An Ontology-Based Decision Support System to Foster Innovation and Competitiveness Opportunities of Health Tourism Destinations

Daniele Spoladore and Elena Pessot

Abstract The competitiveness of nature-based Health Tourism (NHT) industry, especially in the Alpine regions, is increasingly linked to the sustainability and exploitation of unique natural resources of tourism destinations, which often lack the access to knowledge and networks of stakeholders to improve their offerings. In this sense, the use of digital tools can open up further opportunities to reconsider value offerings and better access different knowledge resources and relationships within the industry network. This Chapter illustrates the collaborative design approach adopted in HEALPS2 for the development of an ontology-based Decision Support System for health tourism destinations. The resulting ontology aims to model the relationships between the available natural resources, the value offerings and the target groups of NHT destinations. Moreover, the Collaborative Design approach foresees the involvement of end-users (i.e. not only tourism destinations, but also the network of stakeholders, and the actual and potential future tourists) as both sources of knowledge and validators of the ontology and its outputs, aiming to inform decision-making processes in a shared knowledge model that leverages on digital tools.

Keywords Health tourism · Evidence-based health tourism · Collaborative development · Ontology-based decision support system · Ontology · Alpine region

D. Spoladore (✉) · E. Pessot
Institute of Intelligent Industrial Technologies and Systems for Advanced Manufacturing (STIIMA) National Research Council of Italy, Lecco, Italy
e-mail: daniele.spoladore@stiima.cnr.it

E. Pessot
e-mail: elena.pessot@stiima.cnr.it

D. Spoladore
Department of Pure and Applied Sciences, Insubria University, Varese, Italy

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1 Introduction

Nature-based Health Tourism (NHT) sees tourists travelling with the goal of receiving healing treatments or enhancing specific health or mental through medically-proven offers based on the effects of natural resources on the human body [1, 2]. The competitiveness of NHT is strictly linked to the exploitation and sustainability of natural resources of tourism destinations: for example, natural healing resources as waterfalls, Alpine herbs and peculiar mountain microclimates offer proven health-promoting effects [3–5]. For the Alpine Space, natural resources play a pivotal role in NHT products, as they are peculiar unique selling propositions and leverage on the authenticity of the Alpine offerings [6]. The unique Alpine natural resources asset can potentially allow different local and regional stakeholders (e.g. tourism service providers, medical professionals, health providers, agriculture, crafts, etc.) to cooperate in the creation of new NHT value chains [2]. However, tourism destinations may lack the knowledge of relevant stakeholders involved in such activities, as well as the opportunity to actively access and participate in a NHT stakeholder network: as consequence, they could miss the opportunity to improve their capabilities in delivering offerings and exploiting the synergic combination of possible NHT sources and activities [7].

Hence, it emerges the need to identify, adopt and develop solutions able to facilitate the connection among regional and local key actors by exchanging evidence-based data and systematizing knowledge and local experiences. In this sense, different NHT stakeholders could greatly benefit from digital solutions, similarly to what is happening both in the healthcare and in the general tourism sectors—being revolutionized by digital tools such as the ones based on Artificial Intelligence and Semantic Web. This kind of digital solutions can foster cross-national cooperation, support the redefinition of competitiveness in the NHT services and deliver better management strategies [8].

This Chapter presents the engineering and development of a Decision Support System (DSS) based on the knowledge elicited from Alpine Space stakeholders of HEALPS2 project. This tool aims at serving as a shared knowledge-base to support Alpine health tourism stakeholders in further understanding the potentialities of their territory, and at suggesting services and natural resources to invest on [9, 10]. Specifically, the approach adopted to develop the HEALPS2 DSS strongly leverages on the sharing and capitalization of expertise and capabilities of the different stakeholders in a collaborative effort, considered fundamental for a successful adoption of digital solutions in the long term. The DSS developed in this section represents the base of the tool developed in Chap. 5 [11], where the ontology underlying the system is used to actively support destination managers and policy-makers.

The reminder of this Chapter is organized as follows: Sect. 2 highlights a few studies adopting ontologies in health or medical tourism contexts, while Sect. 3 underlines the opportunities of leveraging on an ontological approach. Section 4 delves into the ontology underlying the DSS, with focuses on the collaborative ontology

engineering process adopted, on the deriving conceptualization and on the ontology's structure. Finally, the Conclusions summarize the main outcomes of this work.

2 Related Work

The adoption of ontologies and Semantic Web technologies for the development of DSSs in the tourism industry is widely documented in scientific literature. Moreover, shared and cooperative ontology engineering is also underlined as a success factor for such DSSs [12]. Nonetheless, there are very few examples of ontology-based DSSs specifically devoted to the industry of health tourism.

The ontological approach is the basis of the work of Chantrapornchai et al. [13], in which health tourism-related information are gathered and organized: domain experts' opinion is used as a way to evaluate the ontology's output. Two examples of ontology-based representations leverage on formalized knowledge to model touristic contexts [14] and provide user-dedicated recommendation in the field of medical tourism in Tunisia [15]. Lee et al. [16] proposed a smart orchestrator leveraging semantic models to formalize knowledge from the medical tourism, general tourism and medical treatment domains.

This work introduces an ontology-based DSS for the formal representation of health tourism destinations' natural resources, services provided and activities based on available natural resources. The ontology is developed leveraging on stakeholders' cooperation efforts and tourism data, with the aim of enhancing the value chain in a cooperative effort and in multiple rounds of knowledge exchange.

3 The Ontology-Based Approach

The HEALPS2 DSS leverages on Partners, stakeholders and destinations' knowledge to deliver suggestions on the economic and competitive potential of nature-based health tourism in the Alpine regions. Particularly, these regions are characterized by a variety of natural health resources and high environmental quality, but they are still not sufficiently integrated in value chains to properly face the demanding market of health travelers.

A promising approach to engineer a digital tool capable of making use of the knowledge shared among Alpine stakeholders is the ontology. Defined as a formal and shared conceptualization of a domain, the ontology is a computable knowledge base that can formalize relevant bits of information pertaining to that domain [17]. Ontology emerged as one of the cornerstones of Semantic Web in early 1990s, and it is nowadays adopted as the backbone of DSSs [18]. In fact, formal models are increasingly recognized among the key enablers of innovation in different health-related industries, where the possibility to rely on formalized expert knowledge can enhance cooperation, support common understanding and information exchange,

orient decision-making [10, 19, 20]. Ontologies are modelled with languages based on Description Logic (DL) [21], which is powerful enough to enable concepts and relationships representation while enabling the generation of inferred knowledge through the use of reasoning programs.

The development of domain ontologies is usually conducted in a cooperative way to elicit all relevant knowledge and facts related to a domain—especially in health-related contexts, in which knowledge elicitation is fundamental [22]. Considering the peculiar involvement of different stakeholders in HEALPS2, the ontology engineering activity followed a collaborative and agile approach to identify, elicit and formalize all the relevant information from the domains addressed by the project (as described in the following Section) [23]. The result of this process consists in a knowledge map of the Alpine health tourism in which different tourism destination can recognize their features and, potentially, produce a self-description. With the use of automated reasoning, destinations' input data are processed to deliver tailored suggestions on which natural resources to exploit (and how to exploit them) in order to enhance the destinations' competitiveness in the Alpine health tourism industry.

4 Engineering and Use of the HEALPS2 Ontology

This Section describes the collaborative approach adopted for the identification and elicitation of the information to be formalized in the HEALPS2 ontology. Also, the conceptualization and development phase are further addressed in its subsections. The ontology engineering methodology adopted for developing the project's ontology is UPONLite [24], since it foresees non-experts in the field of Semantic Web to adopt common tools to provide a conceptualization of different domains of knowledge. UPONLite is an "agile" engineering methodology, i.e. it presents a non-rigid structure for knowledge elicitation and conceptualization activities: considering the high number of stakeholders involved in the project, an agile ontology engineering methodology suits best with the necessity of gathering domain insights from many sources [9, 23]. Specifically, developers and domain experts were involved into three main phases: Domain analysis, Domain conceptualization, Implementation and development.

4.1 Knowledge Elicitation for Domain Analysis

The ontology engineering process in UPONLite starts with the identification and definition of the concepts and relationships (i.e. lexicon and glossary) of the domain. In HEALPS2, the knowledge elicitation process is essential to get relevant concepts and relationships. Often mentioned as a bottleneck for ontology engineering [25], knowledge elicitation is a very delicate and time-consuming activity. Taken into account the high number of stakeholders involved in the project, informal and formal methods

were conveniently adopted to ease achieving specific goals, such as identifying the most relevant bits of knowledge and produce an accessible and shared conceptual model to be developed into an ontology.

As mentioned in the Preface of this book [1], HEALPS2 research project fosters the collaboration among various stakeholders throughout the whole health tourism values chain. Thus, the involvement of these stakeholders in the knowledge elicitation activities covers an essential role to ensure capturing relevant information, and get relevant concepts and relationships. Stakeholders' ideas, opinions and knowledge were elicited through six national stakeholders' meetings (three held online due to pandemics' restrictions, and three held respectively in Austria, France, Slovenia, with the average participation of 15 stakeholders each) and one international stakeholders meeting (held online, with the participation of over 50 stakeholders). The purpose of these meetings was to select the concepts and relationships of interest in the Alpine health tourism domain of knowledge, and to agree on a definition for each of them. By leveraging on the KPI model [26] and on HEALPS2 project partners' support, data collected were transformed in quantifiable KPIs—which contributed to build the base concept and relationship model.

The relevant concepts and relationships elicited during the stakeholders' meetings were then put together into a conceptual map, which also encompassed KPIs descriptions. As foreseen by the methodology, stakeholders made use of different and familiar tools to made their ideas and opinions explicit, including unstructured interviews, brainstorming, active discussions, spreadsheets and documents.

4.2 Domain Conceptualization

While the domain analysis phase relied heavily on stakeholders' knowledge, the subsequent conceptualization phase leveraged more on project partners' inputs. In particular, the KPI model [26] was integrated in the conceptualization of the domain, since it provides a common and agreed framework to capture relevant information on the tourism destinations. The information was represented in the form of a conceptual map (Fig. 1), in which the main concepts and relationships were discussed and defined.

The domains elicited in the previous phase were multiple. From a health tourism perspective, the main groups of patients who could benefit from nature-based health

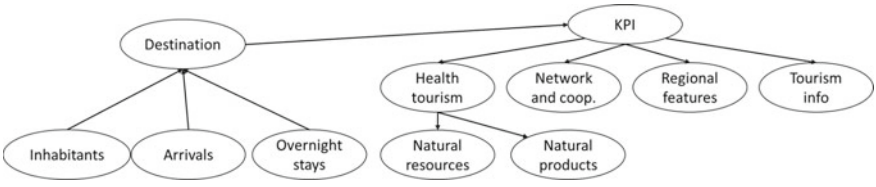

Fig. 1 An excerpt of the conceptual map deriving from the domain conceptualization phase

tourism in the Alpine space were identified. Similarly, the medical but also the health economic and tourism perspectives consider important to know which natural resources can be used and in which way—i.e., which products and services can be provided. There are also relevant quantitative indicators regarding the tourists' arrival, their overnight stay and provenance, to assess the tourism inflow in a specific tourism destination.

The result of the Domain analysis and Conceptualization phases brought to the following concepts to be addressed:

- Target Groups (TGs): each corresponding to a group of tourists suffering from a chronic condition or physical limitations, for which nature-based health tourism activity can provide benefits (e.g.: lack of mobility, diabetes and metabolic disorders, skin conditions, exhaustion and tiredness, etc.).
- Tourism in general: a concept in which data describing a specific tourism destination and its touristic inflow are detailed (tourists' arrivals, their country of origin, duration of stays, tourists' age and gender, destination population density, economic impact of tourism on the destination—tourism intensity, overnight stays per 1000 inhabitants).
- Natural Resources: a concept divided into the main natural resources populating the Alpine space (blue spaces, forests, waterfalls, altitudes, protected areas, specific flora), their products (mineral waters, nature-based local products such as Alpine dairy products, farm products, honey, etc.), and essential indicators to assess the degree of environmental pollution through a set of metrics (air pollution, light pollution, noise pollution).
- Regional Features: a set of descriptive concepts that identifies and defines the main characteristics of a health tourism destination, also listing the services it can provide (e.g.: health manager, nutritional advice, mountain hiking activities, spa treatments, physiotherapy, etc.); some services are correlated with the availability of one or more natural resources.
- Cooperation and Networking: a success factor for health tourism destinations was identified in the opportunities to participate in cooperative networks (regional, national or international).

After identifying these the concepts and their features, KPIs were linked to each domain feature to allow the ontology to quantify data regarding tourism destination and their services, as well as the existence and use of natural resources.

4.3 Implementation and Development

The conceptual model containing the logical and mathematical relationships among concepts was implemented into an ontology using the Protégé ontology editor [27]. Resource Description Framework (RDF) [28] and Ontology Web Language (OWL) [29] were adopted as ontological languages, with rules written in Semantic Web Rule Language (SWRL) [30]. The HEALPS2 ontology encompasses more than 85

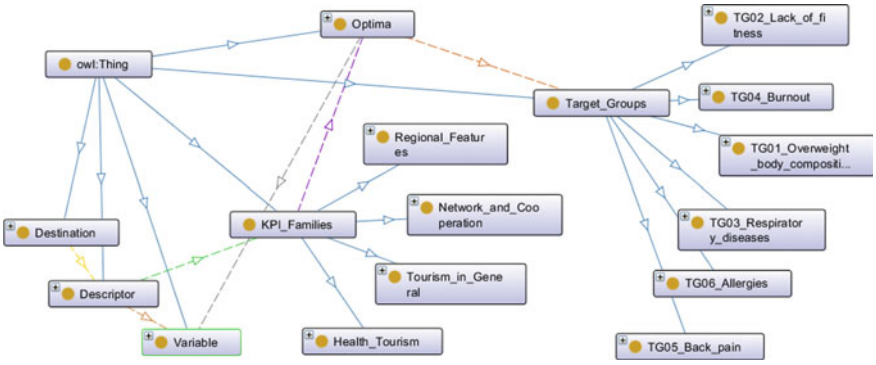

Fig. 2 A graphical representation of the main concepts composing the HEALPS2 ontology's taxonomy and their relationships (generated with Protégé ontology editor)

classes, 9 object properties, 57 datatype properties and includes 1075 individuals (for a total of 7265 axioms, including SWRL rules). Figure 2 shows an excerpt of the taxonomy of the developed ontology.

The DL consistency of the ontology was checked with the Pellet reasoner [31], as it is one of the few reasoners able to process SWRL built-in functions (necessary to state mathematical relationships among concepts). The ontology prefix is "hlp".

4.4 Using HEALPS2 Ontology to Represent Health Tourism Destinations

The set of KPIs necessary for describing a destination in the ontology is represented by four classes (`hlp : Health_tourism`, `hlp : Network_and_Cooperation`, `hlp : Regional_features`, `hlp : Tourism_in_General`). Each of these classes is further specified by subclasses. The ontology allows representing a health tourism destination as an OWL individual belonging to the class `hlp : Destination`. Each destination is described by a set of `hlp : Descriptors` (one for each KPI, for a total of 56 descriptors), which `hlp : quantifies` a specific KPI. Using this pattern, it is possible to assert that a destination can count on a specific natural resource (`hlp : exists`), which can (or cannot) be currently used for tourism purposes (`hlp : use`) and which can generate health-related natural products (`hlp : product`), as shown in Fig. 3.

The TGs are also represented in HEALPS2 ontology as classes and individuals. Each of the TG is linked to a KPI and an optimum value—i.e. the degree to which a specific destination feature (natural resource, product, service, etc.) can help or intervene on the health issue represented by the TG—is stated (as illustrated in Fig. 4).

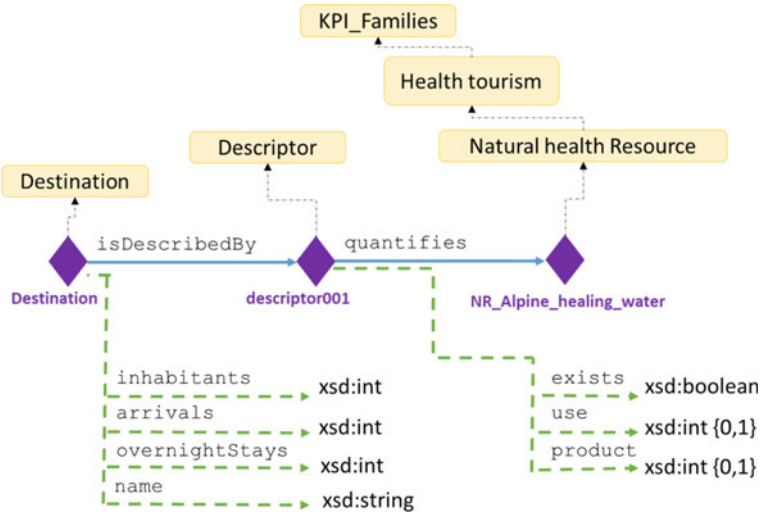

Fig. 3 An excerpt of the HEALPS2 ontology illustrating the modelling of a destination and the representation of a KPI (labelled rectangles represent classes; diamonds indicate individuals; dashed arrows indicate datatype properties, full-line arrows indicate object properties; the rdf:type of an individual is stated with a dotted arrow)

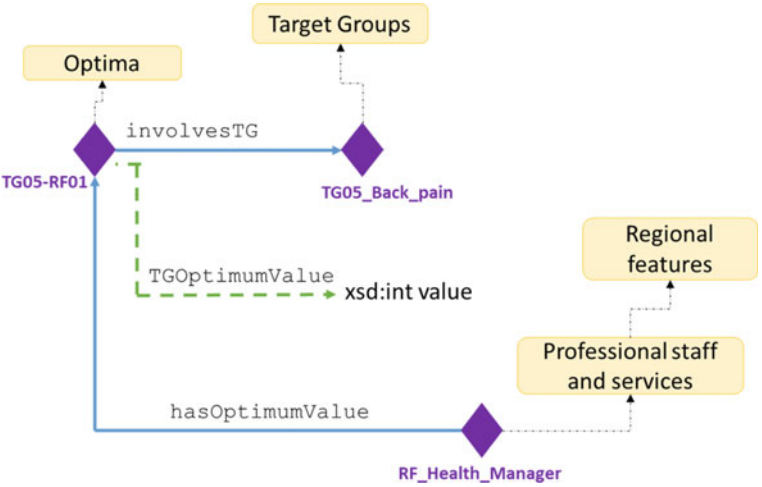

Fig. 4 The representation of an optimum for a TG. The "importance" of having a health manager for people characterized by back pain is stated through an integer value (ranging from a minimum of 1 to a maximum of 10)

Fig. 5 The score (`hlp : VAR_value`) inferred for a variable associated to a TG and a descriptor (generated using Pellet reasoner)

Each destination, described and valorized by its descriptors, is then compared with the values depicted for the optima using SWRL rules. Through a reasoning process, the results of the comparison processes are then further elaborated attributing scores to the destination, and are finally stored in individual variables (Fig. 5). The scores—which are delivered to the application, as described in Chap. 5 [11]—indicate the preliminary level of adequacy of the tourism destination for specific TGs.

The DSS is therefore able to calculate the differences occurring between the optimum values for each TGs and the effective values hold by a destination: in this way, the ontology supports the identification of those natural resources and/or services worth investing on. To populate the ontology and test the SWRL rules, project partners were to provide four Alpine health destinations and their information.

5 Conclusions and Future Works

This Chapter presented an ontology-based DSS to support NTH destinations in innovating and enriching their product offerings by leveraging on local natural resources. Specifically, it describes the collaborative engineering process and delves into the ontology's structure as its result, highlighting how it can contribute in identifying the natural resources or services to be exploited for enhancing the nature-based health tourism offer of destinations. The DSS also provides an example of knowledge-based digital tool for Alpine health tourism, and its results are further adopted by an application specifically dedicated for destination managers and policy makers.

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