logistic require the management within companies for managing the production through the supervising the transports. So, in this way, it influences on the industry's activities.

In addition, industrial activities have the ecological influence on the ecosphere and environmental geographies such as emission and disposal waste. Moreover, industries coordinate the organization of industries for governance decision making and this coordination is associated with the expectation of social capital.

The relationships of explained entities missed in the semantic graph of DOTK ontology. So, the comparison between generalized semantic graph of DOTK ontology of Troyes (figure 5.6) and semantic graph of DOTK of Troyes (figure 4.14) help to have a complete semantic graph of DOTK ontology (figure 5.7). In fact, figure 5.6 cover the missed relationships in figure 4.14.

The complete semantic graph has some advantages:

- It demonstrates the relationships between most of the entities of territorial knowledge
- It could be detailed more for each entity
- It is possible to present a new graph with more detail and extend the relationships between the details
- It could be developed through the other researchers in the domain of sustainable development in future.

5.4 Case 2: organizations of sustainable development in Troyes

Three sustainable development organizations in Troyes are selected for final validation of DOTK ontology. These organizations help the enterprises in Troyes for implementation of sustainable development. The aim of this validation is to investigate whether DOTK ontology is useable or

assist the enterprises for sustainable development through these organizations or not. Moreover, the interviews with organizations aid to answer the third question research. To recall, the third research question is: territorial knowledge helps which level of hierarchical corporate levels for sustainable development?

These organizations act for executing of sustainable development within enterprise in Troyes. So, they are selected to answer the objective of this research. As mentioned before, the objective is to aid the enterprises for sustainable development through territorial knowledge. So, in following sections, these organizations are presented.

5.4.1 Organization 1: Troyes Champagne Métropole (TCM)

Since January 2017, the agglomeration community of Troyes Champagne Métropole⁵ has been created. Composed of 81 municipalities, it is the merger of the 3 communities of communes of Bouilly Mogne Aumont, Seine Melda Coteaux and Seine Barse, extended and the municipalities of Bucey-en-Othe, Estissac, Fontvannes, Messon, Prugny and Vauchassis. The agglomeration administers the daily life of 168,350 inhabitants over an area of 889 km². Figure 5.8 shows the municipalities and communities of Troyes Champagne Métropole.

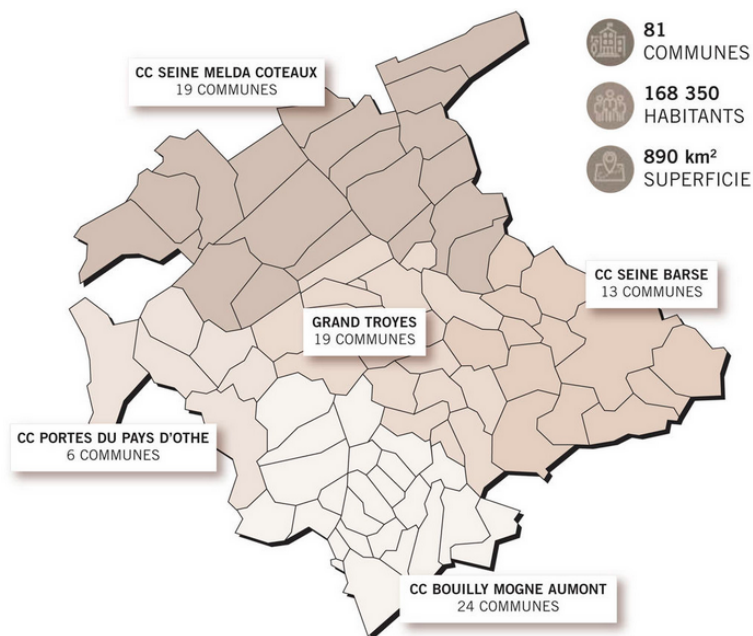


Figure 5.8: The agglomeration community of Troyes Champagne Métropole.

⁵ <http://troyes-champagne-metropole.fr/>

The main competences of Troyes Champagne Métropole are:

- **Economic development:** areas of industrial, commercial, tertiary, craft, tourist, port or airport activities; local trade policy and support for commercial activities of community interest; tourism promotion;
- **Landscaping:** SCoT and sector diagram; PLU, planning document; creation and realization of ZACs of community interest; organization of mobility;
- **Social balance of housing:** PLH, housing policy of community interest; actions and financial support for social housing; land reserves; actions in favor of housing for the disadvantaged; improvement of the built-up building stock;
- **City policy:** diagnosis and directions of the city contract; animation and coordination of contractual arrangements; action programs of the city contract;
- **Reception for Travelers:** development, maintenance and management of reception areas;
- **Environment and sustainable development:** climate change, household waste: collection and treatment.

5.4.2 Organization 2: Business Sud Champagne (BSC)

Business Sud Champagne⁶ is the new economic development agency of the Aube and South of Haute-Marne.

The missions of Business Sud Champagne are:

- The promotion of the territory;
- Business prospecting;
- Structuring of sectors of regional interest;
- Support for strategic businesses;
- Developing and ensuring the operational implementation of the strategic action plan to achieve the objectives set by the board of directors, while ensuring a real complementarity of actions with the economic development actors of the territory;
- In close connection with stakeholders in the economic development of the South Champagne territory, it put in place the territorial marketing tools and procedures aimed at the development and economic promotion of South Champagne, ensure a mission of

⁶ <https://www.aube-developpement.com/>

prospecting companies and make an offer advanced engineering in the direction of the companies of the territory (in particular for reconversions, research of financings ...).

It will be tasked with attracting new businesses, new investors, new project developers and new skills. Its role will be to enhance the attractiveness of the territory, to consolidate the image, to diversify the economic fabric and to create a pole of excellence at the gates of greater Paris. On the other hand, it succeeds Aube Development, which was a service of the CCI of Troyes and Aube.

5.4.3 Organization 3: Biogaz vallée

Biogaz Vallée⁷ is an organization that it is open to all players, national and international, wishing to advance the biogas sector by creating value in the territories, in France. Biogaz Vallée has five key missions to structure a sustainable and value-added sector:

- Accelerate the connection and networking;
- Share best practices to promote sustainability and local ownership of units;
- Facilitate access to financing;
- Develop the creation of skilled industrial jobs;
- Stimulate innovation to gain competitiveness and be able, in the long run, to be exempt from the subsidy.

Biogaz Vallée claims its local roots in Troyes, in the Aube, in the Grand Est region. However, the action scope of the cluster is national. The cluster is aimed at professionals in the sector. Its members are first and foremost providers of solutions and services: manufacturers, equipment manufacturers, developers, service and consulting companies, funders, insurers, network operators, etc.

The organization has prohibited any bias for an ideal model or unit size, as long as it covers a sustainable economic reality and that it fits in a relevant and sustainable way in its local context.

5.5 Interviews with the organizations to validate the DOTK ontology

As mentioned, three organizations in Troyes are selected for interview. To recall, Troyes Champagne Métropole (TCM), Biogaz vallée and Business Sud Champagne (BSC) are three

⁷ <http://www.biogazvallee.eu/>

organizations for interview. Concepts of DOTK ontology and implementation of DOTK ontology of Troyes presented to top-manager of these organizations during of interview. In fact, DOTK ontology of Troyes consist the entities of DOTK ontology and resources of Troyes. Moreover, the complete semantic graph of DOTK ontology introduced to them.

The main goal of interviews was the presentation of territorial resources of Troyes in order to understand whether the extracted resources of Troyes by DOTK ontology are useable for sustainable development objectives by these organizations or not. In other words, validation of these extracted territorial resources by top-manager of organizations can confirmed the usability of DOTK ontology that can aid them to find more territorial resources in this geographical territory for sustainable development. In fact, it can be confirmed that DOTK ontology assist the enterprises indirectly through these organizations. Therefore, some questions were prepared to survey about the DOTK ontology during of interview with top-managers. The questions are:

- Can DOTK ontology help you for sustainable development?
- Do the concepts of DOTK ontology and DOTK of Troyes are explicit?
- Does DOTK ontology help to add other elements to resources of Troyes for sustainable development?
- Do the resources of DOTK of Troyes are useable for your work for sustainable development?
- DOTK ontology helps to which level of hierarchical level of enterprises?
- Does the semantic graph is usable and applicable for representing the relationships of entities?

So, the interviews are done to present the DOTK ontology of Troyes and semantic graph. The mentioned questions asked from the top- managers in continuing the interview. In the following sections, the results of the interview investigate.

5.5.1 Finding from the interview with organizations

The interviews were performed with the top-manager of each organization separately. After presenting the objective of this research and DOTK ontology, the extracted resources of Troyes by entities of enduring, abstract and perdurant were investigated by the top-manager. The extracted resources of Troyes through the concepts of DOTK ontology were confirmed with top-managers that show the usability of DOTK ontology for their organizations for sustainable development

objective and geographical territory. Also, the entities of DOTK ontology were explicated for them, because the essence and meaning of these entities guide them to add some other resources to the DOTK ontology of Troyes. In other words, they asked for explanations of top concepts such as enduring, perdurant and abstract that were not understandable in current language. However, they immediately understand the entities of ontology through the sub-entities of enduring, perdurant and abstract and add elements to ontology of Troyes. Because, the essence and meaning of enduring, perdurant and abstract was understandable through the meaning of their sub-entities in DOTK ontology which were in domain of sustainable development. So, it is concluded that the entities of DOTK ontology are explicit for the top-manager.

So, adding the resources to DOTK ontology of Troyes by the top-managers show that DOTK ontology has the ability for extracting the territorial resources of each geographical territory for sustainable development of its enterprises.

Moreover, it is confirmed by the top-managers that they could find the most of entities and resources for sustainable development of enterprise in the DOTK ontology of Troyes. So, it is justified the usability of DOTK ontology in their works for implementation of sustainable development within enterprises in Troyes.

In order to answer the third research question of this thesis, it is asked from the top-managers. They confirmed that DOTK ontology and the semantic graph can assist the strategic level of its organization for their decision making for sustainable development. In other words, DOTK ontology of Troyes gives the viewpoint of strategic development to the top-manager for implementing of sustainable development within enterprises. In fact, the existence of territorial resources of Troyes help the top-manager during of their cooperation with strategic and tactical level of enterprise for implementation of sustainable development within enterprises. It is concluded that DOTK ontology of Troyes could help the decision making of strategic and tactical level of enterprises about sustainable development indirectly through the top-managers of organizations.

Moreover, entities of DOTK ontology and semantic graph are general and it is possible to extend more details about the entities. Discussion of more detail about the entities of DOTK ontology and semantic graph assist to have the ontology with more entities in detail and semantic graph with more relationships. So, these more details and relationships can aid the organizations to understand more meanings about the entities of DOTK ontology for integrating into their work for sustainable development.

Additionally, it is validated by top-managers that the semantic graph can facilitate the presentation of the relationship of entities according to the demand of enterprise for different projects. So, it could assist the enterprises for the strategic and tactical decision making in different projects of sustainable development because of its facilitating presentation of relationships between entities and their impacts. Furthermore, the methodology for building the semantic graph aid the organizations to build a new semantic graph according to every new project of enterprises that it helps to facilitate the presentation of relationships between entities of their projects. So, the semantic graph helps the better communication for decision making in strategic and tactical level of enterprises.

Also, one of the interesting questions of the top-managers was about the adaptability of DOTK ontology with the demands of enterprises according to their project for sustainable development. In fact, it was important for them to know whether DOTK ontology or semantic graph can be adapted with the demands of enterprises for the project of sustainable development in every geographical territory or not. This question is answered by the nature of entities of DOTK ontology. DOTK ontology covers the different essence and meaning of different territorial resources. In other words, DOTK ontology: (i) has a large scope, (ii) can be highly reused in different modelling scenarios, (iii) is conceptually well founded, and (iv) is semantically transparent. So, it is flexible to adapt to the different demand of enterprises because of the large scope of it.

One of another question of top-managers was about the implementation of the methodology of the building of semantic graph on another case study of their projects. The methodology of the modelling of semantic graph through the Text Mining by Voyant-tools allows to analyze any other case studies and presents a new semantic graph. In fact, this methodology allows to build a new semantic graph for the different projects of sustainable development that enterprises demand from the organizations. So, it concludes that the methodology of the building of semantic graph can be used for every case study in the different project of organizations to help the top-manger to make a decision for sustainable development and facilitate the presentation of relationships between entities.

So, these multiple surveys are conducted to validate the usability of DOTK ontology of Troyes and semantic graph. So, the asked questions and their answers, as explained previously in details, are listed in table 5.1. This table shows the questions that are asked from top-mangers Moreover, tis

table demonstrate the questions that are asked by top-mangers about the DOTK ontology and semantic graph.

Table 5.1: Survey of interviews with organizations.

Asked questions from top- managers of organizations	
Question	Answer
1. Can DOTK ontology help you for sustainable development?	The extracted resources of Troyes through the concepts of DOTK ontology is confirmed
2. Do the concepts of DOTK ontology and DOTK ontology of Troyes are explicit?	The essence and meaning of these entities guide him to add some other resources to the DOTK ontology of Troyes
3. Does DOTK ontology help to add other elements to resources of Troyes for sustainable development?	Through the essence and meaning of entities
4. Do the resources of DOTK of Troyes are useable for your work for sustainable development?	They can find the most of entities and resources for sustainable development of enterprise that are extracted by DOTK ontology
5. DOTK ontology helps to which level of hierarchical level of enterprises?	Aid the strategic and tactic to make a decision for sustainability
6. Is the semantic graph usable and applicable for representing the relationships of entities?	Aid the strategic and tactic to make a decision for sustainability. Also, the semantic graph can facilitate the presentation of relationship of entities according to the demand of enterprise for different projects
Asked questions by top- managers of organizations	
1. Can the DOTK ontology and semantic graph adapt with the demand of enterprises for different project?	The nature of entities of DOTK ontology covers the different essence and meaning of different territorial resources
2. Can the DOTK ontology and semantic graph implement on the another case study (another geographic territory)?	The methodology of building of semantic graph can be used for any case study in different project that enterprises demand from the organizations and help the strategic and tactical decision for sustainability

5.5.2 Usability of DOTK ontology by adding the other resources to DOTK of Troyes

As mentioned, the usability of DOTK ontology is confirmed by top- manager of organizations through the adding of other resources for sustainable development to the DOTK ontology of Troyes. In fact, the nature of entities of DOTK ontology allowed the top-manager to add the

complementary resources to the entities of abstract, enduring and perdurant of DOTK of Troyes. So, the entities of DOTK ontology of Troyes are completed. Therefore, it shows that the entities of DOTK ontology are explicit for top-manager of each organization that could add the other resources to the DOTK ontology of Troyes. The aim of this section is to discuss the other resources that are added to the DOTK of Troyes by top-manager during interviews.

The first entity that is investigated by top-manager was the quality as sub entity of enduring. During of project of **climate changes**, the **energy consumption**, **waste** and **bio-diversity** are measured with the entity of quality such as: present of emission, weight and size of waste. Moreover, some influences of bio-diversity consider by entities of quality to measure the influence on human health, natural space and climate change. In fact, climate change decrease through the protection of natural space. So, in this way, it can create value for climate changes and bio-diversity can reduce the harmful impact on human health.

Another entity of enduring is the **physical scale** as a sub-class of the physical object. Physical scale considers in the local, regional, national and international scale. The climate change investigates in **local scale** in Troyes. Also, the **ecological rules of region of Grand-Est** through the strategy of SRADDET (Schéma Régional d'Aménagement de Développement Durable et d'Égalité des Territoires) consider on the regional scale. SRADDET prepares the ecological rules according to the objective of climate changes for Grand-Est. **European rules for climate change** are determined for the **national scale** in France.

Moreover, **hydroelectric** is one of the resources for generating electrical energy in Troyes that it is considered in France. In fact, it has a second level of electrical energy generating in France.

Forest and **wood** are considered as the sub-class of biomass in natural resources of Troyes. In addition, **waste can be recycled** by the existing technology in Troyes and then, convert to the new form of the product. So, waste is categorized as sub-class of natural resources.

Economic capital as sub-class of non-agentive social object is very significant as a territorial resource of Troyes. The **circular economy** as a subset of economic capital has a vital role in relation to social capital. **Cooperative agriculture** is one of the resources of the circular economy in Troyes. The farmer can store the agricultural products in two shops in Troyes to sell the product and in this way, they can help the circular economy and society. Moreover, **Foyer Aubeois** is an association the recycling through the integration of the social economy by resold the equipment and social redistribution help the circular economy of this geographical territory. In addition,

repairing of the old bicycle is another project of circular economy in Troyes that help the economy of this territory to improve the sustainable development from the economic, environmental and social point of view.

The agentic social object is another entity of endurant that develop **social services**. For example, there is the association as the **social mediator** that give the consultation to the habitat for **economization of the energy** of buildings. So, this association can aid the relation between economy and social capital for sustainable development. In addition, the **health environment of Pollan** helps human society by rehabilitation of buildings and their isolation through the **optimization of material and energy consumption**.

E-grain and Petit débrouillards are two associations that develop the **aid to the individual and groups** of social capital such as public education, vocational training, the organization of an educational and cultural nature, education **movement for individual and collective behavior of sustainable development and global citizenship**.

Textile industries in Troyes use the water in their daily works that increase the pollution risk of water (environmental risk). So, it is created an isolate industrial zone through the environmental geography to decrease the environmental influence on the water and increase human security and health.

Figure 5.9 demonstrates the endurant resources of Troyes that are added to the DOTK ontology of Troyes by top-manger of oranzizations during the interviews. The blue entities are the resources of Troyes that are proposed by the top-managers. Also, red entities are the resources which are found from internet sites during first validation (section 5.3.2).

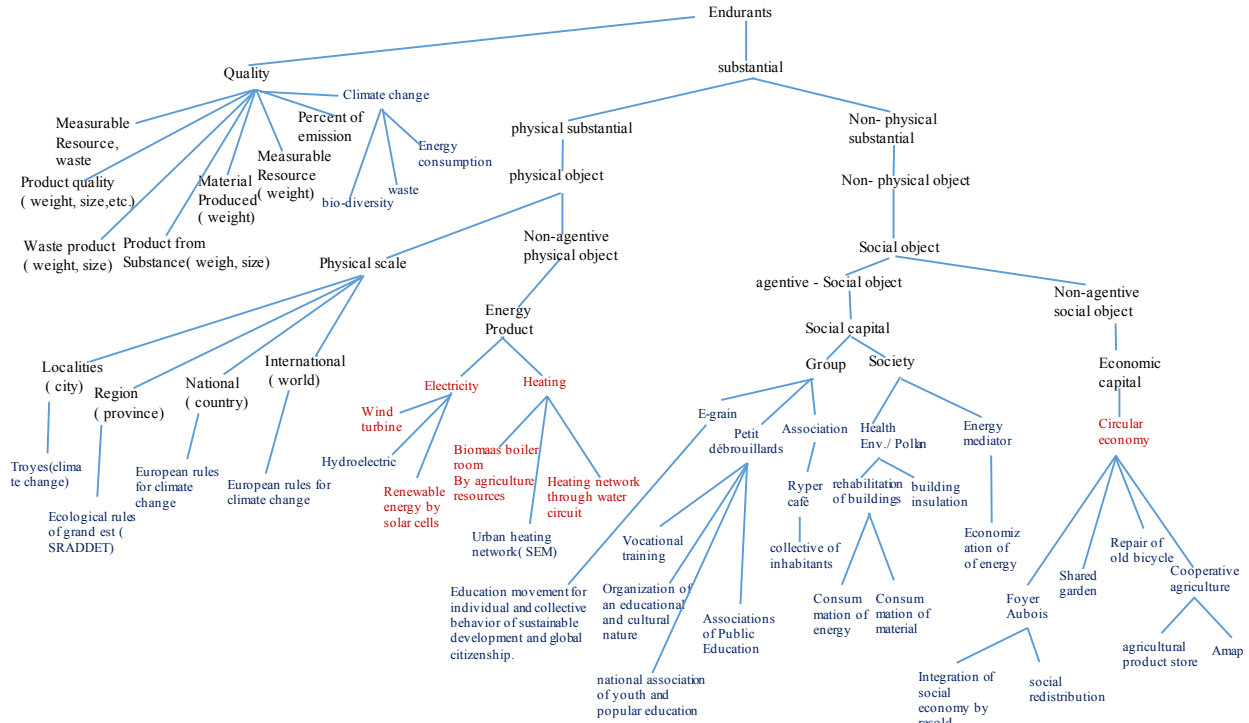


Figure 5.9: Endurant resources of Troyes which are added by top-manger of organization to DOTK ontology of Troyes.

In continuing the interview, the entities of the abstract of DOTK ontology are investigated. Some **diagnostic entities** proposed as abstract. These diagnostic entities in **climate changes project** of TCM that consist: the **quality of water and air, waste, energy and biodiversity**.

In addition, the **capability of an industrial organization** implements by the organizations. These organizations do the different activities to increase the capability of the industrial organization. For example, Biogaz vallée acts as the **facilitator for better diffusion of information between the industries by different workshops and interview** to help the sustainable development's implementation within industries. So, Biogaz vallée aids the business opportunity and solicitation exchange between industries through these workshops and interviews. Moreover, it helps the capability of industrial organization for **optimizing of logistic, energy, use of materials** and etc. Also, inter-enterprise displacement Plan by **Park of grand Troyes** aid the **reducing of the budget** related to the movement, better accessibility of industries and improve the social relations.

In relation to the **behavior** entities, the organization such as TCM develop the **collective activities** for sustainable development. The goal of collective activities is to help the enterprise for **optimizing of cost, security of actors and packaging**.

Culture as an entity of non-physical region of abstract in Troyes is considered for the objective of **sustainable mobilization and mobilizing of the population**. **Sustainable mobilization** improves the culture of **urban displacement** through the **city co-voiturage**, **clean vehicles** and **bicycle** in Troyes. Thus, sustainable mobilization reduces the environmental impact and has a positive influence on the sustainable development of the geographical territory. Moreover, **mobilizing of the population** is done via **events and workshops**, **communication between peoples** in these events and workshops and **political organization** by the city council.

The **property** attribute includes physical properties, chemical properties and eco-properties of a substance. So, the properties such as **recyclable**, **harmful**, **cleaning**, **non-recyclable** are considered as substance property in DOTK ontology of Troyes by enterprises for sustainable development.

The blue entities in figure 5.10 shows the abstract resources of Troyes that are added to the DOTK ontology of Troyes by top-manger of organizations during the interviews.

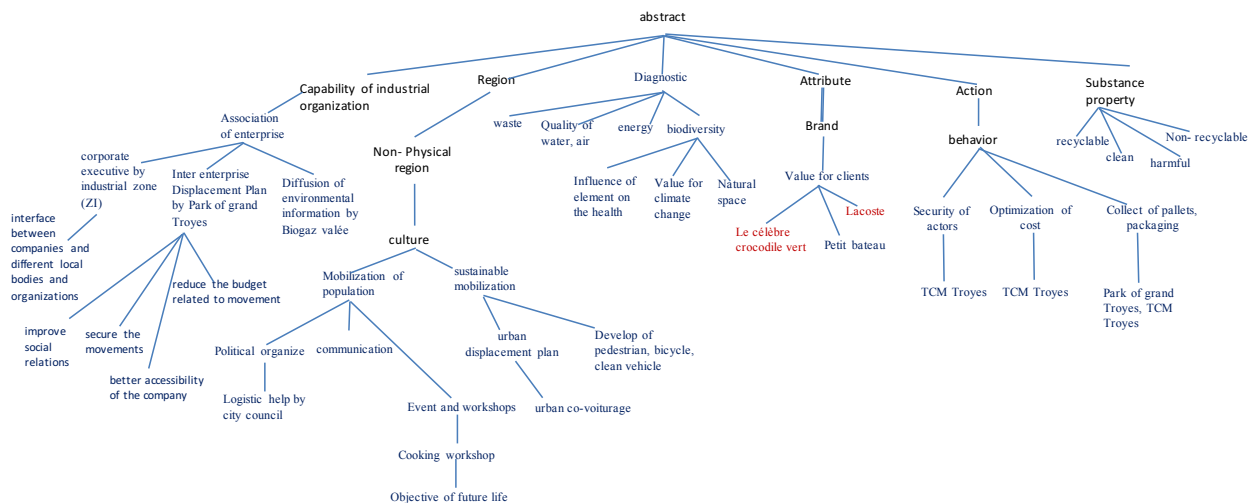


Figure 5.10: Abstract resources of Troyes which are added by top-manger of organozations to the DOTK ontology of Troyes.

5.6 Use cases for DOTK ontology of Troyes

Two use cases for DOTK ontology of Troyes is discussed during of interview with Business Sud Champagne (BSC). These use cases can assist the enterprises for implementation of sustainable development by BSC through the DOTK ontology of Troyes. So, these use cases of BSC consist:

1. The enterprises that demand from BSC for implementation of sustainable development.

2. The organization that search the enterprises for implementation of sustainable development Moreover, another use case is related to the real example in Troyes for the usability of DOTK of Troyes.

3. TCAT (Transport en Commun de l'Agglomération Troyenne)

TCAT is part of the multi-year programs of Troyes Champagne Métropole (TCM) in order to apply the guidelines of the community in terms of global travel policy, according to principles of direct management and transparency of financial flows. Moreover, the TCAT, whose bus network benefits from a great wave of innovations, is doing everything in close collaboration with TCM to offer the best conditions of travel in the respect of the quality of life and sustainable development. The goal of this section is to show how the territorial resources of DOTK ontology of Troyes can be usable for the organizations to implement sustainable development. In the following subsection, these use cases are explained by DOTK ontology of Troyes by BSC or TCM.

5.6.1 Use case 1: The enterprises that demand from BSC for implementation of sustainable development

It should be recalled that BSC is an economic development agency which help enterprises for economically sustainable development. There are the enterprises in Troyes that they request from the BSC for implementing sustainable development in its enterprise. So, following steps show the implementation of sustainable development by BSC as is shown in figure 5.11:

1. At the first step, the BSC consider what does the enterprise need. In other words, the first step is the analysis of needs.
2. At the second step, BSC can consider the needs of the enterprise in the DOTK ontology of Troyes to compare the existence of territorial resources with the needs of the enterprise. Because there are all of the necessary resources for sustainable development in the DOTK ontology of Troyes which can help the BSC to present them for enterprises. Moreover, BSC can explore the needed territorial resources of enterprise which don't exist in the DOTK ontology of Troyes.
3. So, at the third step, BSC can develop or find 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 BSC can find the resources or one alternative solution to respond to the demand of enterprise.

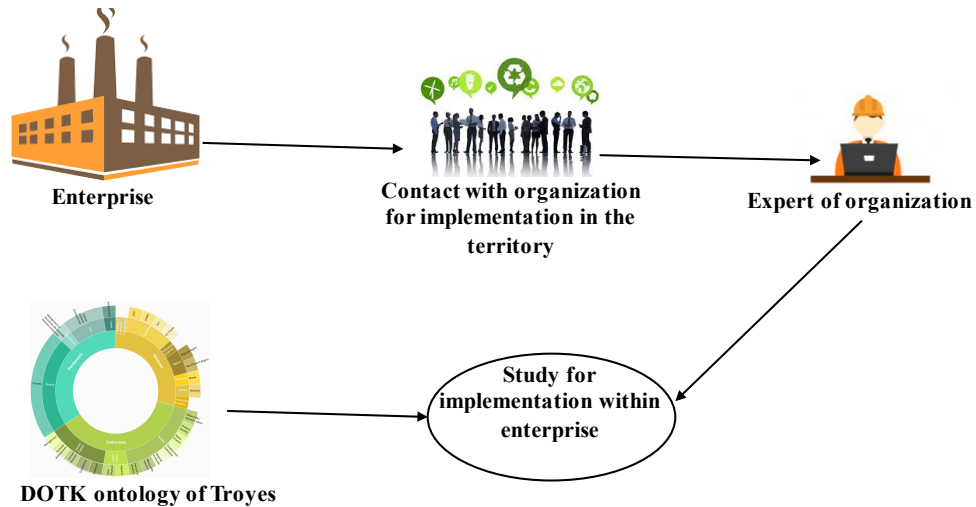


Figure 5.11: Scenario of use case 1.

Also, when the BSC is completing the necessary resources of Troyes to answer the request of the enterprise, the enterprise can **learn** from organization about the considered information to do sustainable development. So, in this way, the enterprise can learn what are the significant considered elements for doing sustainable development.

At this section is explained how the BSC uses the DOTK ontology of Troyes for executing of sustainable development of in different projects of enterprises. So, it can be concluded that the DOTK ontology of Troyes can help the strategic and tactic level of enterprise indirectly through the strategic level of BSC. Therefore, BSC by DOTK ontology of Troyes and territorial resources could aid the decision making for sustainable development within enterprises. The sequence model this use case is demonstrated in figure 5.12.

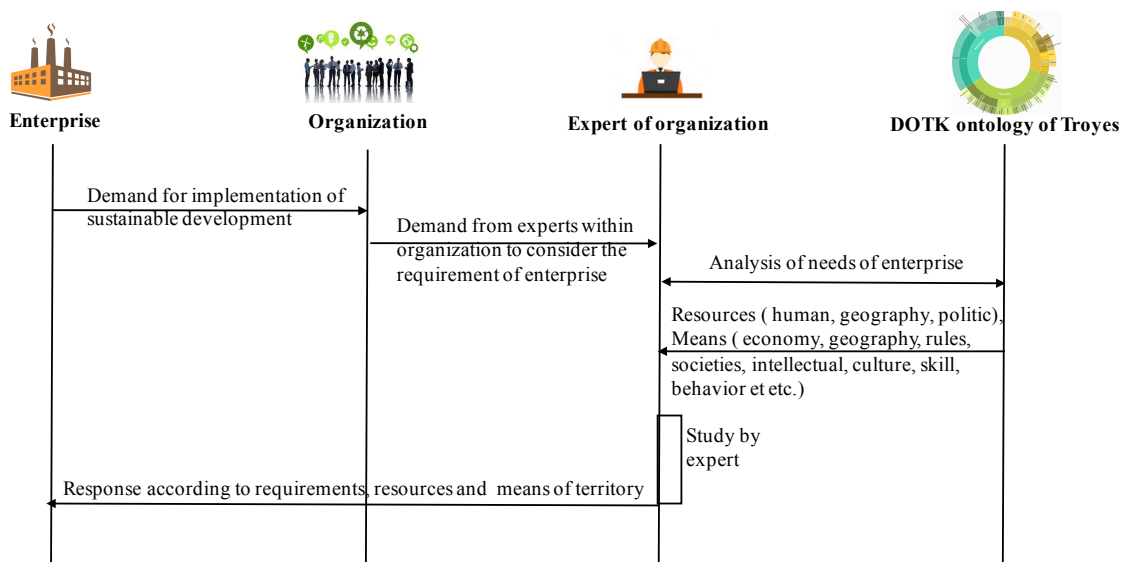


Figure 5.12: Sequence model of use case 1.

5.6.2 Use case 2: The organization that search the enterprises for implementation of sustainable development

BSC, also, searches the other enterprises in the other geographical territory to transfer them to Troyes and help them for implementing sustainable development. Scenario of this use case explains in below and it is demonstrated in figure 5.13.

1. At first, BSC considers all of existent territorial resources in the DOTK ontology of Troyes
2. At the second step, the BSC search the enterprises that can be interested in these territorial resources in a particular domain.

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, BSC can present the existing resources of logistic to the enterprises that want to transfer to Troyes. So, it is not necessary to study the resources that they are studied previously. Therefore, DOTK ontology can facilitate the presentation of resources and then, the BSC can prepare the report for the enterprises based on the existing resources to bring the enterprises in Troyes.

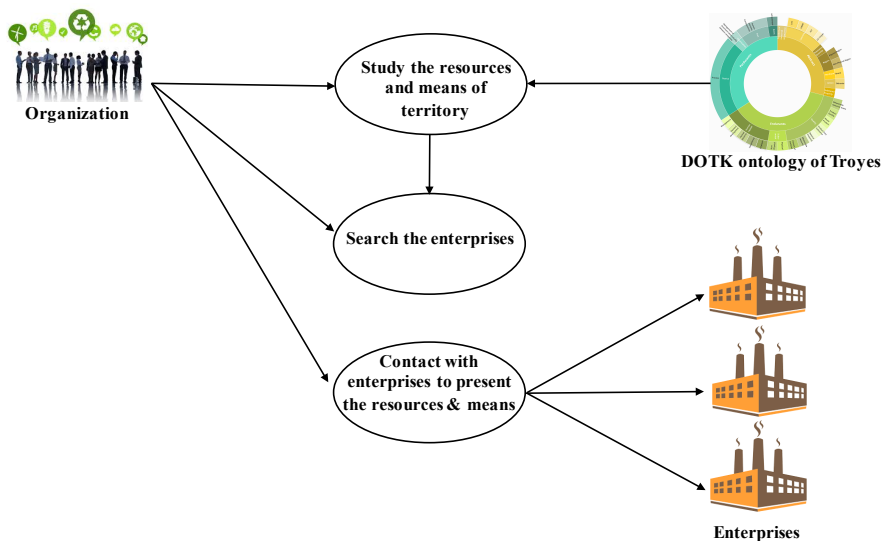


Figure 5.13: Scenario of use case 2.

In other words, there are some enterprises that are interested to transfer in Troyes but they don't information about the existing resources in Troyes. So, DOTK ontology of Troyes can help the

BSC to present the existing territorial resources of Troyes to the enterprises. Moreover, the semantic graph helps to the strategic decision making of enterprises. Therefore, in this way, BSC can help the implementation of sustainable development and decision making of the strategic level of enterprises for their transformation to Troyes. Figure 5.14 shows the sequence model of scenario of use case 2.

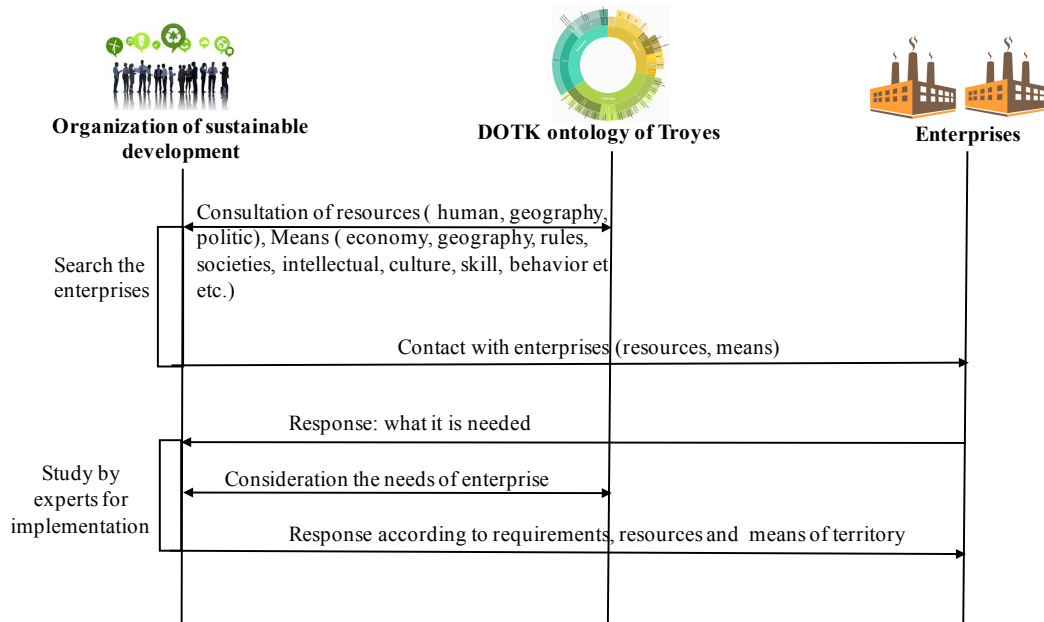


Figure 5.14: Sequence model of use case 2.

5.6.3 Use case 3: usage of DOTK ontology of Troyes for TCAT

As mentioned, TCAT is public transport of the Troyan agglomeration. Also, it cooperates with TCM in order to apply the guidelines of the community in terms of global travel policy in Troyes. Implementation of sustainable development for different projects of TCAT by TCM is explained in the following steps.

1. At the first step as use case 1, TCM considers what TCAT need for the project.
2. At the second step, TCM can find the existent and non-existent territorial resources in DOTK ontology of Troyes in relation to the project of TCAT.

Then, TCM can develop the resources for the improvement of the project of TCAT. Therefore, DOTK ontology of Troyes helps the TCM to analyze the real resources, real needs and develop the resources for this project of sustainable development. These steps are shows in figure 5.15.

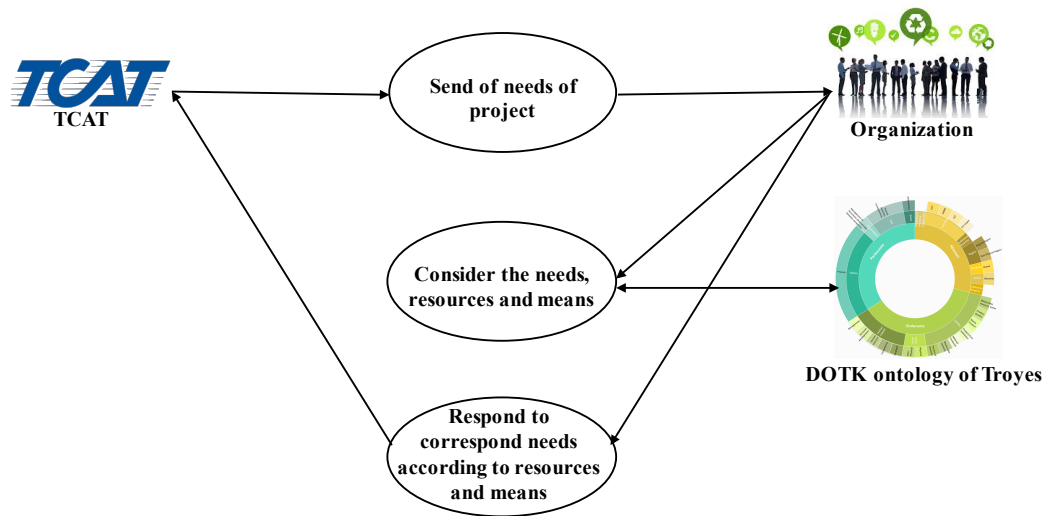


Figure 5.15: Scenario of use case 3.

It can be concluded, resources of DOTK ontology of Troyes in the project of TCAT cover the three dimensions of sustainable development (social, economic and environmental). In fact, there are the resources such as culture, behavior, social object, environmental regulation, rules, quaternary economy and etc. in the DOTK ontology of Troyes that justify the usability of all dimensions of sustainable development. Sequence model of this use case is presented in figure 5.16.

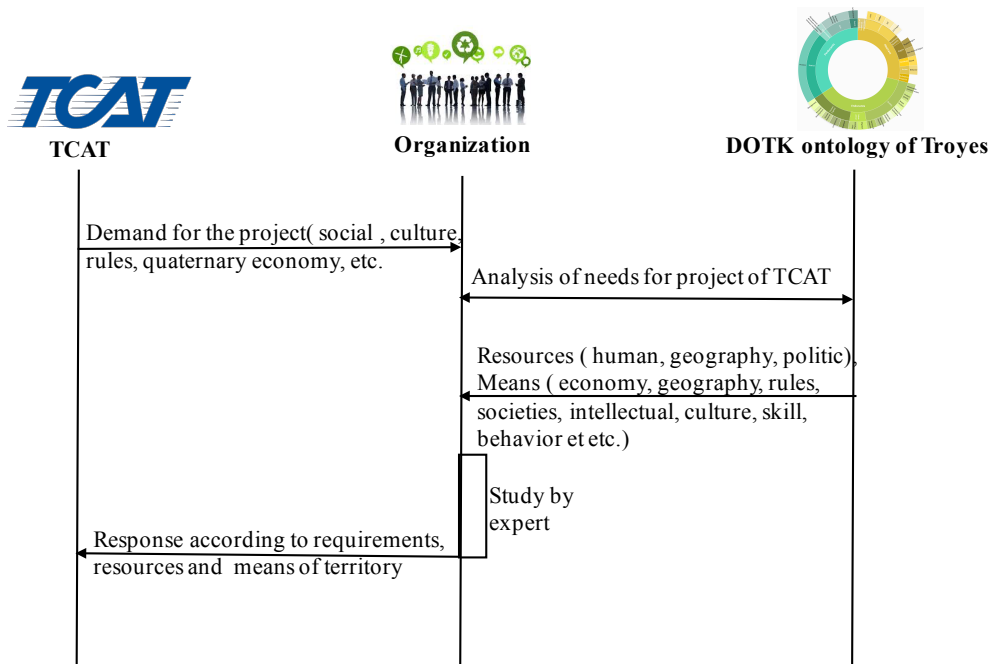


Figure 5.16: Sequence model of use case 3.

5.7 Conclusion

Modelling of application ontology with a real case is addressed in this chapter to validate the usability of DOTK ontology for enterprises and geographical territory. The first contribution consists of presenting the DOTK ontology of Troyes to validate the capability of DOTK ontology for identification of tangible and intangible resources of each geographic territory. This identification helps both organizations and territory for the objective of sustainable development. Moreover, a semantic graph of relationship between entities of DOTK ontology is presented by demonstration of relationship between entities and their influence on each other entities. For this purpose, a completed semantic graph is proposed that shows the more relationships and details.

The second contribution of this chapter consists of validating the DOTK ontology by presentation of DOTK ontology of Troyes and semantic graph to three sustainable development organizations in Troyes. As the results, these interviews confirmed the usability of DOTK ontology of Troyes for the organizations during their sustainable development projects.

In addition, three use cases scenario of DOTK ontology of Troyes for sustainable development are defined by BSC and TCM. These scenarios justified the usability of DOTK ontology of Troyes for implementation of sustainable development within enterprises through the organization. Moreover, these scenarios were only for utilization and readability to help the organization to know about the usage of DOTK ontology of Troyes.

Furthermore, it is validated that DOTK ontology of Troyes and semantic graph help the strategic decision for sustainable development and it could aid the strategic and tactical level of enterprises indirectly.

Chapter 5: Validation of DOTK: building an application ontology of Troyes	
Descriptive study (step of implementation and validation of the proposed ontology. Two types of evaluation are recommended: the use of the method for building an application ontology and its usefulness for enterprises)	Part 5.2
	Real case 1 for first validation: <ul style="list-style-type: none"> • Identifying of real case (Troyes) for building an application ontology
	Part 5.3
	Methodology for Modelling of DOTK ontology of Troyes: <ul style="list-style-type: none"> • Identifying the territorial resources (tangible & intangible) of Troyes through the DOTK ontology • Clarifying the entities of abstract in DOTK of Troyes • Clarifying the entities of endurant in DOTK of Troyes • Clarifying the entities of perdurant in DOTK of Troyes • Semantic graph of DOTK ontology of Troyes and the methodology for building a semantic graph
	Part 4.4
	Cases 2 for second validation: <ul style="list-style-type: none"> • Identifying the three enterprises in Troyes • Description of domain activities of these enterprises
	Part 5.5
	Interviews with enterprises to validate the DOTK ontology: <ul style="list-style-type: none"> • Description the finding from the interview with enterprises • Usability of DOTK ontology by adding the other resources to DOTK of Troyes
	Part 5.6
Use cases for DOTK ontology of Troyes: <ul style="list-style-type: none"> • The enterprises that demand from BSC for implementation of sustainable development. • The enterprises that the BSC search them for implementation of sustainable development. • Usage of DOTK ontology of Troyes for TCAT 	

6. CONCLUSION

Sustainability is concerned with the tension between the aspirations of mankind towards a better life on the one hand and the limitations imposed by nature on the other hand. In the course of time, the concept has been re-interpreted as encompassing three dimensions, namely social, economic and environmental. Different ancient philosophers discussed the essence and existence in the world and epistemology of nature that helped the life of human through the understanding of these subjects. In fact, it can be said that the ancient philosopher's subjects about the essence, existence and epistemology of nature have the objective of human development. Avicenna argued that the fact of existence cannot be inferred from or accounted for by the essence of existing things. He discussed that the form and matter by themselves cannot interact and originate the movement of the universe or the progressive actualization of existing things. Existence must, therefore, be due to an agent-cause that necessitates, imparts, gives, or adds existence to an essence (El-Bizri, 2001). Before of Avicenna, Aristotle attempted to classify the things in the world- where it is employed to describe the existence of being in the world. It is the study of existence, of all the kinds of entities that make up the world. In Aristotle's philosophy, the study of existence is an ontology. Sometimes 'ontology' is used in a broader sense, to refer to the study of what might exist; 'metaphysics' (El-Bizri, 2003).

Moreover, in this research, we were interested about the social knowledge as the social aspects of sustainability. The social knowledge as a human right is developed at first time by Cyrus (539 B.C) to improve the better life of human in its geographical territories (Wiesehofer, 2001). Simultaneously meeting the three criteria of social purpose, ecological prudence and economic efficiency measured by social means rather than simply by microeconomic profitability. So, all of the criteria for human development measure with social means that the promote the participative and deliberative dimensions of the local exercise of democracy.

These created fields by philosophers and researchers need to represent. Moreover, it needs to understand the nature of knowledge of these filed to aid the social aspects of human to infer the relationship between society and the existence and essence in nature. Logic as a precise method for reasoning about the knowledge is developed by Aristotle. But, Logic is only for inferring of the knowledge. So, it needs to represent the vocabulary of this knowledge. Ontology help to represent the nature and essence of knowledge and existence.

Logical structuring is the link between our ontology and philosopher inference about existence and essences. In fact, in our ontology, we have structured the knowledge that comes from the logic that

based the general ontology. Moreover, our ontology is tried to represent the existence and essences of sustainable development to develop the society, ecological crises and economic benefits of a geographical territory. Also, this ontology can help the human development of the territory as an objective of sustainability. Because this ontology is tried to consider the aspect of human capital such as culture, learning, skills, knowledge, a capability that help sustainable development from a social point of view.

Moreover, political capital such as governance, democracy, rules and regulations aim to build a balance between individual preference. In fact, it can be said that political capital integrates to human development and it must coordinate sustainable strategies and expectations from civil society. In addition to the social aspect in developed territorial ontology, environmental crises in relation to the human activities for economic benefits are considered. In summary, this territorial ontology tried to consider the existing elements of sustainable development that aid human development through the industrial organization.

6.1 Contribution to this research

The global aim of this research was to help the sustainable development of industries located in the system with five dimensions of real sustainability. For this purpose, a complete study about the system of under consideration and 5 dimensions of real sustainability is performed. It is found that the territorial dimension should also be considered, adapting global policy to local specificities to develop appropriate solutions. Moreover, the territorial dimensions should be integrated into industrial activities for sustainable development. Based on the presented literature review, the capture of knowledge about its territories for integrating territorial resources into the company's activities for sustainability is not developed in the different researches. Moreover, it is addressed that there is a lack of knowledge within industrial companies about its territory and environmental status. Subsequently, finding a tool for representing the type of territorial knowledge and integration to the industrial activities are followed through the ontology. The final step was the validation of usability of territorial ontology through the proposed real case of Troyes to show the identified territorial resources could help the strategic and tactical level of enterprises in term of decision making for sustainable development. In fact, this ontology creates a structure which helps to discover the new entities of territory for sustainable development goals.

This chapter outlines the major conclusions that can be drawn from the research presented in this thesis. Firstly, a summary of the research is presented. Secondly, the implications of the research are outlined, the contribution to current knowledge is presented.

Each of the research objectives was tackled in order to address overarching three research questions.

6.1.1 Research objectives

There were several research objectives forming the foundation of the research. This section outlines each objective, how it was addressed, the main findings and where this can be found within the thesis.

Objective 1: To highlight the absence of capture of territorial knowledge for integrating into the company's activities for sustainable development

This objective was addressed by the literature review in section 2.7. It is identified that consideration of territorial features is a kind of strategy for sustainability within industrial companies. Therefore, we looked for a fundamental solution to identify the support of territory as a resource flow for implementation of sustainability into industrial companies. So, supportive descriptive literature searches about the considering of territory in different works for sustainability were carried out (Table 2.1) to identify the specifications of territory and integration for sustainability. Finally, it is highlighted that capture of knowledge about features of the territory is not developed in different researches.

Objective 2: To identify that ontology is a tool of knowledge representation to identify the territorial knowledge

This objective was addressed in section 3.4, 3.5 and subsection of 3.5.3 by fact that ontological analysis clarifies the structure of knowledge. It is justified that without ontologies or the conceptualizations that underlie knowledge, there cannot be a vocabulary for representing knowledge. It is investigated that ontology, as one the tools of knowledge representation, could share the common understanding of a domain that could be communicated between people and application systems. In consequence, the principles for modelling a territorial knowledge are clarified to show the steps for modelling an ontology.

Objective 3: To propose a territorial ontology to show the relation of concepts of territorial knowledge for local or regional territory.

This objective was addressed by a methodology for modelling a territorial ontology. Therefore, a descriptive ontology for territorial knowledge (DOTK) is proposed through the following a methodology for modelling an ontology which is characterized in sections 4.3, 4.4 and 4.5. Moreover, the semantic graph demonstrates the attribute between concepts of DOTK ontology for understanding of their relationship and rule between concepts.

Objective 4: To identify the validation of DOTK ontology through building an application ontology and proving the usability of application ontology for enterprises

These objectives are addressed in chapter 5 by identifying the territorial resources of real geographical territory (Troyes). In consequence, the usability of DOTK ontology of Troyes is proved via the interview with three organizations of sustainable development. It is justified that DOTK ontology of Troyes and semantic graph could help the strategic decision making of enterprises for sustainable development through these organizations indirectly.

The research objectives mentioned above, describe the general and specific aims and outcomes that this thesis intends to achieve. They are directly linked to our research questions, which are explained in the next section.

6.1.2 How the research questions have been answered?

Based on the completed research objectives, it is possible for the three research questions; this section outlines each of the research questions, how they have been answered and which objective contributed to them.

Research question 1: Which types of territorial knowledge affects the sustainable objectives of industrial companies?

This research question was addressed using objective 1 and 3. As explained, there is a strong relation between the capture of territorial knowledge and sustainable development of local or regional industrial companies. For this purpose, a descriptive study is done to find the different territorial knowledge which helps the sustainable development within industries. Moreover, sustainability requires a semantic approach in order to understand the relationships of concepts of territorial knowledge. So, it needs to present a territorial ontology. At first step for modelling a territorial ontology, a taxonomy of the elements of territorial knowledge and sub-elements based on 5 dimensions of sustainability are categorized as tree flowchart. This categorization shows the types of territorial knowledge that influence on the sustainable development of industrial

companies (section 4.3).

Research question 2: How to represent and share this knowledge for sustainability's objective within industrial companies?

This research question was addressed using objective 2 and 3. It is explained about the importance of knowledge representation. It is found that ontology, as one of the tools of knowledge representation, could share the common understanding of a domain that could be communicated between people and application systems. Therefore, it is focused on the ontology as a tool for representation of territorial knowledge and sharing of this knowledge. So, in order to model a territorial ontology, a methodology and principles for modelling of ontology are followed. Thus, at the first step, elements of territorial knowledge and sub-elements based on 5 dimensions of sustainability are categorized. Then, DOLCE ontology is selected as a foundational ontology for normalizing of elements of territorial knowledge. DOLCE ontology can facilitate comprehension of territorial knowledge concepts and nature of this knowledge for actors of hierarchical levels to integrate sustainability in their activities. Therefore, a descriptive ontology for territorial knowledge (DOTK) is proposed through the following of methodology for modelling an ontology. DOTK ontology represents the "why reasoning" of each entity of territorial knowledge as a guide to help the actors of hierarchical level within companies. Moreover, the semantic graph demonstrates the attribute between concepts of DOTK ontology for the understanding of their relationship and rule between concepts. Also, the semantic graph as a guide helps the comprehension of semantic describing.

Research question 3: Territorial knowledge helps which level of hierarchical corporate level for sustainable development?

This research question was addressed using objective 4. Modelling an application ontology with a real case is investigated to validate the usability of DOTK ontology for enterprises and geographical territory. The first contribution consists of presenting the DOTK ontology of Troyes to validate the capability of DOTK ontology to identify the tangible and intangible resources of each geographical territory to help both enterprise and territory for sustainable development objective. Moreover, a semantic graph of the relationship between entities of DOTK ontology is presented to demonstrate the relationship between entities and their influence on each other entities. For this purpose, a completed semantic graph from the comparison is proposed that shows more relationships and it can be detailed about each entity.

The second contribution consists of validating the DOTK ontology by presentation of DOTK ontology of Troyes and semantic graph to three sustainable development organizations in Troyes. As the results, these interviews have confirmed the usability of DOTK ontology of Troyes for the enterprises during their sustainable development projects.

In addition, three use cases scenario of DOTK ontology of Troyes for sustainable development of enterprises by BSC and TCM are defined. These scenarios demonstrate how DOTK ontology of Troyes help the enterprises through three organizations. Furthermore, it is validated that DOTK ontology of Troyes and semantic graph help the strategic decision for sustainable development and they could aid the strategic and tactical level of enterprises.

After identifying and addressing three phenomena, which are addressed by research questions, I hope to attain the research goal.

Global research aim: capture and representation of territorial knowledge by providing a territorial ontology and semantic graph help the hierarchical level of enterprises for better understanding and common sharing of concepts of territorial knowledge.

This thesis presents a territorial ontology for including territorial resources features in sustainable development steps. The state of the art clarified the lack of capture of territorial knowledge as a major gap for finding the possible concepts for sustainable development of enterprises. It is vital to provide a means of knowledge representation to bridge this gap and to smoothly continue the capture of territorial knowledge. By providing the means for capturing and representing of territorial knowledge, it is possible to share the common understanding of territorial concepts for sustainable development.

6.2 Limitations

In this section, I am going to concentrate on the aspects whose limitations had the greatest potential impact on the research:

Lack of prior research studies on this topic: Capture of knowledge about the territories is not developed in the different researches of this field, this caused some difficulties at the beginning of research in the literature review and state of the art sections. On the other hand, this issue serves an important opportunity to identify gaps in the literature and to describe the need for further research.

The difficulty for finding the elements of territory in relation to sustainable development: As the objective of this thesis was to identify the territorial elements that aid the sustainable

development of enterprises. So, finding the territorial element was difficult because of insufficient studies in this domain. Moreover, the domain of sustainability is very large and it was so difficult to find all of the territorial elements in the relation to sustainable development of enterprises. Therefore, it is tried in this research to identify the main and necessary element of territory for the objective of sustainability. But, the entities of proposed territorial ontology are provided the opportunity to add other founded elements to this ontology by other researchers in future. In other words, this territorial ontology is provided a structure for future works in this domain.

Lack of industries in the domain of sustainable development in Troyes: Accesses to proper industries in term of sustainable development was another limitation in Troyes. In order to understand how this ontology and semantic graph can help the operational level of industries, it was necessary to do a direct interview with operational actors and present the territorial ontology to them. Because we couldn't find the industries in the domain of sustainable development in Troyes, territorial ontology is validated by the organizations that implement the sustainable development within enterprises. So, this question has remained without response that whether territorial ontology can aid the operational level of industries or not.

Lack of consideration of all entities of perdurant by organizations: Perdurant consist of non-physical entities in the territorial ontology. So, it covers the human and political capital of territory for sustainability. But, all of the entities of perdurant don't take into account by organizations during their activities for sustainable development. Moreover, entities of perdurant are very interesting field which is necessary to consider all of its aspects by organizations for sustainable development in relation to human capital.

6.3 Future research

Finally, the discussion outlined in this chapter and the conclusion identified in this chapter highlighted several potential areas for future research. These fall into two main areas:

6.3.1 Short term

Developing of more details about the entities of DOTK ontology: The presented entities of DOTK ontology are general concepts for sustainable development. There is the possibility in this ontology according to the presented methodology, to develop the entities of DOTK ontology with more details. So, it is possible to extend the more details about each entity in the specific domain.

Moreover, there is the possibility to develop more details of relationships between entities of the semantic graph in a specific domain of each entity according to our methodology for building a graph.

Visualization of DOTK ontology: DOTK ontology is presented as tree flowchart. These tree flowcharts are not usable for the website. So, finding a method for visualization can help to use this ontology for websites. Therefore, it can be visualized to use enterprises within hierarchical levels, particularly in the tactic strategic level. So, the visualization of DOTK ontology can be considered in short term works.

In term of visualization, there are some possibility to present the concepts of DOTK ontology. There are some forms for design of DOTK ontology to visual it. These forms are: form of pyramid, nested circles, circular. Moreover, these forms should be tested.

Extension of scenarios of use cases: as mentioned, the organizations consider the DOTK ontology of Troyes to implement sustainable development within enterprises in Troyes. So it is possible to provide a possibility for enterprises to consider the DOTK ontology of Troyes directly. Then, they demand from organizations to implement sustainable development in their enterprises according to the existent territorial resources. Finally, organizations can give the response to the demand of enterprises. Therefore, different scenarios can be extended for usability of DOTK ontology of Troyes.

6.3.2 Long term

Implementing DOTK ontology to help the operational level of enterprises: As mentioned, there is a lack of implementation of DOTK ontology to aid the operational level of enterprises. So, finding a method for implementing DOTK ontology at the operational level of enterprises can be developed in future research. However, it can explicit and help the better communication concepts of territorial resources between three level of strategy, tactic and operation within enterprises.

Developing a software: As mentioned, this territorial ontology creates a structure which helps to discover the new entities of territory for the objective of sustainable development. Moreover, it can be used in every geographical territory. Moreover, the relationships between entities are shown through a semantic graph. So, territorial ontology and semantic graph create the possibility to show the relationships between entities of territories which influence on the aspects of sustainability.

So, the identified entities by territorial ontology can be used in developing software for sustainable development objectives. So, it will be usable in the hierarchical level of industries to explicit the knowledge in relation to sustainable development. Use of these rules and concepts produce new knowledge to integrate into specific application ontology. So, it will be interesting to develop a methodology to evolve DOTK ontology continuously.

List of publications

Journal:

- A.Ezoji, N. Matta, (2019) “Guides to Implement Sustainable Development within Enterprises through a Territorial Ontology”, journal of cleaner production, submitted and under review 2019.

Conferences:

- A.Ezoji, N. Matta, (2018, September) “ How territorial knowledge on the sustainable development within companies ”, the 10th International Conference of Knowledge management and Information System (KMIS), Seville, Spain, published 2018.
- A.Ezoji, N. Matta, (2018, November) “ DOTK : descriptive ontology for territorial knowledge for sustainability”, IEEE, the 14th International conference of SITIS, Workshop of Knowledge Acquisition Reuse & Evaluation (KARE), Las palmas de gran Canaria, Spain, published 2018.
- A.Ezoji, N. Matta, (2019, August) “ Identification of territorial resources based on domain ontology (DOTK) for sustainability ”, the 9th IFAC, International conference on Manufacturing Modeling, Management, and control (MIM), Berlin, Germany, accepted 2019.
- A.Ezoji, N. Matta, (2019, August) “Territorial knowledge ontology as a guide for the identification of resources of the territory toward sustainability, the 22th International Conference of Engineering Design (ICED), Delft, Netherlands, accepted 2019.
- A.Ezoji, N. Matta, (2019, April) “ Identification of territorial resources based on domain ontology (DOTK) for sustainability ”, 16ème Colloque National, l’Industrie du Futur, Une Révolution pour l’Humain? (S.mart), Vallée de la Maurienne, France, accepted 2019.
- A.Ezoji, N. Matta, (2019, September) “ Assist the sustainable development within industries through the territorial knowledge ontology ”, the 11th International Conference of Knowledge management and Information System (KMIS), Vienna, Austria, accepted 2019.

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Appendix A: French version

Résumé français

**DOTK: ontologie territoriale comme un outil pour
aider les industries pour le développement durable**

A. 1 Introduction

Le concept de durabilité est complexe. Toutefois, il est possible de dégager certaines de ses caractéristiques les plus fondamentales et générales en adoptant une approche systémique (Gallopín 2003). Les questions de durabilité touchent toutes les composantes de notre société, des individus aux organisations régionales et mondiales : les crises écologiques ou sociales majeures sont dues à la surconsommation des ressources naturelles et à l'inégalité croissante à l'échelle locale et mondiale. La durabilité ne consiste pas à préserver des ressources, un produit, une entreprise ou une organisation, mais plutôt à ne pas systématiquement dégrader le système socio-écologique mondial. En fait, la durabilité est une propriété du système ; par conséquent, les produits, les services, la technologie ou l'organisation ne peuvent pas être durables à eux seuls, mais peuvent être des éléments de systèmes durables (Allais et al., 2017). De plus, l'attention croissante accordée au développement durable encourage les entreprises à intégrer les questions de durabilité dans leurs activités. Pour accroître la performance de cette intégration, les aspects durables devraient être intégrés à tous les niveaux hiérarchiques de l'entreprise, depuis les décisions stratégiques globales prises par la haute direction jusqu'à la planification et l'organisation par la gestion tactique, aux activités quotidiennes d'ingénierie et de production de la zone opérationnelle (Zhang et al., 2013).

Une stratégie durable ne peut donc pas être considérée comme une question indépendante : elle doit être intégrée dans la stratégie globale de développement des entreprises. Cette intégration doit soutenir des objectifs durables afin de s'aligner sur les autres tendances et contraintes actuelles des entreprises à l'échelle mondiale. Pour ce faire, l'entreprise doit soigneusement et raisonnablement décomposer la « durabilité » en plusieurs actions ou attributs pour l'aider à comprendre (Hallstedt et al., 2010). Ainsi, une définition anthropique de la durabilité avec 5 dimensions (5D) a été adoptée (Figuiere et Rocca, 2008). Il se concentre sur les objectifs de durabilité du développement humain (sphère sociale). L'environnement est considéré comme le facteur limitant de l'activité anthropique (sphère écologique). La sphère économique est considérée comme un moyen (et non comme un but) qui permet la réalisation des objectifs sociaux par rapport aux frontières écologiques. La sphère politique doit définir des orientations de développement et doit être suffisamment forte pour avoir préséance sur les acteurs économiques. La sphère politique est considérée comme un lieu de débat public et d'orientation sociétale et décisionnelle à long terme. En fait, les politiques publiques sont la seule façon légitime de définir l'intérêt public et le bien commun ; par conséquent, elles doivent

coordonner les stratégies industrielles durables et les attentes de la société civile (Allias et al., 2017). La dimension territoriale devrait également être prise en compte, en adaptant la politique mondiale aux spécificités locales pour développer des solutions appropriées. Un territoire est une combinaison complexe et évolutive d'un ensemble d'acteurs dans lequel se déroulent des activités humaines et de l'espace géographique que ces acteurs utilisent, aménagent et gèrent (Moine, 2006). Concernant le rôle croissant des ressources territoriales pour la durabilité et selon la revue de littérature (Allais et al., 2015, Vadoudi et al., 2017, Zhang et al., 2013), certains chercheurs ont examiné le rôle des ressources territoriales sur la durabilité sous différents aspects.

A.2 Formulation de problèmes de recherche et questions de recherche

En termes d'utilisation des ressources territoriales pour un objectif durable au sein des industries et d'assistance aux niveaux hiérarchiques, la méthode a été étendue pour appuyer la sélection de l'objectif stratégique vers la durabilité par l'intégration des ressources territoriales dans le processus de conception. L'intégration des ressources territoriales dans le processus de développement des produits aide le niveau stratégique, la conception du produit durable et l'exploration des ressources de leur territoire. En outre, une meilleure circulation de coopération entre les niveaux hiérarchiques pour un objectif durable, seulement, est considérée du point de vue environnemental et d'autres termes de durabilité n'ont pas été pris en considération. De plus, les ressources territoriales ne sont pas prises en compte. De plus, l'interaction entre l'état environnemental du territoire et l'impact environnemental du produit peut aider à l'examen de la conception pour la durabilité.

Toutefois, une attention insuffisante a été accordée à toutes les ressources intangibles et tangibles du territoire qui peuvent contribuer à la durabilité au sein des entreprises industrielles. De plus, l'intégration des ressources territoriales (intangibles et tangibles) au niveau hiérarchique peut aider les industries à assurer leur durabilité. Ainsi, le manque de connaissances sur les caractéristiques du territoire et le manque de connaissances sur l'environnement du territoire constituent un obstacle à la recherche des concepts possibles de durabilité. Ainsi, il est nécessaire d'organiser et d'identifier les connaissances territoriales pour la durabilité dans l'entreprise. L'objectif scientifique est centré sur l'identification de la façon de représenter les ressources territoriales comme la connaissance territoriale et rendre explicite cette connaissance pour les acteurs du niveau hiérarchique. La figure

Il montre la prise en compte du système et les cinq dimensions de la durabilité. Les entreprises en tant qu'objet d'étude sont situées dans cet écosystème. Au niveau hiérarchique des entreprises industrielles (organisation industrielle). Il faut comprendre cette prise en compte du système afin d'accroître leurs connaissances au sujet de leurs ressources territoriales afin d'intégrer ces connaissances à leurs activités de durabilité. Augmentation de la connaissance du niveau hiérarchique, influence sur la prise de décision de la stratégie pour créer de la valeur pour l'humain par rapport à la connaissance des territoires.

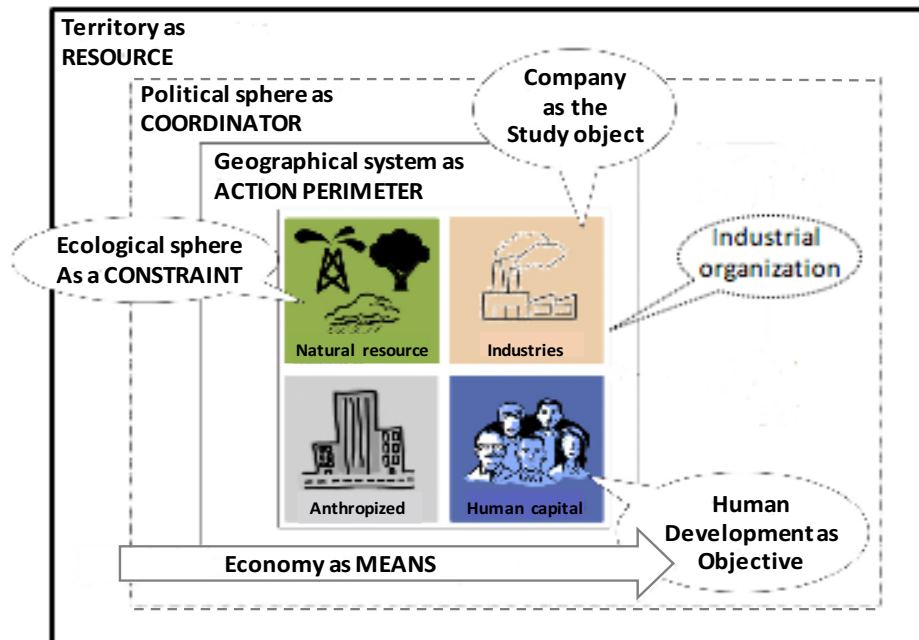


Figure 1: Les cinq dimensions de la durabilité (adapté des travaux d'Allias et al., 2017)

Basé sur la revue de littérature, il est précisé que la détermination des ressources territoriales peut contribuer à la durabilité au sein des industries. Cependant les types de ressources territoriales qui affectent les objectifs durables des entreprises industrielles ne sont pas clairement identifiés. Ce qui nous amène à se poser les questions de recherche suivantes :

1. Quel type de connaissance territoriale affecte les objectifs de durabilité des entreprises industrielles
2. Comment représenter et partager ces connaissances pour atteindre l'objectif de durabilité au sein des entreprises industrielles ?

En fait, trouver une méthode pour comprendre, comment les ressources territoriales peuvent aider les industries et répondre à ces deux premières questions, permet de répondre à la troisième question. La troisième question de cette thèse est la suivante :

3. Les connaissances territoriales peuvent aider quel niveau organisationnel hiérarchique dans une entreprise ?

En fait, nous supposons que les ressources territoriales et la durabilité ne sont pas indépendantes et que les caractéristiques du territoire influenceraient le développement durable au sein des entreprises industrielles. Mais nous ne savons pas comment ces ressources influenceraient la durabilité, en particulier comment représenter et partager ces connaissances territoriales.

A.3 État de l'art

La bibliographie nous a aidé à comprendre qu'il est nécessaire de saisir les connaissances sur les caractéristiques des territoires pour intégrer les ressources territoriales dans les activités de durabilité de l'entreprise. Il est donc nécessaire de représenter cette connaissance. La représentation des connaissances est un sujet multidisciplinaire qui applique des théories et des techniques pour développer des ontologies comme représentations partagées des connaissances. De plus, il est constaté que l'ontologie est un outil qui peut aider à expliciter la ressource territoriale pour la durabilité.

Fondamentalement, le rôle des ontologies dans le processus d'ingénierie des connaissances est de faciliter la construction d'un modèle de domaine. Une ontologie fournit un vocabulaire des termes et des relations permettant modéliser le domaine. Selon la proximité du domaine en question avec l'ontologie, le support est différent. Toutefois, la nature d'une ontologie l'empêche d'être directement applicable à des domaines particuliers (Studer et al., 1998). En 1993, Gruber avait défini à l'origine la notion d'ontologie comme une « spécification explicite d'une conceptualisation » (Gruber, 1993).

En sa forme la plus forte, une ontologie essaye de capturer la connaissance universellement valable, indépendante de son utilisation, une vue étroitement liée à son origine philosophique. Des chercheurs a rapidement renoncé à cette vue, parce que l'utilisation il s'est avéré que spécifique de connaissance a influencé son modelage et représentation. D'autres chercheurs visent à capturer la connaissance de domaine, indépendante de la tâche ou de la méthode (Guriono, 1995). L'analyse ontologique clarifie la structure de connaissance. Étant donné un domaine, son ontologie forme le

cœur de n'importe quel système de représentation de connaissance pour ce domaine. Sans ontologies ou les conceptualisations qui sont à la base de la connaissance, il ne peut pas y avoir un vocabulaire pour représenter la connaissance. Ainsi, ce système de représentation et le vocabulaire, doivent exécuter une analyse ontologique effective (efficace) du champ ou du domaine. Des analyses faibles mènent aux bases de connaissance incohérentes. De plus, les ontologies permettent le partage de connaissance. Pour construire une langue de représentation de connaissance basée sur l'analyse, nous devons associer des termes avec les concepts et des relations dans l'ontologie pour concevoir une syntaxe pour la connaissance en termes des concepts et des relations. Nous pouvons partager cette langue de représentation de connaissance avec d'autres qui ont des besoins semblables de la représentation de connaissance dans ce domaine, éliminant ainsi le besoin de reproduire le processus d'analyse de connaissance. Les ontologies partagées peuvent ainsi former la base pour des langues de représentation de connaissance spécifiques à domaine. Cette sorte de partage augmente énormément le potentiel pour la réutilisation de connaissance (Chandrasekaran et al., 1999).

A. 3. 1 Hypothèse

L'ontologie est au cœur de toute description de connaissances : la connaissance est intimement liée à l'ontologie puisqu'elle est nécessairement exprimée en termes d'ontologie. Par conséquent, la conception de l'ontologie d'un domaine est une question clé pour la représentation des connaissances (Gruber, 1993). En fait, nous supposons que l'ontologie peut faciliter le partage et l'échange des connaissances territoriales dans les divers niveaux hiérarchiques des industries afin d'accroître le rendement durable. Ainsi, une ontologie de domaine fournit une structure conceptuelle et une clarification qui rendent explicites et précises les notions territoriales importantes pour la durabilité.

Ainsi, l'hypothèse de cette thèse peut être exprimée comme suit :

« L'ontologie territoriale peut faciliter le partage des connaissances territoriales et justifier la ressource du territoire pour l'objectif de développement durable des industries »

A. 4 Ontologie descriptive pour la connaissance du territoire (DOTK)

L'objectif est de modéliser une ontologie territoriale afin de représenter les caractéristiques du territoire pour un éventuel concept de durabilité. Selon la méthodologie utilisée (Bachimont, 2000) pour manipuler une ontologie territoriale, la première étape consiste à créer une taxonomie des connaissances territoriale qui affecte la durabilité des entreprises. Ainsi, l'état de l'art est centré sur les éléments du territoire qui affectent la durabilité au sein des industries. Par conséquent, une taxonomie avec quatre principales parties du territoire est proposée et d'autres éléments trouvés sont classés comme sous-éléments de ces quatre parties. Ainsi, la taxonomie des connaissances territoriales est décrites selon les catégories de capital géographique, humain, économique et politique.

Ensuite, nous avons choisi une ontologie générique à de normaliser les éléments de la taxonomie territoriale pour la modélisation de l'ontologie. Après normalisation, on présente l'ontologie descriptive des connaissances territoriales (DOTK) et ses notions.

Afin de montrer les relations entre les concepts de l'ontologie DOTK, un graphique sémantique est étudié. Ce graphique basé sur les outils de Text Mining comme Voyant-tools⁸. Voyant-tools est l'un des logiciels libres Text Mining qui est utilisable sur Internet

1. En résumé, la méthodologie de modélisation de l'ontologie territoriale peut être expliquée dans les étapes suivantes : Détermination de la catégorisation conceptuelle des connaissances territoriales
2. Considération de l'ontologie fondamentale pour la normalisation (base fondamentale de l'ontologie)
3. Spécialisation de l'ontologie de haut niveau (Gangemi et al., 2003) selon les taxonomies conceptuelles des connaissances territoriales pour la modélisation d'une ontologie dans le domaine du territoire pour la durabilité.
4. Modélisation de l'ontologie DOTK

Dans les sections qui suivent, les différentes étapes de la méthodologie sont expliquées en détail avec leur logique et leurs objectifs.

A. 4.1 Catégorisation conceptuelle des connaissances territoriales

⁸ <https://voyant-tools.org/>

Le territoire est largement touché par les activités de l'entreprise et l'entreprise peut être largement touchée par son territoire. Il est donc nécessaire de définir la notion de ressource intangible et tangible du territoire comme connaissance territoriale qui soutient l'intégration du développement durable dans les entreprises. La dimension territoriale devrait être prise en compte, en adaptant la politique mondiale aux spécificités locales afin de développer une solution appropriée pour l'industrie (Moine, 2006). Afin de décrire les connaissances territoriales, il est nécessaire de justifier les principaux éléments des connaissances territoriales et leurs sous-éléments. Ainsi, les principaux éléments de la connaissance territoriale qui sont extraits de la littérature, sont : capital humain, géographique, économique et politique qui est adapté avec 5 dimensions de la durabilité. Le capital humain est évalué comme un fournisseur de valeur clé en intégrant le capital individuel, social et organisationnel comme l'une des principaux éléments du territoire (Gobert and Allais., 2016). Le capital organisationnel au sein de l'entreprise assure l'utilisation efficace des ressources. Les individus et les groupes sociaux identifient l'interaction avec leur environnement au sein d'un système géographique (Barreteau et al., 2016). Les activités humaines se produisent dans le système géographique géré par les intervenants (Nitschelm et al., 2016) et le capital infrastructurel dans le système géographique utilisé pour des projets et des installations spécifiques visant à améliorer la productivité (Gobert and Allais., 2016). La gestion du capital géographique se fait par entité politique (Barreteau et al., 2016). En outre, le capital économique crée de la valeur pour l'homme et l'industrie par le biais du produit pour la consommation humaine et fournit la ressource pour l'activité industrielle (Nitschel et al., 2016).

L'objectif de la catégorisation est d'identifier les éléments du territoire qui contribuent au développement durable des entreprises selon 5 dimensions de la durabilité. La figure 2 montre tous les éléments des connaissances territoriales pour la modélisation d'une ontologie.

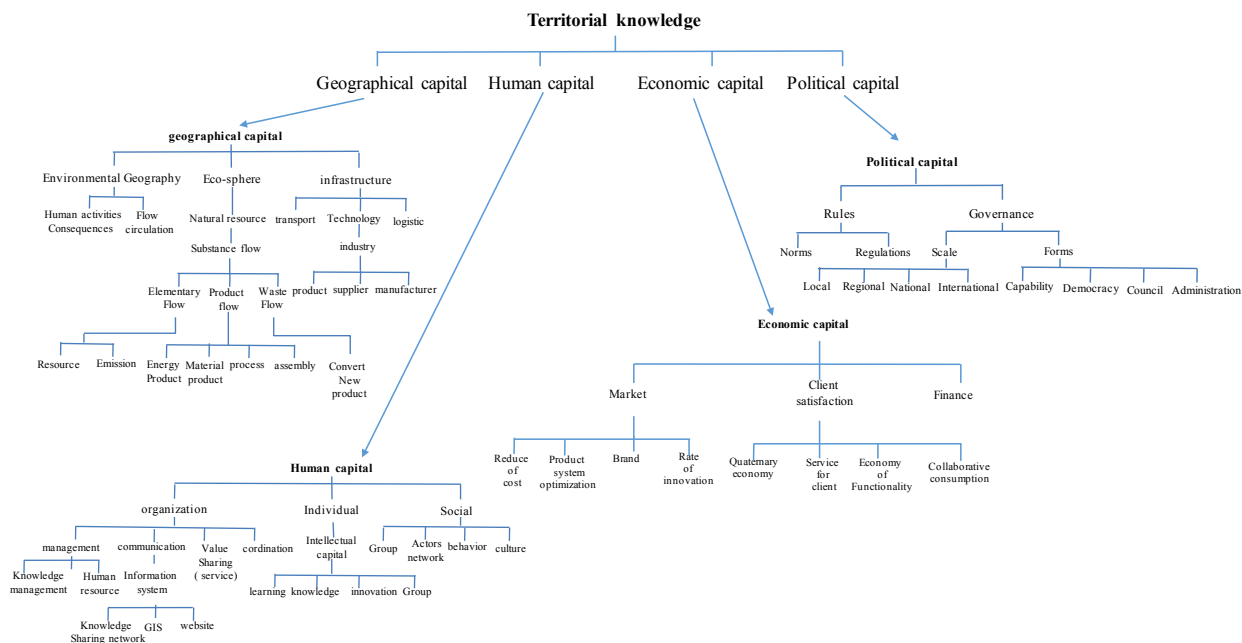


Figure 2: Catégorisation conceptuelle d'éléments de connaissance territoriale

A.4.2 Ontologie fondamentale pour la normalisation de la catégorisation conceptuelle des connaissances territoriales

Les ontologies fondamentales peuvent aider à la normalisation d'éléments de la connaissance territoriale. Les ontologies fondamentales sont des ontologies qui (i) ont une grande portée, (ii) peuvent être très réutilisables dans différents scénarios de modélisation, (iii) sont conceptuellement bien fondées, et (iv) sont sémantiquement transparentes et richement axiomatisées (Borgo and Masolo, 2009). DOLCE (Ontologie descriptive pour l'ingénierie linguistique et cognitive) est le premier module d'une bibliothèque d'ontologies fondamentales et l'idée est de rendre les justifications et alternatives sous-jacentes à ces choix aussi explicites que possible, à la suite d'un isolement attentif des options ontologiques fondamentales et de leurs relations formelles. Cette ontologie a un biais cognitif et vise à capturer les catégories ontologiques qui sous-tendent le langage naturel et le bon sens. Comme le montre son acronyme, DOLCE a un biais cognitif clair, en ce sens qu'il vise à capturer les catégories ontologiques sous-jacentes au langage naturel et au bon sens humain (Gangemi et al., 2003).

DOLCE est basé sur une distinction fondamentale entre les entités durables et persistantes et abstraites. Les Endurants sont entièrement présents (c'est-à-dire que toutes leurs parties appropriées sont présentes) à tout moment. Perdurants, d'autre part, simplement prolonger dans le

temps en accumulant différentes parties temporelles, de sorte que, à tout moment ils sont présents, ils ne sont que partiellement présents, en ce sens que certaines de leurs parties temporelles appropriées (p. ex., les phases précédentes ou futures) peuvent ne pas être présentes. La définition la plus courante des abstracts est qu'il s'agit d'entités qui n'existent ni dans l'espace ni dans le temps (Eisemann, 2009). Il y a tellement d'éléments physiques et non physiques dans la catégorisation conceptuelle des connaissances territoriales qui sont compatibles avec les endurants (3-Dimensions) et les perdurants (4-Dimensions) dans l'ontologie DOLCE. Ainsi, DOLCE peut aider à la normalisation des éléments du savoir territorial

A.4.3. Ontologie DOTK

Comme mentionné précédemment, l'ontologie DOLCE peut aider à normaliser l'élément de catégorisation conceptuelle des connaissances territoriales pour les spécialiser selon leur essence et leur signification. Les résultats de cette spécialisation sont une Ontologie Descriptive pour les Connaissances Territoriales (DOTK). Le DOTK clarifie la nature et le « raisonnement » des éléments du savoir territorial. Dans cette étape de modélisation de l'ontologie DOTK, les éléments de la catégorisation conceptuelle des connaissances territoriales sont normalisés par des notions d'abstrait, d'endurant et de perdurant. Les différences entre ces notions et leur genre ne sont que des conditions nécessaires pour construire une taxonomie d'ontologie. L'essence des notions devrait être saisie en attribuant des définitions complètes des notions et de leurs propriétés essentielles. Ainsi, la construction d'une ontologie est de décider quel objet conserver du domaine étudié. De plus, la notion d'objet correspond à l'ontologie du domaine. Ainsi, la définition de sous-notions en déterminant les caractéristiques essentielles permet de construire l'ontologie du domaine. Chaque sous-notion se compose de ses propriétés. De plus, la signification des propriétés doit être comprise à travers ses positions dans l'ontologie.

La figure 3 montre la hiérarchie de classe de l'ontologie DOTK effectuée par protégé.

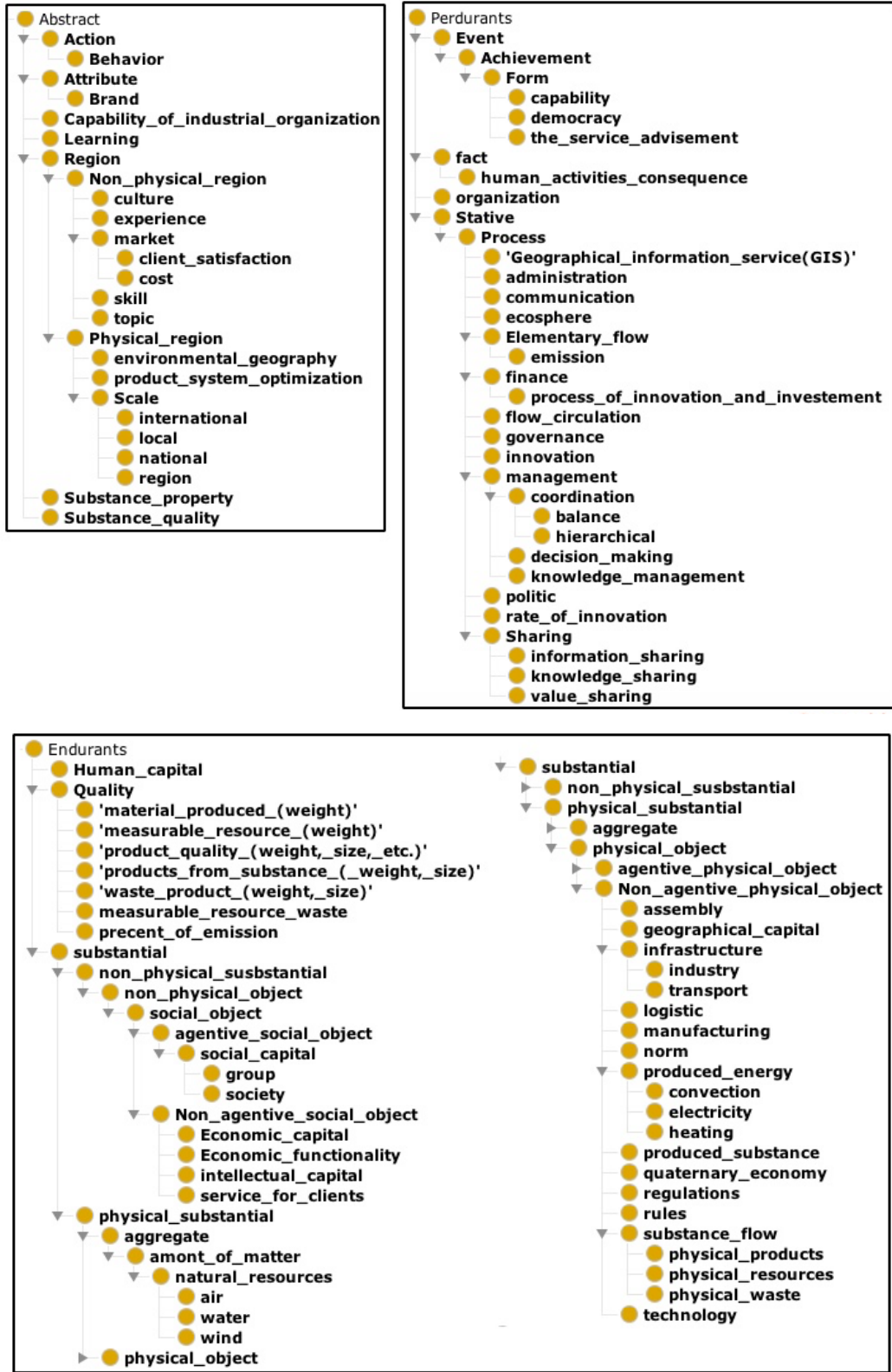


Figure 3 : classe hiérarchique de l'ontologie DOTK.

A.4.4 Graphe sémantique de l'ontologie DOTK par TextMining

L'une des applications de l'ontologie est l'organisation de l'information sémantique et le soutien de l'outil d'inférence pour découvrir de nouvelles connaissances et relations hiérarchiques (Zhan et al., 2010). Le graphe sémantique montre la relation entre les différents concepts de l'ontologie DOTK.

La méthodologie pour construire ce graphe à la première étape est l'extraction de texte des termes connexes de l'ontologie DOTK. L'exploration de textes est la découverte de mots et de termes en extrayant l'information des ressources écrites au moyen de théories linguistiques (Hearst et al., 2003). Ainsi l'outil TextMining Voyant Tools a été appliqué aux textes correspondants d'où sont extraits les termes sources des concepts de l'ontologie DOTK.

Les textes des différentes connaissances territoriales des sciences scientifiques dans ce domaine, tels que le capital politique, économique, géographique et humain, sont intégrés en Voyant Tools. La production de TextMining de textes de connaissance territoriale par Voyant Tools a permis de produire quatre graphiques sémantiques. Chaque graphique montre les relations entre les principaux concepts de chaque capitale territoriale. Ensuite, ces quatre graphes seront mélangés pour démontrer les relations entre tous les concepts de la connaissance territoriale ensemble. Enfin, un graphe complet de l'ontologie DOTK est réalisé. La figure 4 illustre le graphe sémantique de l'ontologie « DOTK » réalisé par Protégé.

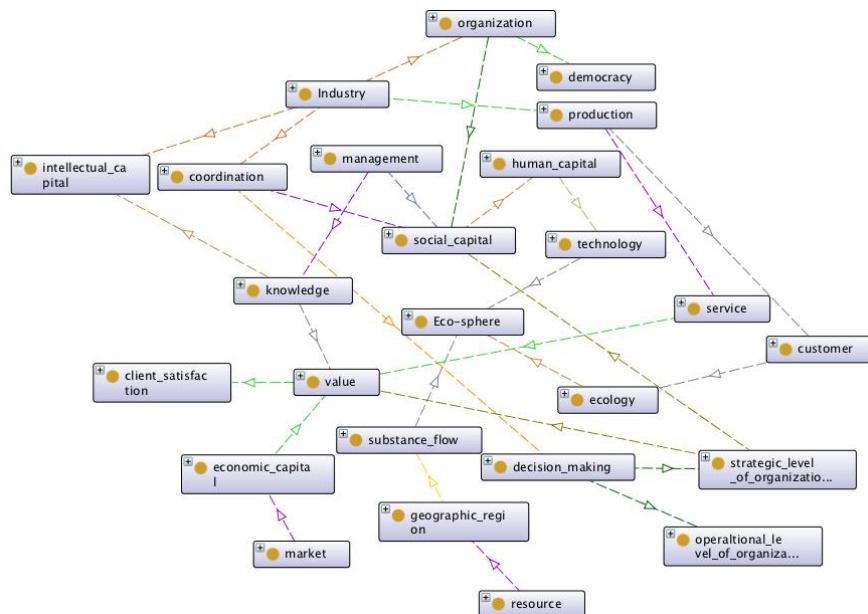


Figure 4 : Graphe sémantique de la relation entre le concept d'ontologie DOTK via protégé

Les avantages du graphique sémantique peuvent être résumés :

- Montrer les relations entre les concepts de l'ontologie DOTK
- Montrer l'influence entre les concepts d'ontologie DOTK par attribut entre eux
- Aider les acteurs des entreprises industrielles (niveau tactique et stratégique) à comprendre l'impact entre les concepts et la règle de ces relations

A.5 Validation de DOTK : construction d'une ontologie applicative de Troyes

A.5.1 Cas 1 : ville de Troyes en Champagne Ardennes

L'objectif de la mise en œuvre de l'ontologie DOTK sur le cas réel du territoire géographique pour montrer que DOTK peut servir de guide pour extraire les ressources tangibles et intangibles du territoire pour aider les entreprises industrielles. La méthodologie d'identification des ressources territoriales de Troyes est la recherche sur le site internet selon les concepts de l'ontologie DOTK. Troyes est une ville française, capitale du département de l'Aube, située dans la région Champagne-Ardenne dans le nord-est du pays. Chaque concept d'ontologie DOTK selon son essence est recherché dans les sites web de ressources et les documents décrivant les ressources de Troyes. Par conséquent, les concepts d'ontologie DOTK aident à trouver la ressource territoriale correspondante à Troyes pour la durabilité. En d'autres termes, les concepts de DOTK agissent comme un guide pour rechercher les ressources correspondantes en ce qui concerne la signification de son concept. Ainsi, les différentes ressources qui aident à la fois les entreprises industrielles locales et le territoire géographique de Troyes, sont identifiées. De cette façon, l'ontologie DOTK de Troyes est complétée. Ainsi, la prise en compte de chaque concept d'ontologie DOTK et des sites Web de Troyes nous aide à identifier ses connaissances territoriales pour le développement durable.

Selon les entités de l'ontologie DOTK, les ressources de l'ontologie DOTK de Troyes sont présentées en trois types d'entités abstraites, durables et persistantes.

Les entités d'ontologie DOTK en tant que résumé sont l'apprentissage, la satisfaction des clients, les compétences, l'optimisation du système de produits et les concepts géographiques environnementaux. La plupart des concepts persistants de l'ontologie DOTK sont situés dans l'objet physique actif et non actif d'entités substantielles qui peuvent aider les industries.

Réglementation, produit énergétique, infrastructure, déchets physiques et logistique, capital économique sont les principaux concepts de substantiel en ontologie DOTK. Aussi, Les concepts permanents de l'ontologie DOTK sont la politique, la gouvernance, l'émission, le partage d'information, la gestion, la communication, l'innovation, les conséquences des activités humaines et l'organisation qui peuvent trouver leurs ressources correspondantes à Troyes.

Donc, conformément à l'essence de ces concepts, les ressources territoriales sont recherchées sur des sites web pour découvrir les ressources territoriales de Troyes qui aident les industries au développement durable selon 5 dimensions de la durabilité. En d'autres termes, l'ontologie DOTK est très utile pour le développement durable car elle peut servir de guide pour identifier la ressource un territoire pour les industries et le territoire géographique. Par exemple, les concepts de ces ressources en tant qu'entités abstraites dans l'ontologie DOTK de Troyes sont présentés à la figure 5. Les entités rouges montrent les ressources de Troyes qui sont extraites des sites Web selon les conceptions de l'ontologie DOTK.

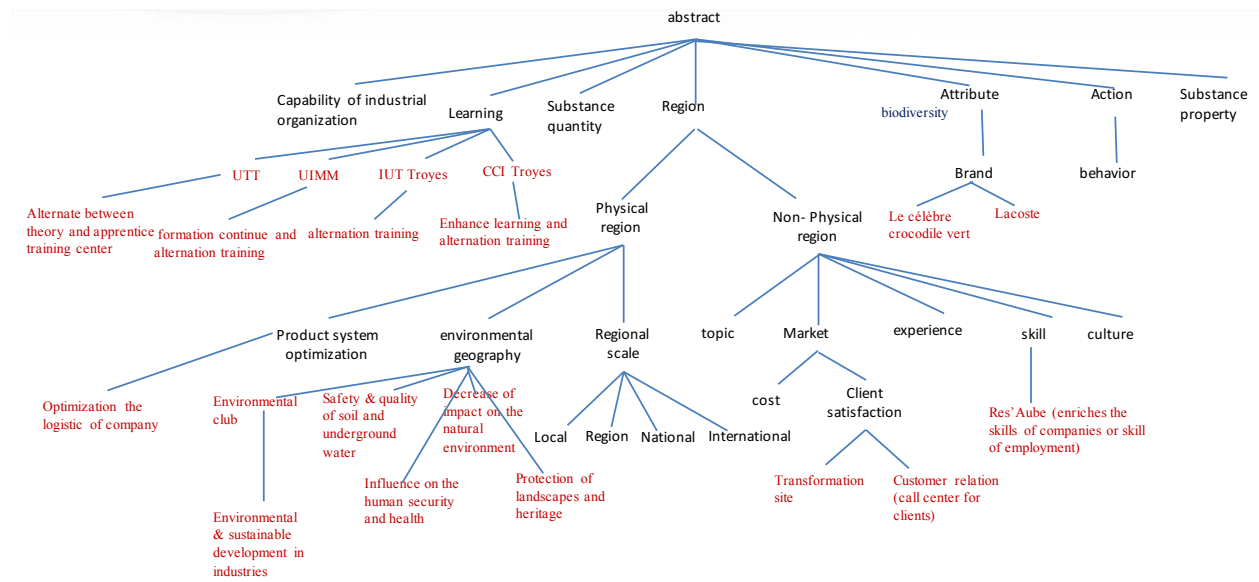


Figure 5: Entités abstraites dans l'ontologie DOTK de Troyes.

A.5.2 Graphe sémantique de l'ontologie DOTK de Troyes par Text Mining

Le graphe sémantique de l'ontologie DOTK de Troyes est construit par la méthode Text Mining via Voyant Tools. Les termes clés de l'ontologie DOTK de Troyes sont extraits par Voyant-tools. En d'autres termes, différents liens fondés par rapport aux ressources de Troyes du site internet, sont intégrés dans Voyant Tools. Ensuite, les termes clés de l'ontologie DOTK de Troyes et leur

relation sont créés par Voyant Tools. Ainsi, selon chaque ressource de Troyes, un graphique est créé. Enfin, grâce au mélange de ces graphiques, un graphique complet de l'ontologie DOTK de Troyes est présenté. Le graphe sémantique de l'ontologie DOTK de Troyes est présenté à la figure 6.

Ce graphe montre la relation généralisée entre les entités de l'ontologie DOTK de Troyes qui aident les acteurs des entreprises locales à Troyes afin de mieux réaliser les impacts entre les entités. Ainsi, il est utile de les intégrer aux activités des entreprises locales. Ce graphe sémantique montre plus de détails la relation et l'effet des entités de l'ontologie DOTK de Troyes.

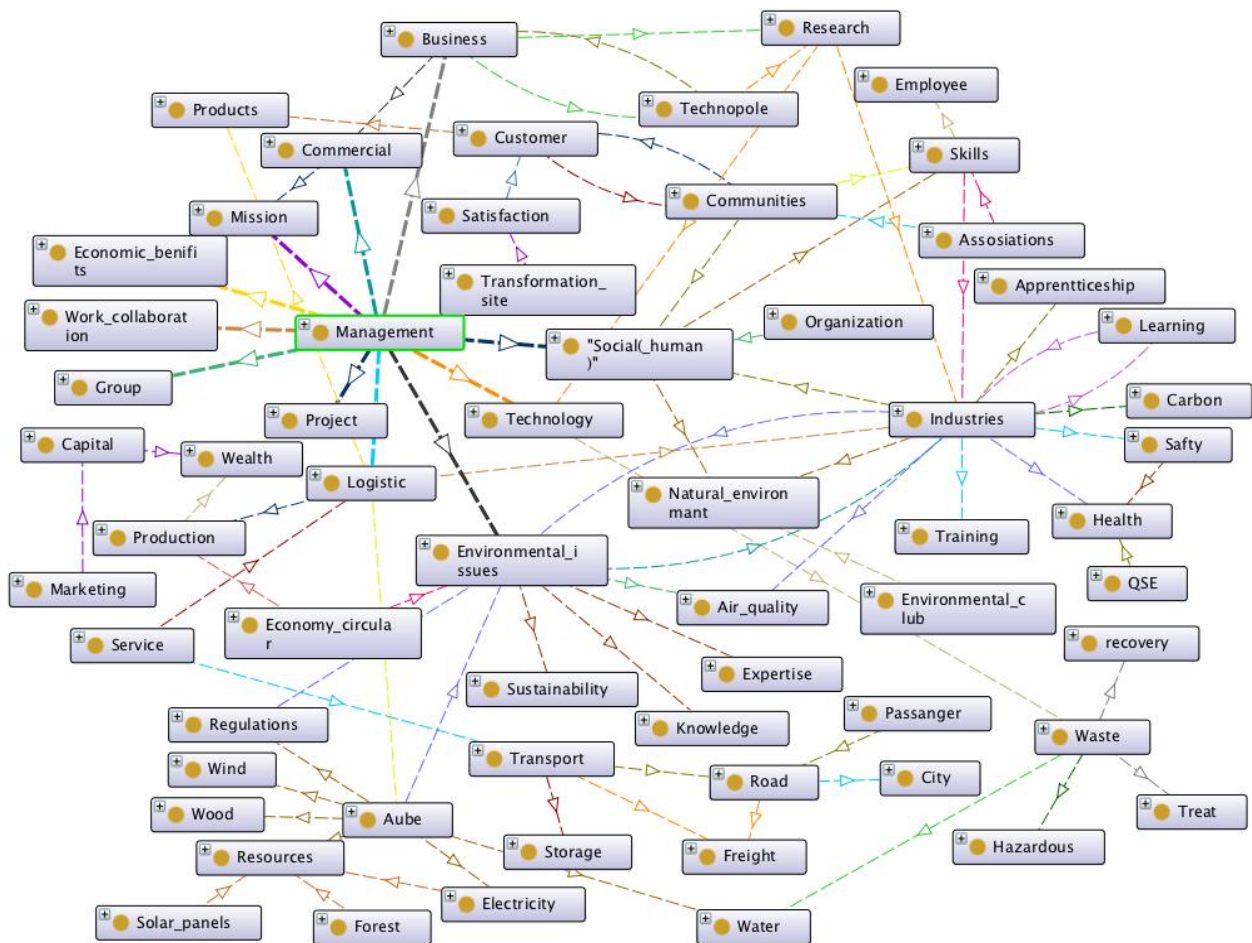


Figure 6: Graphe sémantique de l'ontologie DOTK de Troyes.

Afin d'avoir un graphe sémantique complet, les relations sont ajoutées au graphe sémantique de DOTK. Le graphe de DOTK de Troyes est créé à partir de la spécialisation des entités tandis que le graphe de DOTK est construit à partir d'entités dans l'ontologie du domaine. En fait, le graphe de DOTK de Troyes peut compléter le graphe de DOTK parce que le graphe de DOTK de Troyes

a plus de relations entre les concepts en raison de la spécialisation de ses entités. Enfin, un graphe complet sémantique de l'ontologie DOTK est présenté, comme le montre la figure 7. Les flèches rouges montrent les relations ajoutées qui sont complétées à partir de la comparaison.

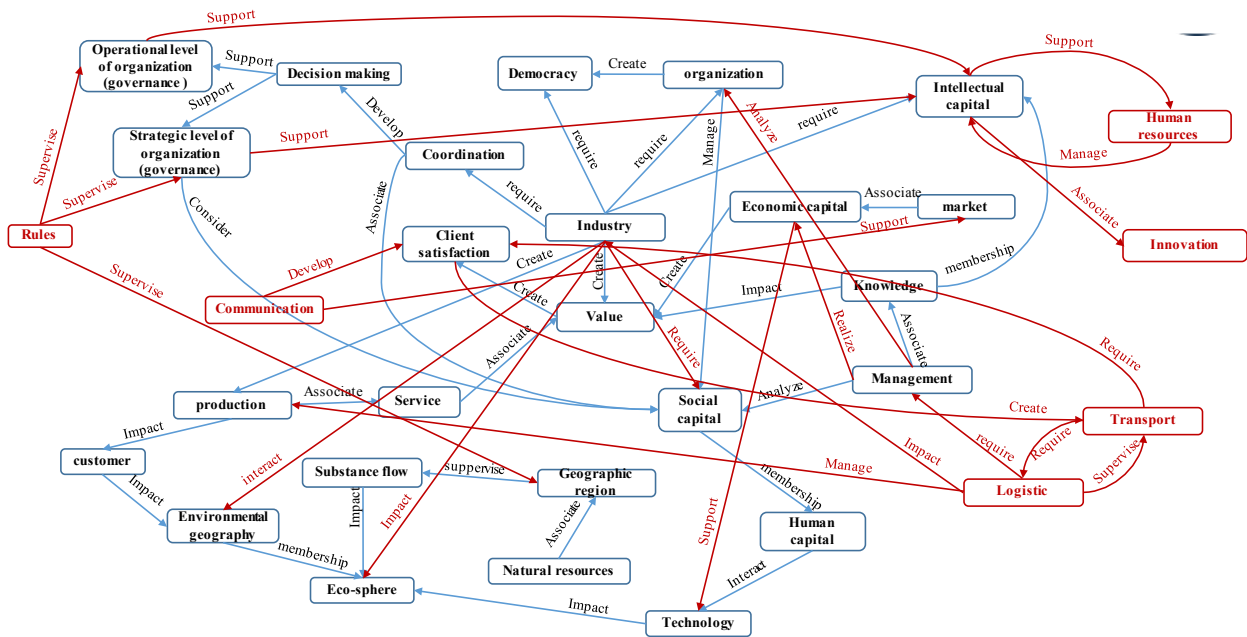


Figure 7: Graphe sémantique complet de l'ontologie DOTK.

Les relations des entités expliquées sont manquées dans le graphe de Troyes qui sont complétées par un graphe de DOTK de Troyes.

Le graphe sémantique complet présente quelques avantages :

- Il démontre les relations entre la plupart des entités du savoir territorial ;
- Il peut être détaillé sur chaque entité ;
- Il est possible de présenter un nouveau graphe avec plus de détails et d'étendre les relations entre les détails ;
- Il peut être développé à travers les autres recherches dans le domaine du développement durable qui se présenteront à l'avenir.

A.5.3 Cas 2 : organisations de développement durable à Troyes

Trois organisations de développement durable à Troyes sont sélectionnées pour la validation finale de l'ontologie DOTK. Ces organisations aident les entreprises à Troyes pour la mise en œuvre du développement durable. L'objectif de cette validation est de déterminer si l'ontologie DOTK est

utilisable pour aider les entreprises au développement durable par le biais de ces organisations ou non. De plus, les entretiens avec les organisations peuvent permettre de répondre à la troisième question de recherche. Rappelons que la troisième question de recherche est la suivante : le savoir territorial aide à quel niveau hiérarchique des entreprises pour le développement durable? Ces organisations agissent dans le domaine du développement durable à Troyes et de l'exécution du développement durable avec les entreprises troyennes.

Ces organisations sont :

- **Troyes Champagne Métropole (TCM)** : Les principales compétences de Troyes Champagne Métropole sont : Développement économique, Aménagement paysager, Équilibre social du logement, Politique municipale, Réception pour les voyageurs, Environnement et développement durable.
- **Business Sud Champagne (BSC)** : Les missions de Business Sud Champagne sont : la promotion du territoire, La prospection d'entreprises, Structuration des secteurs d'intérêt régional, Soutien aux entreprises stratégiques.
- **Biogaz vallée** : Biogaz Vallée a pour mission de structurer un secteur durable et à valeur ajoutée : Accélérer la connexion et le réseautage, Partager les pratiques exemplaires pour promouvoir la durabilité et la propriété locale des unités, Faciliter l'accès au financement, Développer la création d'emplois industriels spécialisés, Stimuler l'innovation pour gagner en compétitivité et pouvoir, à long terme, être exempté de la subvention.

A.5.3.1 Entretiens avec les organisations pour valider l'ontologie DOTK

L'ontologie DOTK de Troyes avec des entités arborescentes abstraites, persistantes et non persistantes est présentée à chaque organisation pendant l'interview.

L'objectif principal des entretiens avec les organisations était la présentation des ressources territoriales de Troyes afin de comprendre si les ressources extraites de Troyes par ontologie DOTK sont utilisables pour les objectifs de développement durable par ces organisations ou pas. Autrement dit, la validation de ces ressources par les gestionnaires d'organisations peut confirmer l'utilité de l'ontologie DOTK qui peut aider les organisations à trouver les ressources territoriales de chaque région géographique pour le développement durable.

Ainsi, lors de ces interviews avec ces organisations l'arbre de concepts de DOTK de Troyes et le graphe sémantique sont présentés accompagné par des questions (énumérées Tableau 1).

Tableau 1 : Sondage auprès des organisations.

les questions que j'ai posées aux top-manager des organisations	
Questions	Réponses
1. L'ontologie DOTK peut-elle vous aider pour le développement durable?	Les ressources extraites de Troyes à travers les concepts d'ontologie DOTK sont confirmées
2. Les concepts de l'ontologie DOTK et l'ontologie de DOTK de Troyes sont-ils explicites?	L'essence et la signification de ces entités le guident pour ajouter d'autres ressources à l'ontologie DOTK de Troyes
3. L'ontologie DOTK contribue-t-elle à ajouter d'autres éléments aux ressources de Troyes pour le développement durable?	Par l'essence et la signification des entités
4. Les ressources de DOTK de Troyes sont-elles utilisables pour votre travail de développement durable ?	Ils peuvent trouver la plupart des entités et des ressources pour le développement durable de l'entreprise qui sont extraites par ontologie DOTK
5. Les ressources de DOTK de Troyes sont-elles utilisables pour votre travail de développement durable ?	Aider la stratégie et la tactique à prendre une décision pour la durabilité
6. Le graphe sémantique est-il utilisable et applicable pour représenter les relations des entités ?	Aider la stratégie et la tactique à prendre une décision pour la durabilité. En outre, le graphique sémantique peut faciliter la présentation de la relation des entités en fonction de la demande de l'entreprise pour différents projets
Des questions qui m'ont été posées par les top-mangers des organisations	
1. L'ontologie DOTK et le graphe sémantique peuvent-ils s'adapter à la demande des entreprises pour différents projets?	La nature des entités de l'ontologie DOTK couvre l'essence et la signification différentes des ressources territoriales
2. L'ontologie DOTK et le graphe sémantique peuvent-ils altérer l'autre étude de cas (un autre territoire géographique)?	La méthodologie de construction de graphique sémantique peut être utilisée pour n'importe quelle étude de cas dans différents projets que les entreprises exigent des organisations et aider la décision stratégique et tactique pour la durabilité

De plus, deux cas d'utilisation de l'ontologie DOTK de Troyes sont discutés lors de l'entretien avec Business Sud Champagne (BSC). Ces deux cas d'utilisation peuvent aider les entreprises pour la mise en œuvre du développement durable par BSC à travers l'ontologie DOTK de Troyes. Ainsi, ces deux cas d'utilisation de BSC se composent de:

1. Les entreprises qui demandent à BSC de mettre en œuvre le développement durable.

2. Les entreprises que le BSC recherche pour la mise en œuvre du développement durable.

Rappelons que BSC est une agence de développement économique.

De plus, un autre cas d'utilisation est lié à l'exemple réel de Troyes pour la convivialité de DOTK de Troyes.

3. TCAT (Transport en Commun de l'Agglomération Troyenne)

L'objectif est de montrer comment les ressources territoriales de l'ontologie DOTK de Troyes peuvent être utilisées par l'organisation pour mettre en œuvre le développement durable.

A.5.3.1.1 Cas d'usage 1 : Les entreprises qui demandent à BSC de mettre en œuvre une démarche de développement durable

Certaines entreprises basées à Troyes demandent à BSC de mettre en œuvre des démarches de développement durable dans leur entreprise. La mise en place de cette démarche se déroule en trois étapes. La première étape consiste pour BSC à considérer les besoins de l'entreprise. La deuxième étape pour BSC, est de considérer les besoins de l'entreprise dans l'ontologie DOTK de Troyes pour comparer l'existence de ressources territoriales avec les besoins de l'entreprise. Cette ontologie regroupant un grand nombre de ressources nécessaires au développement durable au niveau de Troyes, elle permet aux entreprises de mieux comprendre la démarche de BSC. Cependant, BSC peut trouver des ressources territoriales d'entreprise nécessaires qui ne sont pas intégrées à l'ontologie DOTK de Troyes. Cela déclenche la troisième étape, qui consiste pour BSC à développer ou trouver les ressources qui n'existent pas par essence dans les entités de l'ontologie DOTK de Troyes et qui permettent de répondre aux besoins de l'entreprise pour le développement durable. Ainsi, de cette façon, le BSC peut trouver les ressources ou une solution alternative pour répondre à la demande de l'entreprise. La figure 8 montre le scénario du cas d'usage 1.

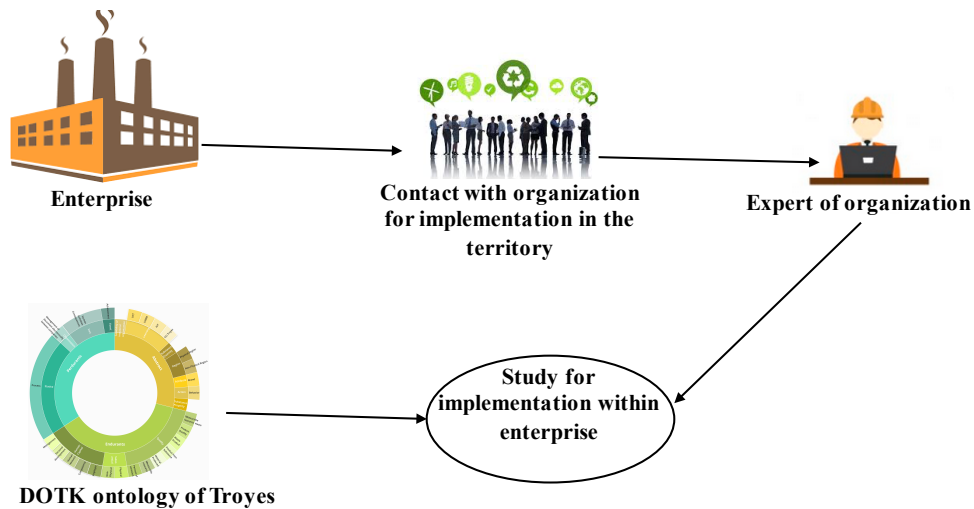


Figure 8 : Scénario de cas d’usage 1.

A.5.3.1.2 Cas d’usage 2 : BSC qui cherche des entreprises pour mettre en œuvre une démarche de développement durable

BSC recherche des entreprises dans d’autres territoires géographiques et les incite à s’installer à Troyes. BSC accompagne ces entreprises dans la mise en œuvre de démarches de développement durable. Dans un premier temps, BSC recherche dans l’ontologie DOTK de Troyes toutes les ressources territoriales qui existent. Dans un deuxième temps, BSC recherche les entreprises qui peuvent être intéressées par ces ressources territoriales dans le domaine particulier. Par exemple, la logistique du parc de Troyes est l’une des ressources territoriales mentionnées dans le DOTK de Troyes. Il y a des sous-ressources et des objectifs clairs pour la logistique du parc de Troyes qui sont clarifiés par l’ontologie DOTK de Troyes. Ainsi, BSC peut présenter les ressources connexes de la logistique aux entreprises qui veulent s’installer à Troyes dans le domaine de la logistique par les ressources existantes. Il n’est donc pas nécessaire d’étudier chaque fois les ressources qui ont été étudiées auparavant. Par conséquent, l’ontologie DOTK peut faciliter la présentation des ressources et ensuite, le BSC peut préparer le rapport pour les entreprises sur la base des ressources existantes pour amener les entreprises à Troyes.

En fait, il y a quelques entreprises qui sont intéressées pour s’installer à Troyes mais elles ne connaissent pas les ressources existantes dans cette ville. Ainsi, l’ontologie DOTK de Troyes peut aider le BSC à présenter les ressources territoriales existantes de Troyes aux entreprises qui veulent s’y installer. En outre, le graphique sémantique contribue à la prise de décision stratégique des entreprises. Par conséquent, BSC peut aider à la mise en œuvre du développement durable et la

prise de décision du niveau stratégique des entreprises pour leur installation à Troyes à travers l'ontologie DOTK de Troyes pour l'objectif de développement économique. La figure 9 montre le scénario du cas d'usage 2.

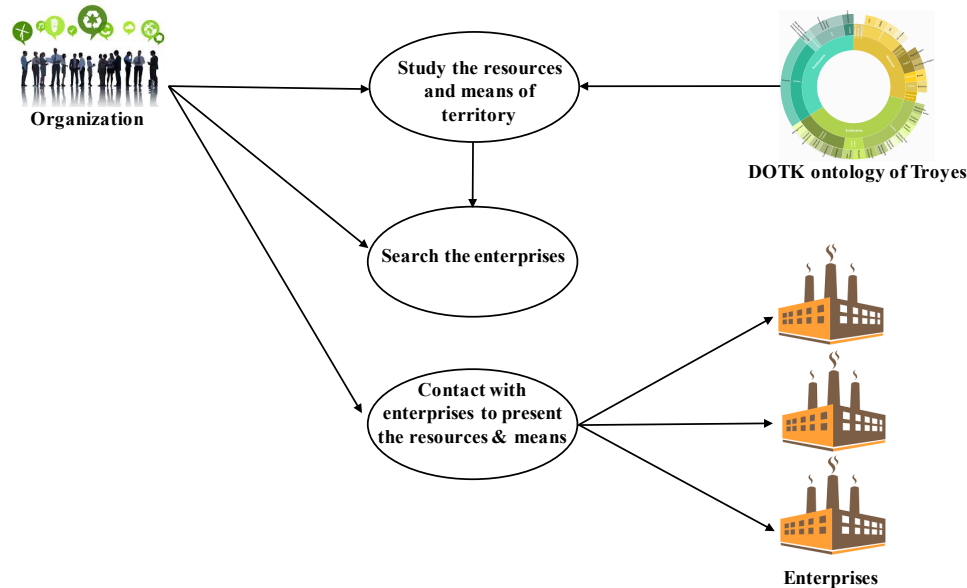


Figure 9 : Scénario de cas d'usage 2.

A.5.3.1.3 Cas d'usage 3 : Utilisation de l'ontologie DOTK de Troyes pour TCAT

La TCAT fait partie des programmes pluriannuels de Troyes Champagne Métropole (TCM) afin d'appliquer les directives de la communauté en matière de politique de voyage globale à Troyes. À la première étape, en tant que cas d'utilisation 1, TCM considère ce dont la TCAT a besoin pour le projet. A la deuxième étape, TCM peut trouver l'existence ou l'inexistence de ressources territoriales dans l'ontologie DOTK de Troyes par rapport au projet de la TCAT. Ainsi, ils peuvent développer les ressources pour l'amélioration du projet de la TCAT. Par conséquent, l'ontologie DOTK de Troyes aide TCM à analyser les ressources réelles, les besoins réels et à définir comment TCM peut développer les ressources pour ce projet de développement durable. Il peut être conclu que les ressources de DOTK ontologie de Troyes dans le projet de TCAT couvrent les trois dimensions du développement durable (social, économique et environnemental). En fait, il y a des ressources comme la culture, le comportement, l'objet social, la réglementation environnementale, les règles, l'économie quaternaire etc. dans l'ontologie DOTK de Troyes qui justifient l'utilisation de toutes les dimensions du développement durable dans le projet de TCAT à travers l'ontologie DOTK de Troyes. La figure 10 montre le scénario du cas d'usage 3.

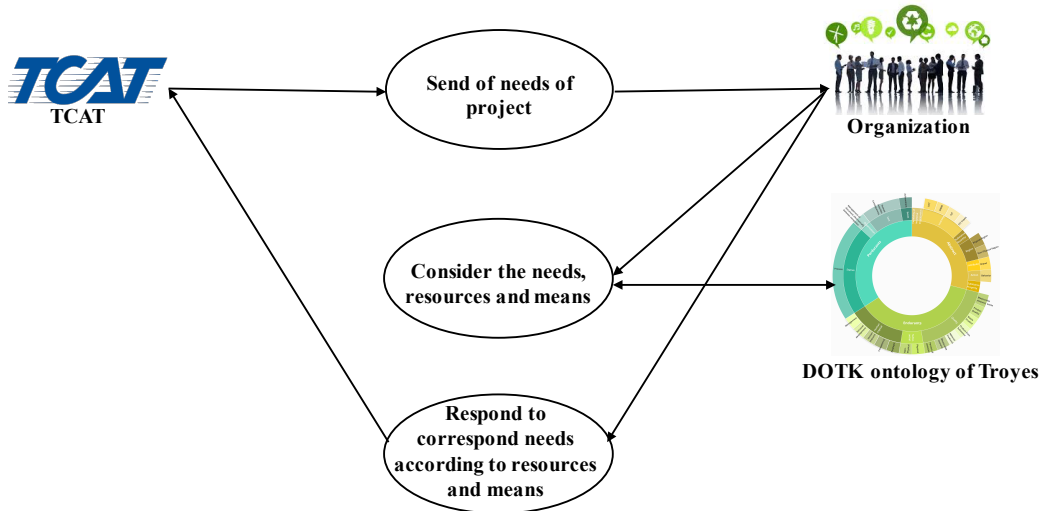


Figure 10 : Scénario de cas d’usage 3.

A. 6 Conclusion et perspective

L’objectif global de cette recherche était d’aider à la mise en place de démarches de développement durable dans des industries situées dans le système avec cinq dimensions de durabilité réelle. A cet effet, une étude complète sur le système de réflexion et sur les cinq dimensions de la durabilité réelle a été réalisée. Il s’avère que la dimension territoriale doit également être prise en compte, en adaptant la politique mondiale aux spécificités locales pour développer des solutions appropriées. De plus, les dimensions territoriales devraient être intégrées dans les activités industrielles de développement durable. Aussi, la capture de connaissances sur ses territoires en vue de l’intégration de ressources territoriales dans les activités de développement durable de l’entreprise n’est pas développée dans les différentes recherches. De plus, on s’attaque au fait que les entreprises industrielles connaissent mal leur territoire et leur statut environnemental. Par la suite, la recherche d’un outil permettant de déterminer le type de connaissance territoriale et d’intégration aux activités industrielles est suivie par l’ontologie. La dernière étape a été la validation de l’utilisation de l’ontologie territoriale à travers le cas réel proposé de Troyes pour montrer les ressources territoriales identifiées pouvant aider le niveau stratégique des entreprises en termes de prise de décision pour le durable développement.

Plusieurs objectifs de recherche ont servi de base à la recherche. La présente section décrit chaque objectif, la façon dont il a été abordé, les principales constatations et l’endroit où cela se trouve dans la thèse.

Objectif 1 : Souligner l'absence de saisie des connaissances territoriales pour l'intégration dans les activités de développement durable de l'entreprise.

Objectif 2 : Identifier le fait que l'ontologie est un outil de représentation des connaissances pour identifier les connaissances territoriales.

Objectif 3 : Proposer une ontologie territoriale pour montrer la relation entre les concepts de connaissances territoriales pour le territoire géographique local ou régional.

Objectif 4 : Identifier la validation de l'ontologie DOTK par la construction d'une ontologie applicative et prouver de l'utilisation de l'ontologie applicative pour les entreprises.

En fonction des objectifs de recherche établis, il est possible que les trois questions de recherche soient abordées. La présente section décrit chacune des questions de recherche, la façon dont elles ont été répondues et leur objectif

Question de recherche 1 : Quels types de connaissances territoriales influent sur les objectifs durables des entreprises industrielles ?

Cette question de recherche a été abordée à l'aide des objectifs 1 et 3. Comme il a été expliqué, il existe un lien étroit entre la saisie des connaissances territoriales et le développement durable des entreprises industrielles locales ou régionales. À cette fin, une étude descriptive est effectuée pour trouver les différentes connaissances territoriales qui contribuent au développement durable au sein des industries.

Question de recherche 2 : Comment représenter et partager ces connaissances pour atteindre l'objectif de durabilité au sein des entreprises industrielles ?

Cette question de recherche a été abordée à l'aide des objectifs 2 et 3. On constate que l'ontologie, en tant qu'outil de représentation des connaissances, peut partager la compréhension commune d'un domaine qui peut être communiqué entre les personnes et les systèmes d'application. Ainsi, afin de modéliser une ontologie territoriale, une méthodologie et des principes de modélisation de l'ontologie sont suivis. Par conséquent, une ontologie descriptive de la connaissance territoriale (DOTK), en tant qu'ontologie du domaine territorial, est proposée par la méthode suivante de modélisation d'une ontologie.

Question de recherche 3 : Les connaissances territoriales peuvent aider quel niveau organisationnel hiérarchique dans une entreprise ?

Cette question de recherche a été abordée à l'aide de l'objectif 4. La première contribution consiste à présenter l'ontologie DOTK de Troyes pour valider que l'ontologie DOTK est capable, en tant

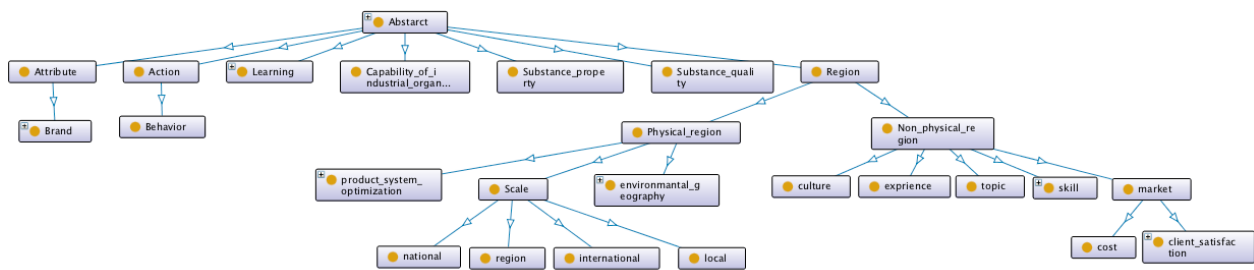
que guide, d'identifier les ressources tangibles et immatérielles de chaque territoire géographique pour aider à la fois l'entreprise et le territoire à atteindre l'objectif de durabilité. La deuxième contribution consiste à valider l'ontologie DOTK en présentant l'ontologie DOTK de Troyes et le graphique sémantique à travers l'interview avec trois organisations de développement durable à Troyes. En outre, trois scénarios d'utilisation de l'ontologie DOTK de Troyes pour la mise en place de démarches de développement durable dans les entreprises par l'organisation de BSC et TCM sont définis. Ces scénarios ont justifié l'utilisation de l'ontologie DOTK de Troyes pour le développement durable des entreprises par l'organisation.

Appendix B

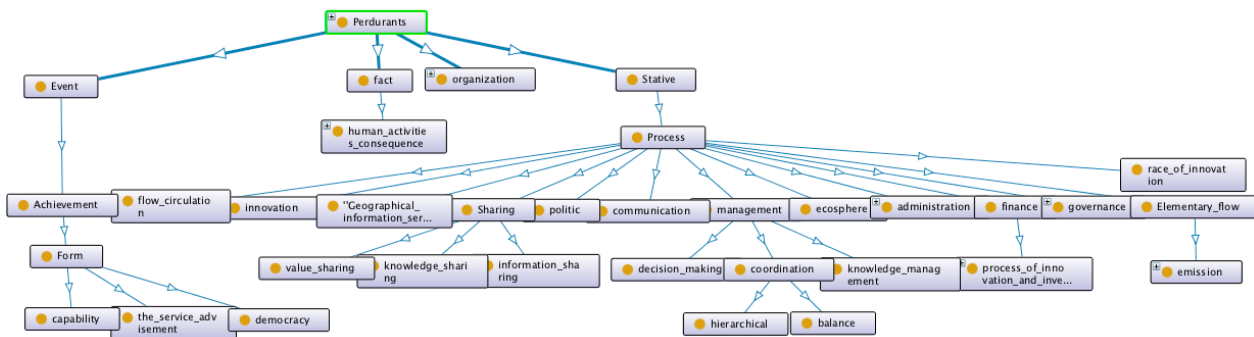
DOTK ontology by Protégé

DOTK ontology in figure 4.10, 4.11 and 4.12 are designed by software of Protégé which are show in below.

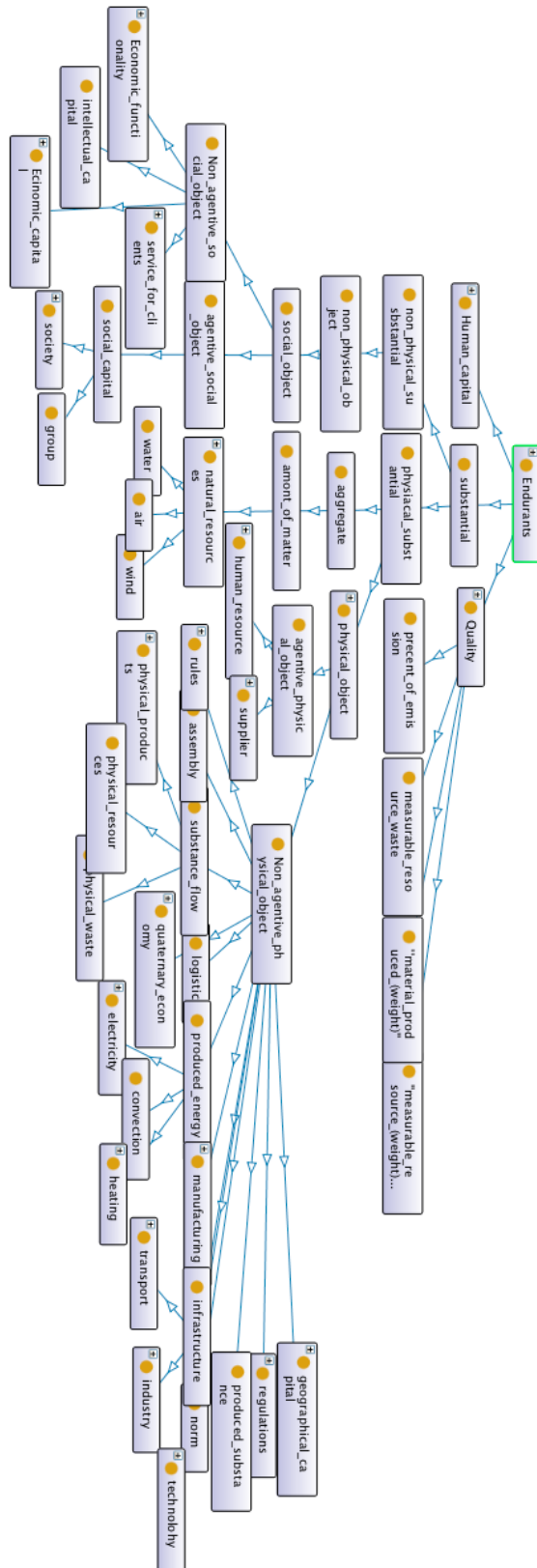
Entities of abstract in DOTK ontology



Entities of perdurant in DOTK ontology



Entities of enduring in DOTK ontology

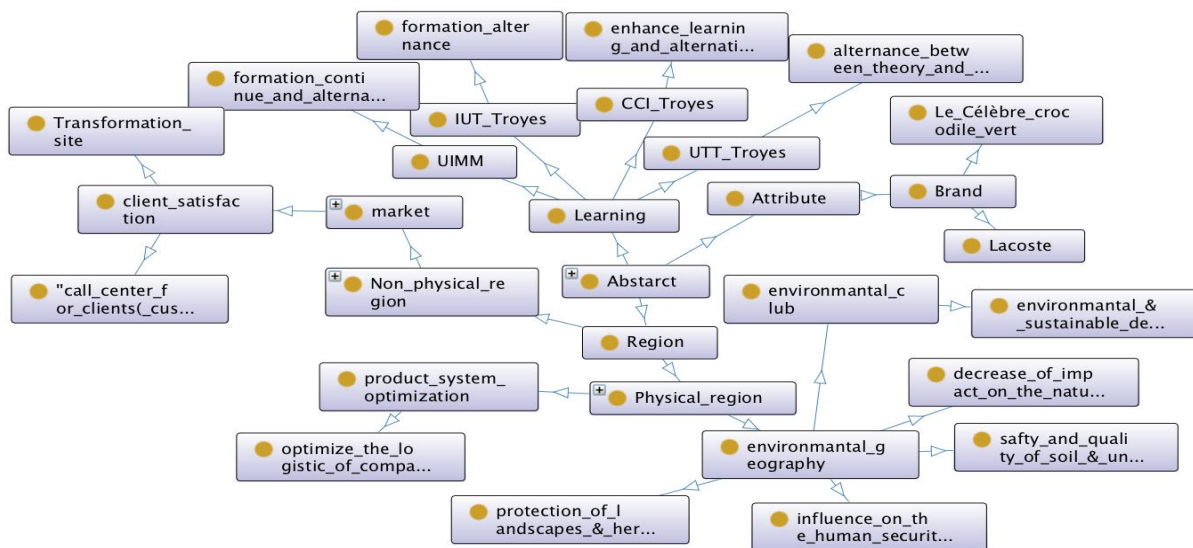


Appendix C

DOTK ontology of Troyes by Protégé

DOTK ontology of Troyes in figure 5.1, 5.2 and 5.3 are designed by software of Protégé which are show in below.

Entities of abstract in DOTK ontology of Troyes.



Entities of enduring in DOTK ontology of Troyes

