Environmental Ontology Localization and Translation Relations

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Abstract

Environmental decision-making depends on seamless communication between EU agencies and administrations. However, the transmission of environmental information is considerably more than a simple exchange of measurements and data. Prominent communication barriers to the creation of a Single Information Space in Europe for the Environment (SISE) include multilingualism and multiculturalism. The elaboration of a concept system, valid for different language cultures thus involves ontology localization, defined as "the process of adapting a given ontology to the needs of a certain community, which can be characterized by a common language, a common culture or a certain geo-political environment" (Cimiano et al 2010). Nevertheless, ontology adaptation first requires a representation framework that includes different syntactic, lexical, conceptual and semantic features. It must also account for dynamism and context, which influence these features at different levels. Context features must also include translation relations and degrees of equivalence because correspondence should not only be established between concepts but also between terms. This paper examines environmental ontology localization and discusses the translation correspondence problems that can arise when context is not considered. The examples pertain to renewable energies and a wide range of other environmental concepts, such as air pollution, coastal structures, and geological formations. This involves an expansion of the usual ontological properties in order to incorporate new translation relations that codify the array of possibilities on the spectrum between the poles of literal translation and free or culturally adapted translation.

1. Introduction

Awareness of linguistic complexity in knowledge representation has intensified over the last ten years as the number of resources in other languages has soared. Currently, there are many environmental data sets available. However, they lack homogeneity, since they were created for very different purposes and in very different formats. Most of them are monolingual English resources whereas others at least claim to be multilingual. Nevertheless, they still reflect static conceptualizations that are not culture-sensitive. This is a challenge for usefully linking and interrelating entities in and between different environmental knowledge resources because this process requires some sort of semantic-oriented cross-lingual ontology mapping framework in which knowledge representations are not restricted to the use of a particular natural language (Fu et al 2010). Indeed, without a coherent description of concepts and terminological variants that take into account the categorization of real world entities by other language communities, no environmental knowledge resource can ever be truly multilingual.

The creation of a Single Information Space in Europe for the Environment (SISE) has been the focus of a wide range of research projects, conferences, and workshops. These initiatives underline the importance of seamless communication between public administrations, environmental agencies, EU institutions, businesses, and the concerned public for effective decision-making. However, this is far from a simple objective since the transmission of environmental information involves more than a simple exchange of measurements and data. Not surprisingly, prominent communication barriers are multilingualism

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(Juceviciene 2008) and multiculturalism. In this sense, O'Flaherty (2008) points out that one of the topics prioritized by the SISE is the use of controlled vocabularies, thesauri, ontologies, and Semantic Web technologies, which would presumably facilitate the flexible chaining of distributed environmental services. He highlights the importance of transforming thesauri into ontologies and of combining and aligning ontologies. Nevertheless, the only solution suggested to overcome obstacles is the rather vague proposal that vocabularies could be used to deal with multilingualism.

Our experience in EcoLexicon (ecolexicon.ugr.es), a multilingual knowledge base on the environment (Faber 2011, 2012; León-Araúz/Magaña/Faber 2011) has shown that the elaboration of a concept system, valid for different language cultures, involves ontology localization. Ontology localization is "the process of adapting a given ontology to the needs of a certain community, which can be characterized by a common language, a common culture or a certain geo-political environment" (Cimiano et al 2010). Nevertheless, the adaptation of an ontology to different language communities first requires a representation framework that includes different syntactic, lexical, conceptual and semantic features. It must also account for dynamism and context, which influence these features at different levels. Context is thus an important construct when describing the concepts and terms of the environmental domain. When dealing with multilingual ontologies, context features must also include translation relations and degrees of equivalence because correspondence should not only be established between concepts but also between terms.

This paper examines environmental ontology localization and discusses the translation correspondence problems that can arise when context is not considered. The examples pertain to renewable energies and a wide range of other environmental concepts, such as air pollution, coastal structures, and geological formations. This involves an expansion of the usual ontological properties in order to incorporate new translation relations that codify the array of possibilities on the spectrum between the poles of literal translation and free or culturally adapted translation.

2. Terminology, the SISE, and the Multilingual Semantic Web

Traditionally, Terminology has dealt with the description and/or standardization of the concepts and terms of a given specialized domain as well as their relations. Recently, it has also evolved towards the development of standard vocabularies and formats for data interoperability in combination with ontologies.The link between Terminology and knowledge representation is widely acknowledged (Buitelaar et al 2011). However, other than definitions and labels, terminological information is often disregarded in the alignment of resources.

For example, the Simple Knowledge Organization System (SKOS) is a recommendation of the World-Wide-Web Consortium (W3C) for a common data model for sharing and linking knowledge organization systems, such as vocabularies, terminologies and thesauri. It has been widely used for semantic interoperability among different environmental resources within the SISE initiative, such as GEMET and AgroVoc.

In SKOS knowledge is conceptually organized in hierarchical and associative semantic relationships. The hierarchical relationships are *skos:broader* and *skos:narrower*. There is one associative relationship, *skos:related*, which is used to assert a different relationship between two concepts and is a symmetric property. As for terms and variants, SKOS proposes Preferred Labels (*skos:prefLabel*), Alternative Labels (*skos:altLabel*) and Hidden Labels (*skos:hiddenLabel*).

Linking different resources, whether monolingual or multilingual, involves the alignment of the entities represented in each of them based on similar meanings. Since SKOS is concept-oriented, correspondences are set through conceptual mappings based on the relations *skos:closeMatch* and *skos:exactMatch*, *skos:broadMatch*, *skos:narrowMatch*, and *skos:relatedMatch*. More precisely, *skos:closeMatch*, which is not transitive, indicates that two concepts are sufficiently similar to be used interchangeably, whereas *skos:exactMatch*, which is transitive, denotes that two concepts have the same meaning. However, these relations, though useful, are often not sufficient to capture the complexity of interlinguistic correspondence. First of all, interchangeability should be applied to terms rather than to concepts. A first meaning correspondence must always be established between concepts, but words are the ones that can be interchanged or not, depending on register, culture, etc. Secondly, this can only be accomplished by taking context and multilingual dynamics into account, since interlinguistic correspondence is not only based on conceptual facets. This means that a *skos:prefLabel* in one language will not necessarily correspond to the *skos:prefLabel* in another language.

SKOS is not a formal representation language and only aims at establishing conceptual correspondences across different resources through binary mappings and taxonomies. In its current form, it can be very useful within the Linked Data initiative (Berners-Lee 2006), but it might not be the best way to deal with multilingualism and linguistic intricacies unless its properties are extended to account for term-based relations and context. In this line, Leroi and Holland (2010) propose a set of guidelines to enable multiligualism in SKOS through the mapping of both concepts and terms. They state that equivalences in a multilingual context can be of three kinds: semantic, cultural and structural.The semantic aspect refers to the meaning of the concept; the cultural aspect refers to the use of a term in a given language or culture; and the structural aspect refers to the semantic relations between concepts. Nevertheless, in section 3.3 we show how and why this classification can be extended.

According to Pillman et al (2010), SISE will have to advance the evolving concepts of semantic interoperability and multilingualism in order to meet its goals. They state that for international information sharing, it is necessary to deal with multilingualism as well as with translation of information between different languages. Not surprisingly, they add that there is a lack of both common terminologies and solutions for multilingualism.

Knowledge, as regarded in Terminology, is something more complex than a thesaurus-like structure. In this sense, ontologies are better suited for accounting for multilingualism and contextual constraints. Nevertheless, they are often considered multilingual when the concepts are accompanied by an *rdf:label* referring to particular languages. However, cross-lingual differences have led to the awareness of dynamic conceptualizations. According to Cimiano (2010), while the translation of labels is an important aspect of the ontology localization process, the conceptualization may also need to be adapted to a different cultural or geo-political context. In fact, it has been criticized that the pivotal role of English as a source language often leads to the translation of labels instead of proper localization. Furthermore, terminologies provide more information than mere *rdfs:labels*. However, natural language information acquired for and within the process of ontology building is often lost in the final representation because of the required univocity of each label. Such limitations have led researchers to propose the inclusion of terminological and linguistic information in the description of classes and properties in a modularized way (Declerk and Gromann 2012), as in *lemon* (Cimiano 2010; Buitelaar et al 2011). In this sense, terminological modules should thus reflect multilingual dynamics by including information related to pragmatics and the real use of terms.

3. Multilingual dynamics

Context is an important construct when describing the concepts and terms of any specialized domain, precisely because the meaning as well as the location of a concept within a knowledge structure can vary, depending on its context. This is true for contexts in the same language and even more so when one tries to establish correspondences between those in different languages. Generally speaking, context can also help to anchor linguistic designations to objective reality by providing background information. Elman (2009: 572) highlights the importance of context and asserts that the meaning of a concept and its linguistic designation is rooted in our knowledge of both the material and the social world. Therefore, the meaning of a word is never ‘out of context’ even when we are not aware of what this context is. For social, historical, and geographical reasons, context can change even for linguistic designations of the same concept within the same language. Nevertheless, when it is a question of mapping linguistic designations in different languages onto the same concept system, multilingual contexts can differ considerably to the extent of creating different conceptualizations of the same reality. This is something that must be considered in any multilingual knowledge resource.

3.1 Multilingual Terminology Resources

A terminological knowledge base is a repository containing a more or less detailed description of a set of specialized knowledge units or terms, which are used by experts in a given domain in different communicative settings and situations. These terms are the linguistic designations of the concepts that represent the knowledge in a given field. When the terminological knowledge base is multilingual, this adds still another level of complexity. The specification of a common conceptual structure applicable to and valid for different language-cultures requires a representational framework that allows for correspondences at different levels as well as for the inclusion of the conceptual-semantic and pragmatic features upon which correspondence is based. Also important is the syntactic information that languages use to encode the various types of conceptual relation that link concepts in different languages as well as the semantic distinctions that reflect different conceptualizations and linguistic designations.

Important multilingual environmental resources are GEMET, AgroVoc, and EcoLexicon.For example, GEMET is a thesaurus that provides a core inventory of general terminology for the environment. It was compiled by merging the terms from a wide range of multilingual thesauri. Version 2001 contains 5298 descriptors, including 109 Top Terms, and 1264 synonyms in English. It provides a numerical equivalence for all the descriptors in 30 languages. Although it includes definitions for terms, the definitions have been extracted from various sources and do not reflect the conceptual hierarchy of the resource. This sometimes leads to definitions that lack precision (e.g. the definition of *afterburning* which does not refer to the process, but to a device). The semantic relations in GEMET are based on SKOS: broader term, narrower term, and associated term. Broader and narrower terms are based on generic-specific and part-whole relations with no difference established between the two.

Although GEMET is a valuable resource, it has certain conceptual and multilingual incoherencies. For example, it lists *pollution* as the broader term for *contamination*, which is not accurate. In English, *contamination* is simply the presence of a substance where it should not be or at concentrations above background. In contrast, *pollution* is a specific type of contamination that results in or can result in adverse biological effects to resident communities. According to Chapman (2007: 492), this means that all pollutants are contaminants, but not all contaminants are pollutants. This distinction is not captured in GEMET. Furthermore, it has no way of capturing different conceptualizations in other languages. For example, the Spanish translation of both *pollution* and *contamination* is given as *contaminación. Polución*, a frequent term in Spanish, is not even included.

AgroVoc is the thesaurus of the Food and Agriculture Organization of the United Nations (FAO). It is a multilingual resource that contains approximately 40,000 terms on a wide range of agricultural and environmental topics in each of the available 19 languages. However, its ontology also reflects the difficulties inherent in creating a conceptual representation valid for various languages. For example, in AgroVoc, *pollution*, *environmental contamination, pollution of agriculture*, *immission* are all regarded as synonyms though *pollution* is the preferred term. In the same way as in GEMET, *pollution* appears as a broader term for *contamination.* Surprisingly, *environmental contamination* is listed as a synonym for *pollution*, which is contradictory since that would mean that *environmental contamination* is a broader term for *contamination* when the structure of the term indicates that this is not the case.

This lack of coherence is also a source of multilingual problems. The Spanish correspondences for *pollution* include *marea negra, inventario de la contaminación, polución de la agricultura, contaminación ambiental,* and *inmisión* though *polución* is the preferred term. Again, it is difficult to see how the more specific concepts of *inventario de la contaminación, polución de la agricultura,* not to mention *marea* *negra*, can be regarded as synonyms of *polución.* AgroVoc thus differs from GEMET since it includes *pollution/polución* though there seems to be very little coherent matching between broader and narrower terms in both languages.

EcoLexicon is a multilingual terminological knowledge base on the environment (Faber/León/Reimerink 2012). It is conceived as a knowledge acquisition tool for a wide range of agents involved in environmental communication in multilingual settings. The knowledge base was initially implemented in Spanish, English, and German. Currently, four more languages are being added: Modern Greek, Russian, French, and Dutch. So far it has 3,527 concepts and 18,596 terms. Users can freely access EcoLexicon, and are able to find the information needed, thanks to a visual interface with different modules for conceptual, linguistic, and graphical data.

Each entry in EcoLexicon provides a wide range of interrelated information. Figure 1 focuses on the conceptual structure of contamination, both in a taxonomic structure and a semantic network, where other types of relations are shown.

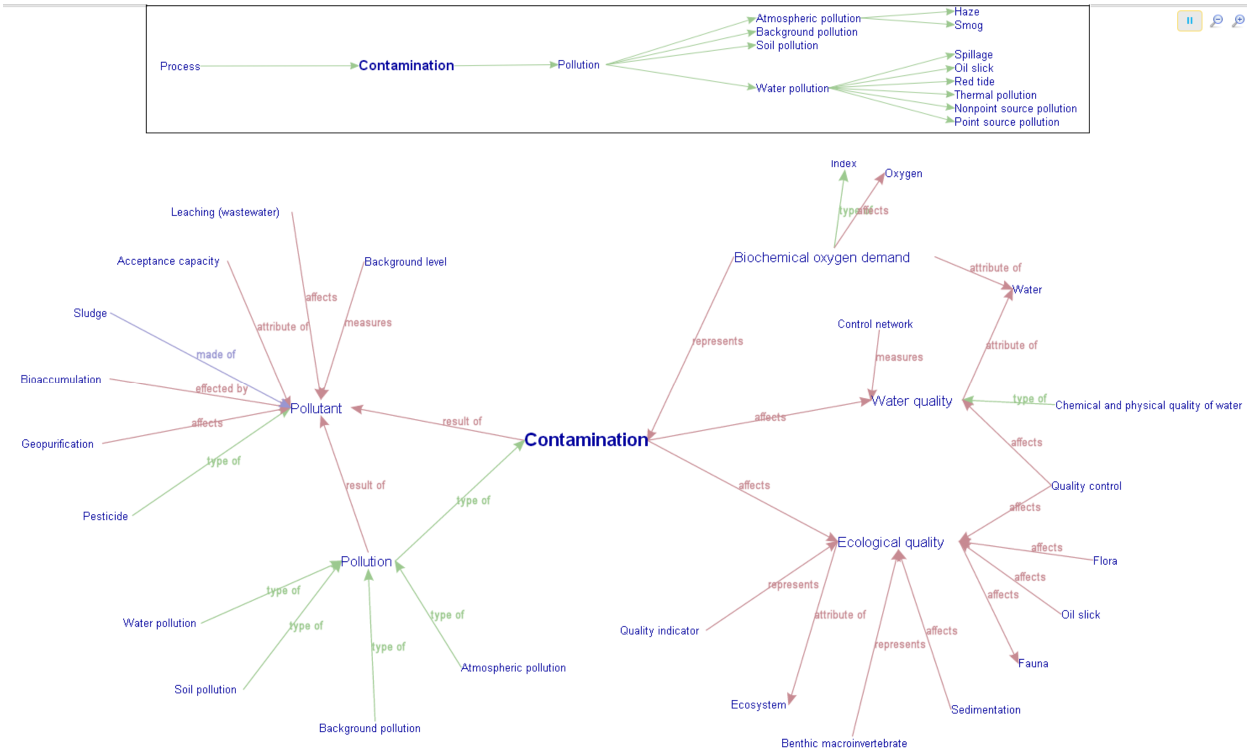

Figure 1
Conceptual structure of CONTAMINATION

In EcoLexicon, CONTAMINATION is defined as the "presence of a substance in the environment that because of its chemical composition or quantity prevents the functioning of natural processes and produces undesirable environmental and health effects". The conceptual network shows that POLLUTION is a type of contamination, which is defined as "the physical, chemical or biological alteration of the air, water or soil", has three subtypes: atmospheric pollution, soil pollution, and water pollution.

EcoLexicon is primarily hosted in a relational database (RDB) but at the same time integrated in an ontological model, which will eventually facilitate its integration in the Semantic Web. In this sense, we believe it is very important to store all monolingual and multilingual variants. The use of multilingual choices is a powerful method for conceptual disambiguation, but monolingual variants also ensure a systematic matching procedure, since not all concepts are named by their canonical form in all data sets.

As previously mentioned, AgroVoc includes under the same concept too many variants that do not refer to the same notion, which would impair the matching process. In contrast, GEMET only includes one term per language, which certainly impoverishes the resource. In this line, Pillman et al. (2010) criticize the fact that GEMET was primarily based on English, which makes multilingualism symmetrical even though there are language-specific concepts which have more or less precise translations to the concepts of other languages. They add that in order to bring European citizens closer to each other –one of the aims of SISE–, SISE should raise awareness of language specific conceptualizations.

This can be accomplished if terminological variants are collected and classified according to how they affect semantics and/or pragmatics, as it is done in EcoLexicon. Figure 2 shows the terminological variants of SOLAR CELL in the user's interface.

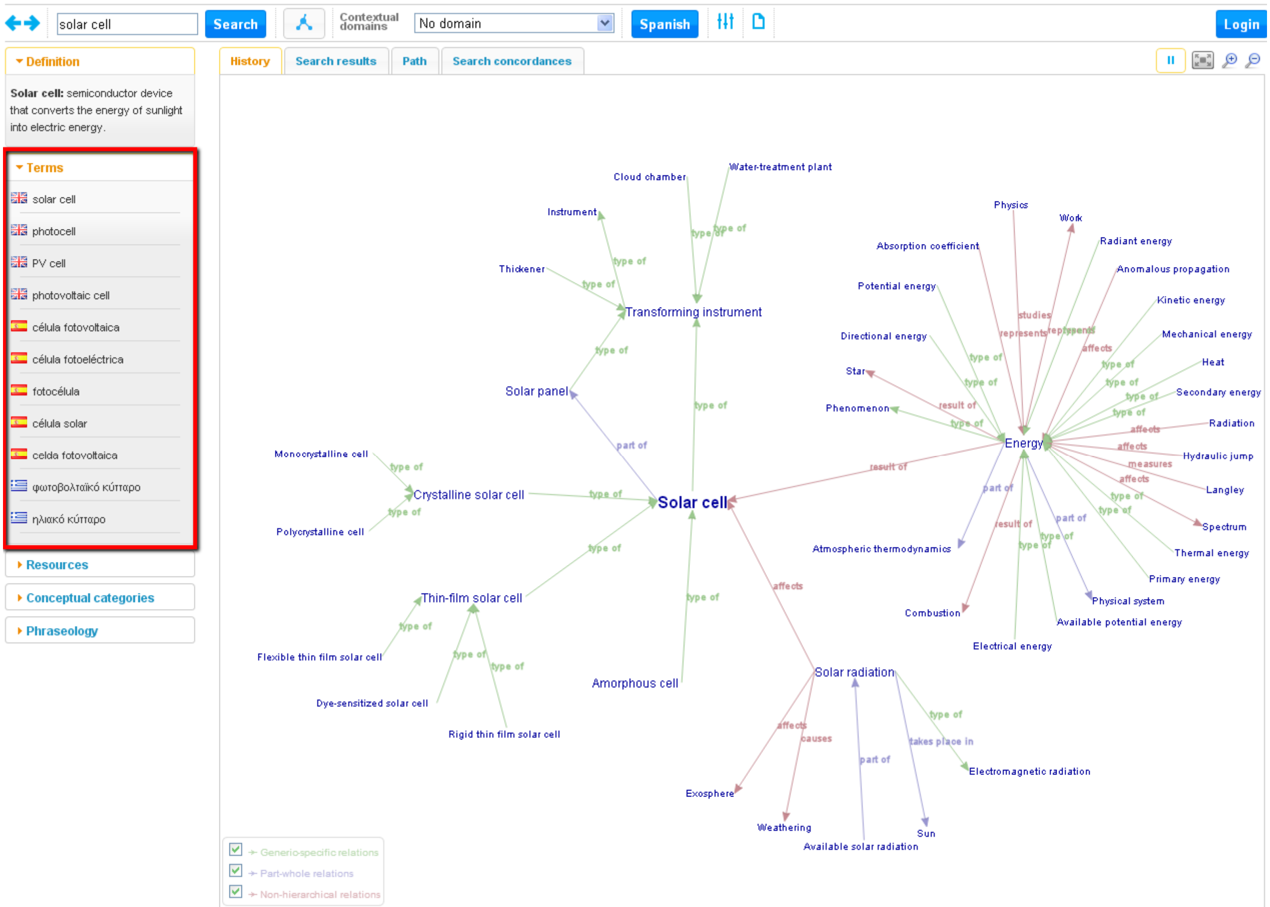

Figure 2
SOLAR CELL linguistic variants in the EcoLexicon user's interface

In EcoLexicon, variants may be constrained by a geographical context, a culture-specific connotation, a communicative setting (e.g. formal or informal), the scientific discipline dealing with the concept, or the conceptual dimension highlighted by the term. All of these constraints result in different multilingual correspondences.

3.2 Cross-lingual problems urther information regarding headings

Equivalence or correspondence between lexical units in different languages is based on shared conceptual meaning but also on term-related factors mainly based on pragmatics, such as register, domain-based nuances and culture-specific differences. Establishing equivalence between languages is undeniably complex. Part of this complexity is due to the fact that the rules do not remain the same, but change with each new translation context. Particularly, when dealing with cross-lingual meaning and vagueness, the following problems arise with regards to both concept and term dynamics:

(1) The entity exists in both cultures but the term for it in one language culture is more general or more specific. As previously stated, *contaminación* in Spanish is a term that covers *contamination* and *pollution* in English. *Polución* is thus a synonym of *contaminación*.

(2) The entity exists in both cultures, but only one language culture has a term for it. The other has not regarded it as sufficiently salient to name. The term *boule*, in the solar energy domain, refers to a type of cylindrical ingot from which wafers are made, but there is no exact equivalent in Spanish.

(3) The entity exists in both cultures yet the terms are not exact correspondents because they highlight different aspects of the concept or focus on it from different perspectives. The English *wind turbine* corresponds to the Spanish *aerogenerador*, however, the literal translation of wind turbine, *turbina eólica* is considered in the Spanish culture a part of the *aerogenerador*.

(4) The entity exists in both cultures and both language cultures have terms for it, but only in one language the concept has been lexicalized in several variants with different communicative or conceptual consequences. The English term *stall* refers to the process by which an engine stops working. In Spanish, the concept may be designated in two different ways depending on the discipline involved. In mechanics, the stopping of an engine is called *calado*, whereas in the wind power domain, it is called *pérdida aerodinámica* or *pérdida de sustentación*. In the same way, *turbine blades* in Spanish are called in different ways based on the turbine types. In hydraulic or thermal turbines, *blade* corresponds to *álabe*, whereas in wind turbines, it is called *pala* or, more colloquially, *aspa*.

(5) The entity exists in both cultures and both language cultures have terms for it, which approximately correspond. However, the lexical categories appear to have different structures in each culture and thus seem to operate on different design principles (e.g. *dock*, *quay* and wharf, and the Spanish *muelle*, *embarcadero* and *dársena*).

(6) The entity exists in both cultures, but its cultural role (utility, affordances, and hindrances) in each one is different. This leads to a conceptual mismatch and lack of semantic correspondence. *Transmission towers* in Canada are usually called *hydro towers*, since there power generation is mainly hydro-electric. They are thus functional equivalents, but the entity in the real-world is not the same.

(7) The entity exists in only one of the cultures, but its name has been adopted in the other culture to refer only to the foreign culture-specific concept. The Australian *billabong*, the African *dambo* or the Canadian *muskeg* are all culture-specific types of wetlands that cannot be found elsewhere..

(8) The entity exists in both cultures, but one culture has recycled a term from the other culture to refer to another totally different concept (e.g. *playa* in West US as *dry lake* and not as the usual Spanish equivalent *beach*, but *salar*).

(9) The entity exists in only one of the cultures and is totally unknown in the other without any designation (e.g. *pejerrey*, a fish that only can be found in South America).

(10) The entity exists in both cultures, but one of the cultures may refer to it with a metonymic designation and be ambiguous (e.g. *groyne* as the equivalent of the Spanish *escollera*, the material it is usually made of).

In order to define translation strategies that successfully address these problems, all the previous senses of context must be considered and interrelated. According to Montiel Ponsoda et al (2011), when there are several terms in each language, it is desirable to unambiguously express which term variant in language A is the translation of which term variant in language B. At this point, translation relations acquire significance. Nevertheless, even when all possible contextual constraints of both source and target terms and concepts are defined, this still does not establish 1:1 correspondences. Instead, a wide range of interrelated variables must still be considered.

3.2 Translation properties

Given the wide diversity of translation contexts, a more extensive classification should be devised, which would include the following:

- *Canonical translations* apply when no equivalence problems arise and the translation relation may be symmetric. For instance, *solar cell* and *célula solar* would be canonical symmetric equivalents. However, this does not mean that when canonical translations are found no other relations are possible for certain terms, since context can impair the degree of equivalence.
- *Generic ←→ specific translations* would address problems 1, 2 and 3 –which are related to cross-lingual categorization differences–, depending on the communicative situation and directionality. A specific-generic translation would apply when translating the Spanish term *contaminación*. Depending on the original sense of the term in context, it should be translated by the more specific term *pollution* or the generic term *contamination*. Alternatively, the following translation relation may also be applied for this problem.
- *Extensional translation* would address problems 1 and 2 and is a kind of generic-specific translation, because the original term is translated by all of the hyponyms of the concept in the target culture. In this way, the English term *shingle*, in the coastal engineering domain, can also be translated by the enumeration of its subtypes (*arena y grava*) since in Spanish there is no umbrella concept for them.
- *Communicative translations* would address problem 4 establishing register correspondence. Depending on the communicative situation, certain terms can be translated as the expert neutral variant or the lay-user variant in the target language (e.g. *pala* or *aspa* for *blade*); or as the preferred term in each discipline (*pérdida aerodinámica* or *calado* for *stall*).
- *Functional translations* would address problems 5, 6 and 7 and involve deculturalising original terms so that receivers can relate to the concept. For instance, *muskeg* can be translated as *turbera*. This equivalent loses its cultural traits but is the closest concept in target cultures from a semantic point of view. Other terms, such as *quay*, *dock* and *wharf* must rely on additional contextual features, since they can all be translated as *muelle*, *embarcadero* and/or *dársena* depending on the size, function and position of the structures. This relation is particularly asymmetric. For instance, *turbera* could hardly ever be translated as *muskeg*, since unless the communicative situation points to this particular type of Canadian wetland, the canonical translation *bog* would apply in most of the cases.
- *Cultural translations* apply when cross-cultural differences impair the translation process and affect both concepts and terms. They would be another way of addressing problems 6, 7 and 8 and consists of adapting original culture-bound terms to other culture-bound terms in the target culture. For instance, the usual canonical translation of *pier* is *embarcadero*, but piers are often recreational areas that do not fit with the Spanish concept. In these cases, the most suitable translation would be *paseo marítimo*, or even *malecón* or *costanera* for South American Spanish, since

even if these kinds of constructions are slightly different, the cultural component of the concept is preserved. When it comes to term cultural variations, even if *salar* is the canonical translation of *dry lake*, when translating for the particular geographical location of West US, the term should be localized to *playa*.

- *Descriptive translations* would also address culture-bound problems and make explicit certain semantic features according to user communication needs (problems 7 and 8) or in order to distinguish a concept that has not been termed in the target culture (problem 2, 9). For instance, for lay users, the term *muskeg* could be translated as *el humedal canadiense muskeg* (the Canadian wetland muskeg), highlighting its hypernym and location. In contrast, the term *boule* can be translated as *gran lingote* (large ingot) or *monocristal periforme* (cylindrical monocrystal). The first translation would describe the size of the *boule* and would also be a generic-specific translation, since it highlights its hypernym (INGOT).The second translation would in turn describe the shape of the *boule* and the material it is made of.
- *Non-translations* also address culture-bound problems (7, 9) when entities and/or lexicalizations do not exist in the target culture (*pejerrey*), but also in highly specialized communication. For instance, terms like *muskeg* or *billabong* can be kept in their original form when the receivers are experts, since they do not need any description or contextualization.
- *Metonymic translations* would address problem 10 and apply when original terms are expressed in the form of a metonymic variant and target terms are not. For instance, *groyne* could be translated both as *espigón* or *escollera* (metonymic variant), but *escollera*, in its coastal structure sense, can only be translated as *groyne*.

The preceding list highlights the fact that translation term pairs are rarely symmetric since any term can have various translations when localization accounts for context.

4. Conclusion

The SISE will never be a reality until linguistic and cultural barriers to multilingual communication have been successfully overcome. Although this is one of the objectives of resources such as GEMET and AgroVoc, the difficulty of linking terms in different languages with SKOS relations has led to evident cases of incoherence because such relations do not envisage the wide range of cross-lingual problems that can arise. Based on our research in EcoLexicon, we have presented an approach to ontology localization that encompasses and specifically contemplates the complexities of multilingualism and multiculturalism in the specification of correspondences between environmental terms in different languages. In this regard, both concept and term dynamics are the result of diverse pragmatic factors, such as domain-based, culture-based and communication-based constraints.

In order to define strategies that successfully address these problems, a set of translation relations has been proposed that encode possible types of translation correspondence, which are based on real-life examples. These examples given are eloquent proof that cross-lingual correspondences cannot be truly established basied on a single worldview or in a symmetrical way. Instead, any multilingual resource must account for context and dynamism in the conceptualization and definition of environmental entities in different language-cultures.

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