Creating a Multilingual Geospatial Thesaurus: GEOSS Societal Benefit Areas Translations for Italian, Spanish, French and Slovenian[*]

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Abstract

The Global Earth Observation System of Systems (GEOSS) Societal Benefit Areas (SBAs) are a set of terms of interest for the development of global spatial data infrastructures. These SBAs form a two level hierarchy (categories and subcategories) ranging from natural disasters to human health. The SBAs are used widely by international geographic information sharing initiatives and policy makers.

One of the uses of the SBAs is to allow users to search a spatial data infrastructure for resources that relate to the theme of interest (category or subcategory) selected. However, the SBAs are currently only specified in English. In this paper, we provide a translation of the SBAs into Italian, Spanish, French, and Slovenian in order to support multilingual search, and we underline the

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issues involved in the translation. Since some of these issues seem to be strictly related to a few discrepancies present in the original version of the SBAs, this paper also proposes a revision of the original set of terms in English.

Keywords: Multilingual thesauri, GEOSS, Societal Benefit Areas, EuroGEOSS

1. INTRODUCTION

The Global Earth Observation System of Systems (GEOSS) Societal Benefit Areas (SBAs) define a set of categories of interest for the development of global spatial data infrastructures. These SBAs form a two level hierarchy (categories and subcategories) ranging from natural disasters to health. The SBAs are used widely by international geographic information sharing initiatives, including INSPIRE[1] and EuroGEOSS[2], as well as GEOSS[3].

One of the uses of the SBAs is to allow users to search a spatial data infrastructure for resources that relate to the theme of interest (category or subcategory) selected. However, the SBAs are currently only specified in English. In this paper, we provide a translation of the SBAs into Italian, Spanish, French and Slovenian in order to support multilingual search together with an illustration of the main issues involved in the process of translation. This is followed by a proposed revision of the original version given some incongruities in the original draft of the SBAs.

The paper is structured as follows. Section 2 provides background about the SBAs within the EuroGEOSS project, within which this work was completed. This explains the motivation for the work and outlines how multilingual thesauri can be used to support multilingual search. Section 3 provides a summary of related work on multilingual ontologies/thesauri creation. Section 4 describes the methodology used for the translation, Section 5 describes the application of the method step-by-step, Section 6 focuses on the issues involved in the process of translation and the ways in which these issues manifested themselves for specific languages: Italian, Spanish, French and Slovenian (also see Appendix B for an overview of the translations). Finally Section 7 provides a discussion on a proposed revision of the SBAs taking into consideration some of the problems involved in the translation and related to the original text.

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[1] http://inspire.jrc.ec.europa.eu/
[2] http://www.eurogeoss.eu/default.aspx
[3] http://www.earthobservations.org/geoss.shtml

2. EUROGEOSS KNOWLEDGE BACKGROUND

EuroGEOSS was an international project (2009-2012) funded by the European Commission to answer the growing demand for monitoring of environmental and geospatial data. It built upon geospatial information systems that were already in operation or had an institutional commitment and extended them using the INSPIRE directive (2007/2/EC)[4] to build up a European spatial data infrastructure[5] and enhance the requirements of GEOSS.

EuroGEOSS extended the current state of the art in semantic interoperability arrangements. It aimed to apply a multidisciplinary research approach to the understanding and monitoring of environmental phenomena revolving around three main areas of thematic application: biodiversity, drought and forests. By so doing, EuroGEOSS aimed to scale up the local dimensions of a geospatial infrastructure to a European system of systems, intended to cover crucial areas in Europe. For this reason, it needed a compact knowledge core to share, discover and retrieve resources in ways that were both technically interoperable and semantically efficient. In order for these resources to be included and discovered the project supported *inter alia* a core base of multilingual knowledge organization systems in the form of ontologies/thesauri that include a semantic internal structure of both horizontal and/or vertical relations between concepts.

The knowledge base of EuroGEOSS was based on two initial core multilingual thesauri: the Group on Earth Observations (GEO)'s Societal Benefit Areas (SBAs) and the European Environment Agency's General Multilingual Environmental Thesaurus (GEMET)[6].

GEO is an international organization responsible for the drafting of the Global Earth Observation System of Systems (GEOSS)[7] plan. This is a 10-year (2005-2015) multi-disciplinary project aimed at contributing to solving big global environmental issues (i.e., climate change, energy consumption, natural disasters) by providing users with the state-of-the-art tools to generate a worldwide network for earth observation. It makes use of a new spatial data infrastructure that connects data-providers with users to endorse societal benefit. The goal of the EuroGEOSS project was to add to the GEOSS plan by generating an interoperable network in Europe focused on a subset of three thematic areas, these being: drought, forestry and biodiversity. The main societal

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[4] DIRECTIVE 2007/2/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 March 2007: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:108:0001:0014:EN:PDF
[5] http://inspire.jrc.ec.europa.eu/
[6] http://www.eionet.europa.eu/gemet
[7] GEOSS: http://www.epa.gov/geoss/index.htm

benefit areas addressed by GEOSS in fact are nine (biodiversity, water, energy, agriculture, climate, ecosystems, disasters, health and weather) and within each area there are subcategories, but these terms are not multilingual (SBAs)[8].

In the work we have conducted under the EuroGEOSS project, these two vocabularies (GEMET and the SBAs) are linked to one another by means of manual mapping by the affiliates to the project working in the relevant domains. These vocabularies are then further extended to embrace other knowledge schemes (Stock and Cialone, 2011). The two vocabularies differ in that the SBAs are a simple environmental thesaurus (a hierarchical structure of nine categories and 57 subcategories), which has been developed for GEOSS. In contrast, GEMET is a more complete environmental thesaurus (including cross-links between terms) whose nomenclature includes a set of metadata keywords in the INSPIRE directives for the creation of a shared European geospatial infrastructure (Lutz et al, 2009).

The choice of these two vocabularies was the outcome of a shared assessment of the most suitable knowledge schemes that could fit the requirements of EuroGEOSS for its information retrieval system. The parameters of such a judgement were diverse, concerning their thematic coverage, free availability and current use. But most of all, since our investigation hinged upon the semantic interoperability to be provided across Europe, we needed to consider parameters for simple and broad linguistic solutions. These included on the one hand the technical language of implementation and linkage (compliant with the W3C, OGC standards and the technologies used within the project, which in our case was the RDF/SKOS data model[9]) and on the other hand the natural languages covered by the ontologies/thesauri. As far as SKOS is concerned, this is a technical model adopted by the W3C to describe any classification scheme conceived as a semantically structured organization of information (such as ontologies, thesauri etc.). It allows the user to establish alignments within and mappings across different ontologies. The relations adopted by SKOS include broadMatch (generalisation); narrowMatch (specialisation); relatedMatch (simple relation); closeMatch (close relation) and exactMatch (same meaning) (Cialone and Stock, 2010).

As far as natural language is concerned, at present GEMET contains terms for 31 different languages whereas the SBAs have been implemented only in English by GEO. Therefore, in order to favour better access to resources and to make the multilingual core more balanced, we, at the University of Nottingham, decided to translate the SBAs into Italian, French and Spanish and the University of

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[8] http://www.geoportal.org/web/guest/geo_home
[9] http://www.w3.org/2004/02/skos/

Ljubljana assisted us with a Slovenian version. This was done to allow each user to perform queries in whatever language s/he was more comfortable with and to return to the user other mapped resources stored both in the language used for the query, and other languages. In conducting the translation, we encountered some issues in the originally defined GEOSS terms, which were not originally conceived as a thesaurus. We provide a discussion of these issues and a proposed adjustment of the English SBAs taking the former under consideration (Appendix B).

3. RELATED WORK ON MULTILINGUAL THESAURI

3.1. Multilingual Thesauri

A common distinction is made between ontologies and thesauri in the semantic (ontology engineering) literature (Gómez-Pérez et al, 2004). An ontology is a specification of a representational vocabulary for a shared domain of discourse — definitions of classes, relations, functions, and other objects (Gruber, 1993). A thesaurus instead is a set of defined concepts usually including some semantic relationships between concepts (i.e. synonyms, antonyms, hyperonyms, hyponyms, etc.), but it is usually less formalised than an ontology, and without the inclusion of logical axioms (McGuinness, 2003).

A number of multilingual thesauri/ontologies have been developed. The most widely used in the geospatial arena are the GEMET Thesaurus[4], created by the European Environment Agency (EEA) and covering 31 different languages and the Multilingual Agricultural controlled Vocabulary (AGROVOC)[10]. The latter was created by the Food and Agricultural Organization (FAO) and it is actually available in about 17 different languages with some additional ones under drafting and revision (Sini et al, 2008). Other multilingual thesauri include Earth[11], an environmental thesaurus developed by the Bari Department of the Water Research Institute[12] although only available in Italian and English; the EU inter-institutional terminology database IATE (InterActive Terminology for Europe)[13] which covers 23 EU official languages and the drought vocabulary developed by domain experts under the EuroGEOSS project which is provided in 15 European languages. Moreover, as mentioned above there are also other less fine-grained multidisciplinary thesauri dealing *inter alia* with less specific geographical and geospatial issues such as EUROVOC[14] maintained by the Publications Office of

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[10] http://aims.fao.org/website/Search-AGROVOC
[11] http://uta.iia.cnr.it/earth_eng.htm
[12] http://www.irsa.cnr.it/
[13] http://iate.europa.eu/iatediff/
[14] http://eurovoc.europa.eu/

the European Union[15]. This last one exists in 22 EU languages with extra 2 non-EU (Serbian and Croatian) languages included. It is used by the European Parliament and serves as a semantic basis for the European Union's terminology. Another example of a generic multilingual thesaurus not specifically focussed on environmental issues is the UNESCO thesaurus[16] developed by UNESCO organization[17]. It mainly deals with education, culture, human sciences and other humanistic subjects and is only available in 4 languages (Russian, Italian, English and French).

3.2.   Guidelines for the Creation of Thesauri

A set of rules and regulations on monolingual and multilingual thesauri has been developed by the ISO (respectively ISO 2788:1986, ISO-5694: 1985). For the creation of a multi-lingual knowledge system, three main *modus operandi* have been postulated (ISO-5694: 1985; Riesthuis, 2005):

- The first one concerns the drafting of a multilingual thesaurus from the ground up;
- The second one refers to the translation of an existing thesaurus setting out from one source language to which linguistic adjustments could and could not be allowed when getting to the target languages;
- The third procedure proposed concerns the merging of monolingual thesauri in different languages.

Among the multilingual thesauri mentioned above such as IATE, UNESCO, EUROVOC to mention a few, we are here focussing exclusively on the largest and most commonly used geospatial/environmental ones. AGROVOC and GEMET will be discussed in more detail (in the subsections below) because they are of particular interest, as they are representative examples of the approaches that can be used for the creation of multilingual thesauri, and because our approach in making a thesaurus a multilingual thesaurus (the Societal Benefit Areas) sets out from the same goal as GEMET and AGROVOC in attempting to establish semantic support for an environmental knowledge system.

3.2.1.   AGROVOC

AGROVOC is the main agricultural (but also environmental) retrieval and query index of the entire Agricultural Ontology Service (referred to as AOS) of the Food and Agricultural Organization (FAO). It offers an easy multilingual access point for the research of resources, accessing mapped vocabularies to find the correspondent translations, to retrieve data at global levels.

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[15] http://publications.europa.eu/index_en.htm
[16] http://databases.unesco.org/thesaurus/
[17] http://www.unesco.org/new/en/unesco/

Not only does AGROVOC involve the translation of its terminology into different languages, but also a mapping with different knowledge schemes. An example is the mapping between the English version of AGROVOC and the Chinese Agricultural Thesaurus (CAT), the latter being thorough and reflecting varied perspectives upon the same area (Liang and Sini, 2006).

As far as the process of translation is concerned, one of the issues involved was related to the possible absence of a definition[18] from one language to the other because of the lack of reality it refers to (the referent) in the culture where the target language is spoken. O'Leary (2007) mentions the term 'Locust Watch' for example present in AGROVOC in some languages such as in Arabic but not in Spanish and presumably such an absence would depend on a lack of this type of plague in the latter area. The original solution proposed in these cases would have been to use the English version to convey the meaning.

However, one of the drawbacks of this approach was to end up creating a culturally biased view towards one dominant language and culture (mostly English and Western) which according to the ISO regulations (ISO-5694: 1985) is not recommended, given the premise that all the languages should be equal (Sini et al, 2008), but in general maintaining expressions belonging to different cultures is crucial for the preservation of the cultural heritage of every country that needs to be respected (Pazienza and Stellato, 2005). For this reason another method is being adopted by the FAO within the AOS concept system in which similar thesauri written in different languages can be mapped (e.g. English and Chinese). A possible drawback of this methodology is that the structural hierarchy or the level of granularity of the different ontologies and thesauri mapped, due to cultural and conceptual differences (Liang and Sini, 2006) might cause mapping difficulties.

3.2.2. GEMET

The approach adopted by the EEA and the CNR in creating GEMET is divergent from FAO's in AGROVOC. It has in fact been conceived as a collective work of merging multilingual (environmental and related) thesauri, of which only one (Infoterra) seems to have been originally written in English (Felluga and Plini, 2001), rather than building up an *ab initio* vocabulary (ISO 5964:1985) and then translating it. This bears resemblance to Doerr's concept of 'interlingua' in the sense that it fuses different thesauri, but it is different in that it does not merge the different terms into a new concept (Doerr, 2001). In fact, notwithstanding the numerous correspondences of concepts in all the languages proposed, and so allowing an easy merging, some terms still appear to be missing.

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[18] A definition is a natural language explanation of the meaning of the thesaurus term or concept.

Some of the issues arising from this approach concern the general cultural as well as linguistic difficulties in merging multilingual thesauri, especially in similar fields, because of their different structures. This, again, involves the mismatches among terms that in some cases could not be harmonized easily from the different vocabularies.

A poly-hierarchy is an answer to the need to reflect the different semantic structures deriving from all the other ontologies/thesauri merged. GEMET in fact is organized into groups, super-groups, themes and concepts[19]. As concerns the imperfect equivalence in the terms' semantics, the elimination and/or introduction of other concepts was a solution. GEMET also introduced definitions and scope notes for eventual disambiguation.

3.2.3. *Methods for the Development of Multilingual Thesauri*

Based on the ISO_5964:1985 for the creation of multilingual thesauri the above mentioned thesauri adopted the following procedures and methods:

- In the case of GEMET the procedure of merging different thesauri from different languages into one big multilingual thesaurus was adopted. The method was based on a collaborative work of matching coinciding concepts across thesauri. This involved the partnership of different bodies of research (Felluga and Plini, 2001), which developed the different thesauri but the collection and merging process was accomplished by EEA and CNR and the main hindrance was due to the unreliability of the translations and the difficulty in allocating them in the right hierarchies.
- In the case of AGROVOC both the procedures of mapping different thesauri in different languages and translating the source English into other equivalent languages were adopted (the latter also in EUROVOC and UNESCO thesauri). Both cases are the result of the collaboration of different institutes. In the first case mapping the Chinese Bilingual vocabulary (or CAT) to AGROVOC was based on mapping each term from the AGROVOC (the source terminology) to CAT (the target terminology) by using the open source java platform Protégé20. The process of translation into other languages instead was left to domain experts in the main language making use of a specific terminology database (FAOTERM21) or interrogating agricultural resources to check the specific use of each term. Translations are then sent to FAO, which is in charge of incorporating them in one only thesaurus.


[19] http://www.eionet.europa.eu/gemet/about?langcode=en
[20] http://protege.stanford.edu/
[21] http://www.fao.org/faoterm

In both methods used for the creation of multilingual thesauri it was the main managing institution (EEA for GEMET and FAO for AGROVOC) to be in charge of editing, collating and putting together the different vocabularies or the different translations without a general public platform as a set for the collaborative process.

4. METHOD OVERVIEW AND ISSUES

Figure 1: SBAs Translations Methodology Diagram
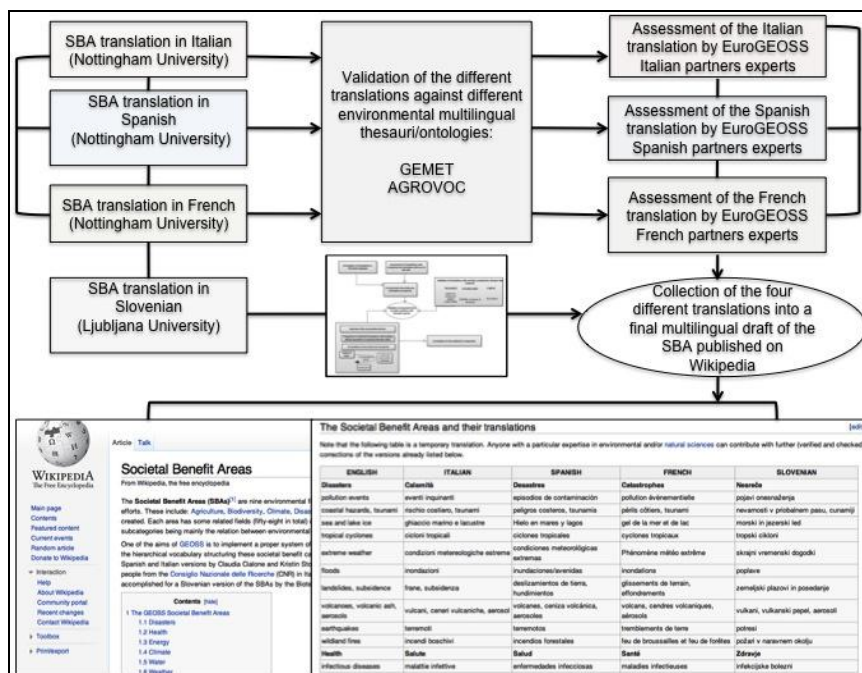
Our approach conforms to the second of the modus operandi previously listed (translation from an existing source language) compliant to the ISO-5964:1985 for the creation of multilingual thesauri. However, as mentioned earlier, the method adopted for its translation within the EuroGEOSS framework is different from the previous ones discussed above. This is different not so much in the translation *per se*, which translates a geospatial vocabulary from a source language to the target languages making use of existing reference vocabularies and environmental resources, as much as in the refinement process, in which we made the translation public to receive as much feedback as possible and generate a creative/collaborative loop to suit a decentralized project such as EuroGEOSS. The Societal Benefit Areas categories and sub-categories are not a EuroGEOSS creation but were drafted by GEO; this means that the vocabulary already existed on its own (for the purposes of GEOSS).

Secondly, the SBAs are not a deeply described set of concepts, but a coarse hierarchical categorization that cannot be compared with the thesauri/ontologies mentioned above. Because of this, it was not a huge task to recognize the terms and classify them. However, in some cases it was difficult to interpret the meaning of the coarse terms, and the SBAs could be improved by more input from thematic experts to explain the meaning of the concepts in each geographic area so as to ease the process of translating from one language to another.

Thirdly, in compliance with the ISO-5694:1985 approach for multilingual thesauri, we opted for a translation of an existing vocabulary without allowing for the original text to be changed. However, the SBAs as they stand need some modification in order to comply with the standard practice of thesaurus making. For this purpose we also propose a revision (in Appendix B and explained in section 7 of this paper) of the SBAs that could be perhaps incorporated in further developments of GEOSS.

As far as the methodology adopted is concerned, the translation procedure was split between the Slovenian (accomplished by the University of Ljubljana) on one side and the French, Italian and Spanish translations (by the University of Nottingham) on the other. Yet in both cases the following step by step procedure was adopted (the general procedure is described in figure 1 above, also check figures 2 and 3 in the following section dedicated to the Slovenian translation):

1. Sketched translation of the original English set of Societal Benefit Areas (SBA) into Italian, Spanish, French and Slovenian;
2. Validation against the semantic support of GEMET and AGROVOC and additional vocabularies for the Slovenian translation;
3. Circulation of a first translation in each language among Italian, Spanish French and Slovenian native speakers and possibly partners of the EuroGEOSS project;
4. Publication of a Wikipedia page with the SBAs categories and sub-categories explained along general lines together with a synoptic table of all the translations;
5. As a final step, a discussion (see section 7) on the incongruities included in the SBAs original terminology and a proposed revision (Appendix B).

5. DETAILED DESCRIPTION OF THE METHOD

5.1. Step 1

A first translation of the original English set of Societal Benefit Areas (SBA) was drafted in Italian, Spanish and French by the University of Nottingham and in Slovenian by the University of Ljubljana. General language corpora or vocabularies were used for the formulation of an appropriate translation of the

SBA terms in Slovenian (see figure 2 below). Specific terminology in the field of geospatial and environmental sciences were sparse in Slovenia, so corpora such as Evrokorpus[22] and Evroterm[23]were used to study the ways in which the terms concerned are used. Both tools are available through a custom-built concordance engine (Željko, 2004, 2004a). Besides these two corpora a sentence-aligned tokenised Slovenian-English corpus, EU ELAN (European Language Activity Network, http://nl.ijs.si/elan/) was used since it is widely accessible. This latter corpus consists of 15 source texts and their translations covering a wide range of domains, the largest subcorpora being EU-related texts and computer manuals. All listed corpora were used as the basis for translation of SBA categories in Slovenian (figure 2).

Figure 2: Process of Formulation of the Slovenian Translation
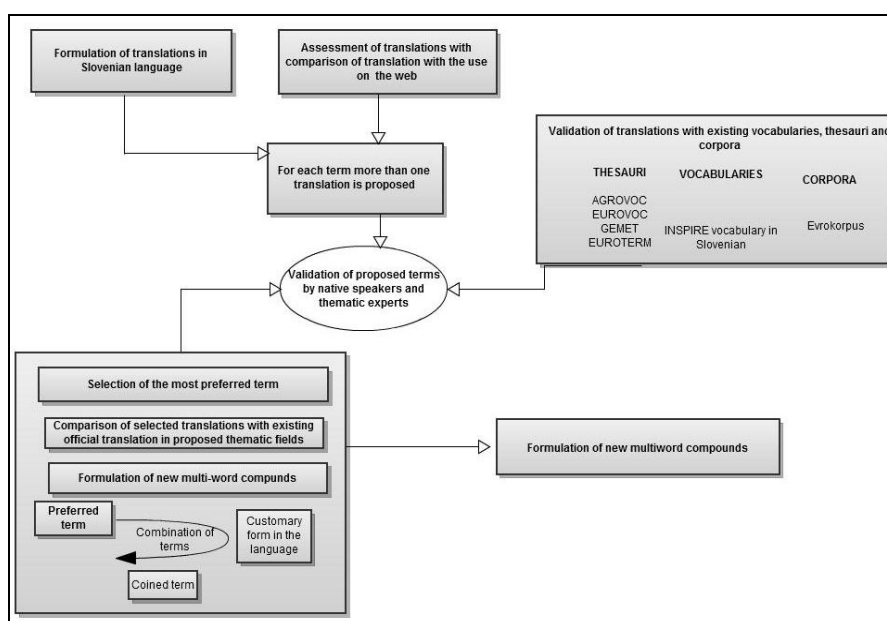
5.2. Step 2

After a first translation each term in each language underwent a process of assessment against the terms already in use especially in GEMET but also AGROVOC to make sure that it complied with a standard terminology in environmental science. Additional thesauri or translations in use on the web were used for cross-checking and validation of the Slovenian version (this developed separately, figure 3 below). Among these were:

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[22] http://evrokorpus.gov.si/
[23] http://evroterm.gov.si/index.php

- Meteorological Thesaurus;
- Geological Thesaurus;
- Geographical Thesaurus;
- Thesaurus of Spatial Planning;
- INSPIRE;
- IATE.

Figure 3: A Sketch of Sources used in the Process of Translation of the SBAs from English to Slovenian
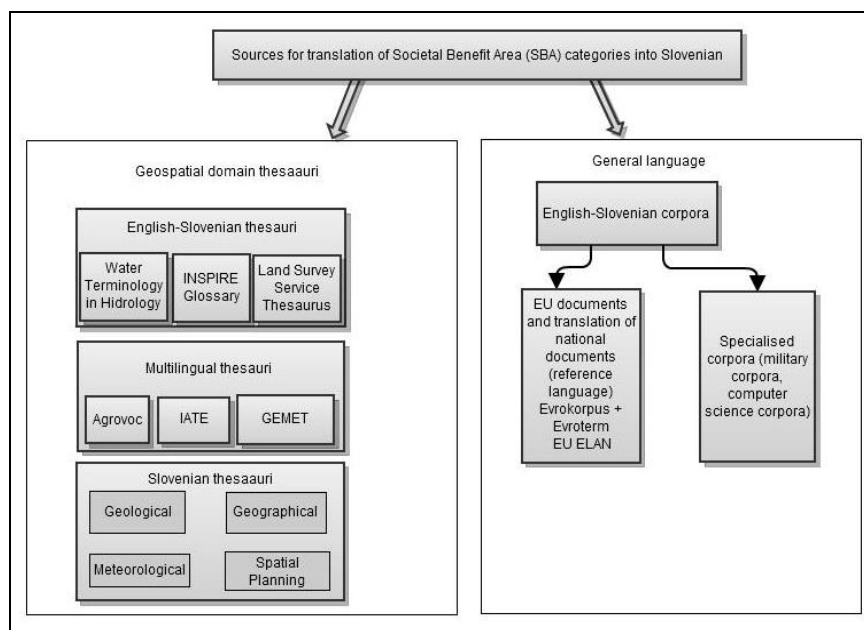
5.3. Step 3

Step 3 involved the inclusion of domain specific and technical experts to double-check the first drafted translation of the SBAs. Where possible native experts were recruited among the partners of the project EuroGEOSS as they had a better knowledge of the terminology in question and its use within the project. Where this was not possible external experts were asked for support.

5.4. Step 4

The publication of a Wikipedia page introducing the SBAs[24] in general terms, followed by a table with the existing translations comprised step 4.

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[24] http://en.wikipedia.org/wiki/Societal_Benefit_Areas

This afforded a chance to collate together the different translations accomplished by different institutions (so Nottingham and Ljubljana Universities), show the edits included to a wider public and to allow space for eventual corrections[25]. This choice proved to be time and cost-saving and served the purpose of making visible the work before decentralized in different websites and documents. We consider that this strategy was also useful for establishing a consensual equivalence among different speakers and partners of the project who could actually compare the different translations synoptically and contact the authors directly or suggest changes on the wiki page[26].

5.5. Step 5

After the translations were accomplished, some difficulties were noticed that seemed to be related to the original drafting of the SBAs. For this reason, in order to offer a better contribution to the community of scientists and policy makers around GEO, we have provided a section (section 7) to discuss eventual changes and improve the thesaurus. This is meant to be a point of reflection for future creations of thesauri/vocabularies/controlled set of terms and their multilingual translations.

6. ISSUES ARISING FROM THE TRANSLATION

Despite the simplicity of the SBAs, there were still issues that have a considerable influence on the referential meaning of the thesaurus' entries. By referential meaning, semioticians (the scientists of meaning in its linguistic, cultural and technical connotations) usually mean the semantic relation between a term (a semantic unit) and the conceptualization it refers to (Nida, 1975). In particular, we faced three types of challenges: one was related to the multiple English revisions of the original text (the SBA source was unstable), the second was related to the technical-linguistic problems of translation, the third to the semantic cultural differences emerging among languages. We summarize them below with examples from each of the languages into which the SBAs were translated.

6.1. Management Problems: Revisions of the English Version

A common problem was identified in both GEMET and AGROVOC concerning the timing of the different translations or translation-related documents (e.g.

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[25] A loop of corrections was made on the Wikipage by people, and the corrections were first reviewed and validated by the authors and by native speakers and eventually included into the Wiki page.
[26] Not many changes were suggested on the wikipage directly by experts but the few received certainly helped improving the quality of the translation.

definitions, scope notes) to be developed, collected and published that might affect the deployment of new published versions of the thesaurus or that, especially in the case of geospatial resources, might hinder the frequent updates these versions require (O'Leary, 2007; Felluga and Plini, 2001).

A similar problem occurred in our approach while attempting to gather the different translations of the SBAs together, as frequent revisions were included and it became difficult to reach a stable version. The SBAs are in fact not a proprietary creation of EuroGEOSS nor a common European Thesaurus addressed to a wider community of scientists but were developed by a third party – GEO and are addressed to policy makers. This means that we did not have the authority to make official changes to the original concept names or meanings, or their categorisations. Moreover, different and more extended versions of the subcategories appeared on the web site once the first translations had already been circulated. Therefore, the translation work of the different revisions became a meticulously strenuous process to follow, to the point of having different originals as well as divergent translations to review.

6.2. Technical-Linguistic Problems in Translating the SBAs

The linguistic peculiarities relative to each language, which can produce technical differences in the referential meaning of the terms, constituted another problem. These peculiarities included plural/singular forms and verbal/noun forms that are homographs.

As far as the plural/singular form of terms is concerned, in Italian for example, unless particular exceptions occur (*pluralia* or *singularia tantum*[27]) it is preferred to use the plural form when talking about general terms. But in other cases the choice does not straightforwardly follow the norm since it might depend on consistency of use. For example the first revision of the Italian translation tried to keep where possible the plurals such as the case of 'climate prediction' translated as 'previsioni climatiche' or in obligatory cases as in 'telecommunication' - 'telecomunicazioni' but in other cases the singular is maintained in Italian as in 'impacts of humans on water cycle' that becomes 'impatto dell'uomo sul ciclo idrologico' or 'drought prediction' that would be 'previsione di siccità' (probably a less frequent activity with respect to normal predictions). In Spanish as well the use of plurals is recommended, an example is the term 'renewable energy' that in Spanish is rendered as 'energías renovables' (see Appendix A). French doesn't seem to present significant differences in plural/singular forms, only the plural term 'pollution events' is rendered with the singular generic form 'pollution évènementielle'. An example from Slovenian is the subcategory 'cancers' for instance that is translated as 'rak', but its plural form can be translated as 'vrste

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[27] From Latin: terms that possess only a plural form (*pluralia*) or only a singular form (*singularia*).

raka' or 'rakasta obolenja'. Slovenian native speakers from the field of public health often use the expression 'rakasta obolenja' as the plural form of 'cancers'. Therefore it was decided to use 'rakasta obolenja' as the most appropriate translation. In general, in the Slovenian translation of the SBA terms, the plural forms of nouns were used based on the convention in Slovenian that any broader term encompassing a group of terms is used in its plural form.

A second issue arose from the use of verbal forms. According to the ISO for monolingual thesauri (ISO 2788-1986), the use of verbal forms[28] (e.g., infinitives like 'adapting to' or participles like 'adapting' alone) is most often not recommended. However, for languages such as English there is the possibility to maintain a verbal form such as 'understanding' or 'predicting' if it functions as a noun. However in other languages this opportunity is less frequent. In Italian for example the respectively correspondent translations 'comprendere' and 'prevedere' would not be recommended and the noun form is used 'comprensione', and sometimes the more general plural form of the noun is adopted as in 'previsioni'. By the same token, Spanish, French and Slovenian reviewers and thematic experts in environmental sciences preferred translating the English verbal forms of nouns with the corresponding generic nouns, which means for instance translating terms such as 'evaluating', 'predicting', 'adapting' etc with 'evaluación', 'predicción', 'adaptación' in Spanish; 'évaluation' 'prédiction' 'adaptation' in French; and 'razumevanje', ocenjevanje', napovedovanje' in Slovenian.

Another technical problem derives from the semantic nature of the spatial infrastructure of our project. This is due to the fact that these are not stand alone translations in their own right but will be used to inter-match with other thesauri constituting the semantic core of the system (which is composed of not just one ontology) (Stock and Cialone, 2011). In this respect there might be incompatibility between some issues addressed in the ISO-5964:1985 standard that seem to go beyond the scope of the data model for representation of these thesauri/ontologies and their mapping procedures (according to the SKOS primer notes)[29]. Translating an entire vocabulary or thesaurus from one language to another can be affected by the external semantic relations or mapping that this thesaurus already maintains with other thesauri.

One of the reasons is that sometimes there is no one-to-one rather a single-to-many translation of concepts from a source language (the language to translate)

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[28] The form of a verb includes tense conjugations, person and number declensions that vary depending on the context of use.
[29] http://www.w3.org/TR/2009/NOTE-skos-primer-20090818/

to the target (the language in which the source is translated), meaning that the same concept can be expressed in a variety of ways across languages, each one with a slight difference in meaning, thus casting doubts on the exact semantics of the concept itself. In Italian for example the term 'grazing systems' finds 'sistemi di pascolamento' and 'gestione del Pascolamento' as two semantically substitutable candidates although the first Italian term could be considered as slightly narrower than the second (since it is implicit that different concrete systems of grazing derive from a pre-planned managing action). Another term is the word for 'floods' whose translation in Italian could be both 'inondazioni' or 'piene', which might be considering examples of overlapping meaning erroneously too easily swapped in Italian since while the first event (an overflowing water mass) requires the second one (the growing of the water mass volume within a basin-river) to happen, the other way round is not always true, so this means that it is not always the case that a full river overflows but a necessary initial condition for an overflowing river is to be full. In Slovenian the same problem comes to the fore due to versatility of this language. The subcategory 'extreme weather' can be translated as 'ekstremni vremenski dogodki' or 'skrajni vremenski dogodki'. Both terms denote the same concept. The multi-word compound 'ekstremni vremenski dogodki' is characterized by the loanword 'ekstremni' for 'extreme' in English, while 'skrajni vremenski dogodki' is a more authentic translation of 'extreme weather' and is from a linguistic perspective the most correct Slovenian translation (translation for extreme is 'skrajni, izredni'). In official documents and everyday use both terms are equally present, but the form 'skrajni vremenski dogodki' was adopted due to the above reason. A way to go round this problem of semantic ambiguity is to locate the meaning in the context of use. A clear example in Slovenian is the term 'fisheries'. This can be translated in three ways as 'ribolovna območja', 'ribištvo' and 'ribogojnice'. In the context of water, 'fisheries and habitat' it is translated as 'ribolovna območja in habitati', where 'fisheries' corresponds to 'ribolovna območja', describing the areas where fishery in different natural areas is possible. In the context of ecosystems, 'agriculture, fisheries and forestry' it is translated as 'kmetijstvo, ribištvo in gozdarstvo', where 'fisheries' is translated as 'ribištvo'.

Therefore the work of mapping between different thesauri makes the process of translation a meticulous job the size of which should not be underestimated. In this sense, if the translation is not correctly accomplished it would then be difficult to state whether the two concepts (defined differently in different languages) have comparable meanings across thesauri. This is the reason why the reference thesauri were adopted where possible, especially GEMET, which is already an established technical environmental thesaurus.

One final technical/linguistic problem involved in the translation of the SBAs was due to some ambiguous terms present in the original version and discrepancies with the standards for creating thesauri (addressed in section 7). This motivated

our attempt to propose a revision of the SBAs (Appendix B), which could be useful for future translations of the thesaurus.

6.3.   Semantic Distance: Cultural Differences in Translating the SBAs

Different investigations deal with the issue of thesaurus translation in different ways. Another issue that has been underlined are the semantic distances across languages and the view that while translating, a wider range of relations (such as close, narrow or broad and not just exact equivalence) should be analysed between terms in different languages (Balestra, 2008) for a better understanding of their meaning.

What is more, it has been stressed that multilingual thesauri are first of all multicultural thesauri (Nykyri, 2010). This brings about a renowned problem in translation concerning ways to find connotative equivalences. An associated set of hindrances related to the previous ones when translating a vocabulary or a thesaurus is the original categorization if not enough documentation is provided, since it might not be easy to figure out to which aspect of reality the linguistic entries refer. The SBAs categories and subcategories were created in English, they were not originally conceived as a thesaurus, documentation about their meaning was hard to find and we did not have any definitions of the subcategories. For this reason in many cases it was difficult to elaborate an exact classification.

In the previous section we already mentioned that when translating a thesaurus, or another type of hierarchically organized knowledge scheme, a difficulty is in providing one-only semantic correspondence for a determined term in the source language. One of the reasons is because terms are part of a conceptualization of a shared reality (Gómez-Pérez et al, 2004) and we know that each classification is dependent upon cultural and, in our case, also geographic peculiarities and their meaning might change according to the context of use (for example a 'school' could be categorized as an institution or as a building). So, we needed to make a distinction between terminological and conceptual similarity. This means that there might not be cases of exact conceptual correspondences (Riesthuis, 2005), even among languages belonging to the same linguistic branch with similar morphology (e.g. languages from the Latin/Italic branch, or the Slavic, or the Germanic) and supposedly spread through close geographical areas thus sharing a relatively large amount of common geospatial resources. Therefore, some concepts could have only a broader or narrower matching in the other (target) language. Some examples of this partial equivalence is seen in Spanish with the term 'pollution events' which was turned into the general 'episodios de contaminación' but that according to native speakers is not pragmatically very common. In Spanish it is more common to use broader terms such as 'desastre ecológico' or narrower terms of the kind of those listed within the subcategories

such as 'vertido tóxico', 'marea negra'. A follow-up example is the term 'silvicultura' which is associated with the English term 'forestry'. These terms have a slight hierarchical difference since in English a distinction is made between the term 'silviculture' intended itself as a branch of forestry only dealing with development and care of forests (Wordnet[30], AGROVOC), whereas forestry is properly defined as the science dealing with the management of forest lands for wood, forages, water, wildlife, and recreation (GEMET). A cross-linguistic example is the term 'wildland fires' that has been translated in French as 'feu de broussailles et feu de forêts' that literally means 'fires of woodbrushes and of forests' as in technical French a portmanteau term similar to the English one does not exist. Therefore it seems that in French the translation is not exactly equivalent but it instead includes two narrower terms. Another issue is the translation of 'land use planning' with the French 'urbanisme'. Other alternatives, e.g. 'planification de l'utilisation du territoire' as it was translated in the Italian (see Appendix B) were not considered suitable. This indicates how languages coming from the same linguistic branch (Romance, in the case of French and Italian) and having in common the same exact word, sometimes use words differently in technical parlance. An example in Slovenian is the term 'coastal hazard' that translates as 'ogroženost priobalnega pasu' and 'nevarnosti v priobalnem pasu' as two semantically interchangeable terms, although the former can be considered as slightly narrower than the latter (it implies that risks in a coastal area derive from pre-planned management actions in this area while the latter term considers all potential hazards). Another example is the subcategory 'wildland fires' that has been translated by some partners as 'gozdni požari', literally meaning 'forest fires,' which corresponds to a narrower English term. Therefore the term was specified as 'požari v naravnem okolju', literally 'fires in natural environment'. A similar example of semantic specificity is the translation of 'oil & gas exploration' suggested by experts to be translated as 'rafinacija in upravljanje prevozov fosilnih goriv' where the specification 'fosilnih goriv' (fossil fuels) is added to the more general term 'upravljanje prevozov'.

In other cases a term in one language might have many versions in another language due to inguistic idiosyncrasies to the point that it becomes difficult to choose the right one and the process might require the help of different native speakers who are experts on the topic or reference thesauri also depending on the difficulties or cultural specificities a language involves. For example, the SBA term 'pollution events' has been translated into Slovenian by some experts as 'pojavi onesnaženja' and by others as 'pojavi onesnaževanja'. Both translations describe 'the indirect or direct alteration of the biological, thermal, physical or radioactive properties of any medium in such a way as to create a hazard or potential hazard to human health or to the health, safety or welfare of any living

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[30] http://wordnet.princeton.edu/

species'. The only difference is that the expression 'pojav onesnaženja' emphasizes the outcome of the pollution process, whereas the expression 'onesnaževanje' emphasizes the duration of the process. In GEMET, AGROVOC and EVROVOC the expression 'pollution' is translated as 'onesnaženje'. Therefore 'pojavi onesnaženja' was used as the most appropriate translation. A similar example of ambiguity is the term 'subsidence.' It can be translated as 'posedanje' or 'pogrezanje'. The only difference between the two terms is in their time component: 'posedanje' is the gradual process of sinking of the earth's crust while 'pogrezanje' is a more sudden sinking. The distinction in use of the first and second expression by native speakers is not clear. In GEMET 'posedanje' is used for 'subsidence'. Based on this, the expression 'posedanje' was used in the GEOSS SBA translation

But semantic problems while translating a thesaurus are not only based on cultural differences. These in fact can also be based on the nature of the original thesaurus and the way its terms have been classified. If these show some issues of semantic grouping, translations to other languages could be affected and rendered difficult to realize (semantic discrepancies of the SBAs are described in section 7).

7. DISCUSSION: ON IMPROVING THE SBAS

The translation work of the GEOSS SBAs has been described in this paper as being challenged overall by three main issues: the multiple revisions of the original text, technical linguistic difficulties, and cultural differences in translation visible across languages. These issues cannot be divorced from the fact that the original version of the SBAs contains many incongruities with multi- and mono-lingual ISO standards that are discussed below.

First of all, the style in which the categories were written is not always compliant with ISO-2788:1986, for the construction of monolingual thesauri. For example according to the standard, verbs or adverbs should be ruled out from any thesaurus' categorization whereas some terms listed in the SBAs are in fact pure verbs or actions such as 'understanding', 'adapting to'. Some of them are not just terms but a combination of what should be a term (e.g., Nowcasting forecast) and a definition (e.g., '0-2 hs'). For this reason it is suggested that under the entry 'climate', or the activities to which it refers to, a noun translation could easily be used such as 'adapting'/ 'adaptation'; 'mitigating'/ 'mitigation' and so forth. Therefore in this case the original text needs further revision to comply with ISO-2788-1986 (see Appendix B).

Moreover, the hierarchy of the SBAs is arguable, since in thesauri, if a term is defined as a 'subcategory' then it means that its relation with the term immediately above is of specialization, to better specify the category and not just

a semantic relation. However, some subcategories in the SBAs are not real specializations, but related concepts. If they are, the terminology used does not make this clear. In this case, some relabeling and reclassifying of the SBAs would be beneficial since it has now been adopted for use as a thesaurus in a number of projects. For example the term 'Agriculture, fisheries and forestry' as it is, is not a subcategory of 'Ecosystems', but rather a related term. Two possible solutions exist to solve this issue. One is to make the two terms related to each other; a second solution (here presented in Appendix B) is to change the name of the category 'Ecosystems' to 'Ecosystem Activities' and include the subcategory as a narrow term but splitting it into three different ecosystem activities: 'Agriculture', 'Fisheries' and 'Forestry' to make it more specialized and less generic.

In other cases where the subcategories could hardly be considered as a specialization of the category and where the previous renaming solution was not possible, the terms that had been defined as subcategories were instead defined as relative terms. Additional categorizations that comply with the technical language adopted to represent the thesaurus (SKOS) such as broad or close relations are possible to represent this technically, but these are not included in the Appendix as they are not crucial to the scopes of this paper.

Some other problems derive from compound words in the SBA subcategories, One example is the term 'telecommunication-navigation'. This combines two terms together but the reason for this combination (and in fact the meaning of the concept) is not clear in the GEO's 10 year Implementation Plan[31], where the Societal Benefit Areas are defined. Moreover, contravening the rules of a common multi-word compound expression, not having a head and a modifier (Riesthuis, 2005) but rather two heads, it can only be interpreted by factoring it syntactically (trying to intermingle the meaning of the two concepts and contextualize them against the general concept of 'water' under which they are subcategorized). This method of interpretation may differ from one language to the other, thus making it difficult to be certain whether the correct translations are being selected. Taking as an example the compound 'telecommunication-navigation' and given that the meaning of this term is not certain, there are at least two ways to solve this issue semantically:

1. If the term is intended to indicate telecommunication devices adopted during water navigation, one solution is to leave the category 'water' as it is but re-categorize almost all the subcategories instead as related terms and relabeling the compound term in a phrase such as 'telecommunication in navigation', itself a related term.

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[31] http://www.earthobservations.org/documents.html

2. If the term indicates a more general relation between telecommunication and navigation activities connected to water, another possible solution could consist on changing the category label itself to indicate a set of activities dealing with water 'water activities', thus leaving almost all the subcategories as narrow terms and split the term into 'water telecommunication' and 'navigation', where both express a type of specific water activity.

The second of these two options was used for our proposed revision to the SBAs (see Appendix B).

Finally the abovementioned technique of referring to an activity when naming the category turned out to be useful in avoiding the need to re-categorize most subcategories (in 'weather' for example the current subcategories seem to be more subtypes of a type of 'weather activity', namely forecasting, and not a type of weather, i.e. dry, humid etc.).

In Appendix B a new revision of the SBAs addresses the issues mentioned above.

8. CONCLUSIONS

This paper has presented a translation of the English GEOSS Societal Benefit Areas (SBAs) into Italian, Spanish, French and Slovenian. The translation itself was relatively straightforward, although a number of issues were identified. Specifically, there were a number of cases in which equivalent terms did not exist across languages, e.g. some terms were either too specific or too general, other were too ambiguous due to particular idiosyncrasies that each language enshrines. What is more, a number of technical difficulties were faced as far as the creation and the revision process of the original text of the SBAs is concerned.

The creation of a common Wikipedia page offered the possibility to receive different inputs from our thematic experts as well as to be noticed by other institutions, and was considered a very useful approach.

We conducted this translation to enable multilingual search by users of resources in a spatial data infrastructure (SDI), and enabled this search with a SKOS implementation of the multilingual thesauri/ontologies (GEMET and the SBAs). However, a number of other uses of a multilingual version of the SBAs are possible, considering that the SBA categories and subcategories are used to support global and European SDIs already. We also hope that other people will provide additional translations into other languages in the future (for which the Wikipedia page could prove useful as a reference platform).

Finally, we propose a number of corrections to the original SBAs categories and subcategories, resulting from our work and following the guidelines specified in relevant standards for the development of multilingual thesauri.

In supporting multilingual search of geographic information, we are aiming for an approach that supports cultural and linguistic differences as they are trying to map them as much as possible instead of converging into one only conceptualization, and thus supporting international diversity and interoperability.

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Appendix A: SBA Translations into Italian, Spanish, French and Slovenian from original text in English

ENGLISH	ITALIAN	SPANISH	FRENCH	SLOVENIAN
DISASTERS	**CALAMITA' NATURALI**	**DESASTRES NATURALES**	**CATASTROPHES NATURELLES**	**NESREČE**
pollution events	eventi inquinanti	episodios de contaminación	Pollution évènementielle	pojavi onesnaženja
coastal hazards, tsunami	rischio costiero, tsunami	peligros costeros, tsunamis	périls côtiers, tsunami	nevarnosti v priobalnem pasu, cunamiji
sea and lake ice	ghiaccio marino e lacustre	congelación marítima y lacustre	gel de la mer et de lac	morski in jezerski led
tropical cyclones	cicloni tropicali	ciclones tropicales	cyclones tropicaux	tropski cikloni
extreme weather	condizioni meteorologiche estreme	condiciones meteorológicas extremas	météo extrême	skrajni vremenski dogodki'
floods	inondazioni	inundaciones/avenidas	inondations	poplave
landslides, subsidence	frane, subsidenza	deslizamientos de tierra, hundimientos	glissements de terrain, effondrements	zemeljski plazovi in posedanje
volcanoes, volcanic ash, aerosols	vulcani, ceneri vulcaniche, aerosol	volcanes, ceniza volcánica, aerosoles	volcans, cendres volcaniques, aérosols	vulkani, vulkanski pepel, aerosoli
earthquakes	terremoti	terremotos	tremblements de terre	potresi
wildland fires	incendi boschivi	incendios forestales	feu de broussailles et feu de forêts	požari v naravnem okolju
HEALTH	**SALUTE**	**SALUD**	**SANTÉ**	**ZDRAVJE**
infectious diseases	malattie infettive	enfermedades infecciosas	maladies infectieuses	infekcijske bolezni
cancers	cancri	cánceres	cancers	rakasta obolenja
respiratory problems	difficoltà respiratorie	dificultades respiratorias	problèmes respiratoires	težave z dihanjem
environmental stress	stress ambientale	estrés ambiental	stress écologique	okoljski stres
nutrition	nutrizione	nutrición	nutrition	prehrana
accidental death and injury	morti e lesioni accidentali	Muertes y lesiones accidentales	décès et blessure accidentelles	poškodbe in nesreče s smrtnim izidom
birth defects	difetti di nascita	enfermedades congénitas	anomalies congénitales	prirojene napake
ENERGY	**ENERGIA**	**ENERGÍA**	**ÉNERGIE**	**ENERGIJA**
oil & gas exploration	esplorazione di petrolio e	exploración de petróleo y gas	exploration de pétrole et de gaz	iskanje nafte in zemeljskega

	gas			plina
refining and transport operations	operazioni di raffinazione e trasporto	operaciones de refinado y transporte	opérations de l'épuration et la transportation	rafinacija in upravljanje prevozov fosilnih goriv
renewable energy operations	operazioni di energia rinnovabile	operaciones en energías renovables	opérations d'énergie renouvelable	upravljanje z obnovljivimi viri energije
electricity generation	produzione di elettricità	producción de electricidad	production d'électricité	proizvodnja električne energije
global energy management	gestione dell'energia globale	gestión de la energía global	gestion de l'énergie mondiale	gospodarjenje z energijo na globalnem nivoju
CLIMATE	**CLIMA**	**CLIMA**	**CLIMAT**	**PODNEBJE**
understanding	comprensione	comprensión	compréhension	razumevanje
assessing	valutazioni	evaluación	évaluation	ocenjevanje
predicting	previsioni	predicción	prédiction	napovedovanje
adapting to	adattamento	adaptación	adaptation (au)	prilagajanje
mitigating	mitigazione	mitigación	diminution	blaženje
WATER	**ACQUA**	**AGUA**	**EAU**	**VODA**
water cycle research	ricerca sul ciclo idrologico	investigación sobre el ciclo hidrológico	recherche sur le cycle de l'eau	raziskave vodnega kroga
resource management	gestione delle risorse	gestión de recursos hídricos	gestion des ressources	gospodarjenje z vodnimi viri
impacts of humans on water cycle	impatto dell'uomo sul ciclo idrologico	impacto de la actividad humana en el ciclo hidrológico	impacts humains sur le cycle de l'eau	vpliv človeka na vodni krog
global biogeochemistry	biogeochimica globale	biogeoquímica global	biogéochimie mondiale	globalna biogeokemija
ecosystem and water quality assessment	valutazione della qualità dell' ecosistema e dell'acqua	evaluación de la calidad del ecosistema y del agua	évaluation de la qualité de l'écosystème et de l'eau	ekosistemi in ocena kakovosti voda
land use planning	pianificazione dell'uso del territorio	ordenación del territorio	Urbanisme	načrtovanje rabe tal
production of food	produzione alimentare	producción alimentaria	production alimentaire	pridelava hrane
weather prediction	previsioni meteorologiche	pronóstico meteorológico	prévision météorologique	napovedovanje vremena
heavy rainfall flood prediction	previsione di pioggia intensa ed inondazioni	predicción de lluvia torrencial y inundaciones	prévision des fortes précipitations et des inondations	napovedovanje poplav zaradi močnih padavin
drought prediction	previsione di siccità	predicción de sequías	prévision de la sécheresse	napovedovanje suš

climate prediction	previsioni climatiche	predicción climatológica	prévision climatique	napovedovanje podnebja
human health	salute dell'uomo	salud humana	santé humaine	zdravje ljudi
fisheries and habitat	pesca e habitat	pesca y hábitat	pêcheries et habitat	ribolovna območja in habitati
management	gestione	gestión	gestion	gospodarjenje
telecommunication-navigation	telecomunicazioni - navigazione	telecomunicación – navegación	télécommunications-navigation	telekomunikacije – navigacija
WEATHER	**TEMPO (PREVISIONI DEL TEMPO)**	**TIEMPO**	**TEMPS**	**VREME**
nowcasting forecasts (0 – 2 hs)	previsioni immediate (0 - 2 ore)	predicciones inmediatas (0 – 2 hs)	prévisions immédiate (0– 2 hs)	zelo kratkoročne napovedi (0 - 2 uri)
very short range forecasts (2 - 72 hs)	previsioni a brevissimo termine (2 - 72 ore)	predicciones a muy corto plazo (2 – 72 hs)	prévisions à très court terme (2 – 72 hs)	kratkoročne napovedi (2 - 72 uri)
medium range forecasts (3 - 10 days)	previsioni a medio termine (3 - 10 giorni)	predicciones a mediano plazo (3 - 10 días)	prévisions à moyen terme (3-10 jours)	srednjeročne napovedi (3-10 dni)
extended forecasts (10 - 30 days)	previsioni estese (10 - 30 giorni)	predicciones a largo plazo (10 – 30 días)	prévisions à long terme (10-30 jours)	dolgoročne napovedi (10 - 30 dni)
ECOSYSTEMS	**ECOSISTEMI**	**ECOSISTEMAS**	**ÉCOSYSTEMÈS**	**EKOSISTEMI**
land, river, coast & ocean management	gestione territoriale, fluviale, costiera e marittima	gestión terrestre, fluvial, costera y marítima	gestion des terres, rivières, gestion côtière et océanique	gospodarjenje s kopnim, rekami,obalami in oceni
agriculture, fisheries, forestry	agricoltura, pesca, attività forestali	agricultura, pesca, silvicultura	agriculture, pêcherie, sylviculture	kmetijstvo, ribištvo, gozdarstvo
carbon cycle	ciclo del carbonio	ciclo del carbono	cycle du carbone	ogljikov krog
AGRICULTURE	**AGRICOLTURA**	**AGRICULTURA**	**AGRICULTURE**	**KMETIJSTVO**
food security	sicurezza alimentare	seguridad alimentaria	sécurité alimentaire	prehranska varnost
fisheries	pesca	pesca	pêcheries	ribogojstvo
timber, fuel and fibre	legname, combustibile e fibra naturale	madera, combustible, fibra natural	bois, combustibles et fibres	les ter energenti in vlakna iz kmetijske in gozdarske biomase

agricultural economy and trade	economia e mercato agricoli	economía y mercado agrícolas	économie et commerce agricoles	kmetijska ekonomika in trgovina
grazing systems	sistemi di pascolamento (gestione del pascolamento)	sistemas de pastoreo	systèmes de pâturage	pašni sistemi
BIODIVERSITY	**BIODIVERSITÁ**	**BIODIVERSIDAD**	**BIODIVERSITÉ (DIVERSITÉ BIOLOGIQUE)**	**BIODIVERZITETA**
conservation	conservazione	conservación	conservation	ohranjanje
invasive species	specie invasive	especies invasoras	espèces invasives	invazivne vrste
migratory species	specie migratorie	especies migratorias	espèces migratrices	selitvene vrste
natural resources and services	risorse naturali e servizi	recursos naturales y servicios	ressources naturelles et services des écosystèmes	naravni viri in storitve

Appendix B: Proposed Revision of the original English Societal Benefit Areas[32]

ENGLISH SBAs		
DISASTERS	**narrow**	**related**
	pollution events	
	coastal hazards, tsunami	
	sea and lake ice	
	tropical cyclones	
	extreme weather	
	floods	
	landslides, subsidence	
	volcanoes, volcanic ash, aerosols	
	earthquakes	
	wildland fires	
HEALTH ISSUES	**narrow**	**related**
	infectious diseases	
	cancers	
	respiratory problems	
	environmental stress	
	nutrition problems	
	accidental death and injury	
	birth defects	
ENERGY ACTIVITIES	**narrow**	**related**
	oil & gas exploration	
	refining and transport operations	
	renewable energy operations	
	electricity generation	
	global energy management	
CLIMATE ACTIONS	**narrow**	**related**
	climate understanding	
	climate assessment	
	climate prediction	
	climate adaptation	
	climate mitigation	
WATER ACTIVITIES	**narrow**	**related**
	water cycle research	global biogeochemistry
	water resource management	land use planning

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[32] Marked in yellow are the changes to the original version of the SBAs.

	impacts of humans on water cycle	production of food
	ecosystem and water quality assessment	weather prediction
	heavy rainfall flood prediction	human health
	Water telecommunication	fisheries and habitat
	navigation	climate prediction
	Water management	drought prediction
WEATHER FORECAST	**narrow**	**related**
	nowcasting forecasts (0 – 2 hs)	
	very short range forecasts (2 - 72 hs)	
	medium range forecasts (3 - 10 days)	
	extended forecasts (10 - 30 days)	
ECOSYSTEMS ACTIVITIES	**narrow**	**related**
	Land management	carbon cycle
	River management	
	Coast management	
	Ocean management	
	agriculture	
	fisheries	
	forestry	
AGRICULTURE ACTIVITIES	**narrow**	**related**
	agricultural economy and trade	food security
	grazing systems	timber, fuel and fibre
		fisheries
BIODIVERSITY	**narrow**	**related**
	invasive species	Conservation of species
	migratory species	natural resources and services