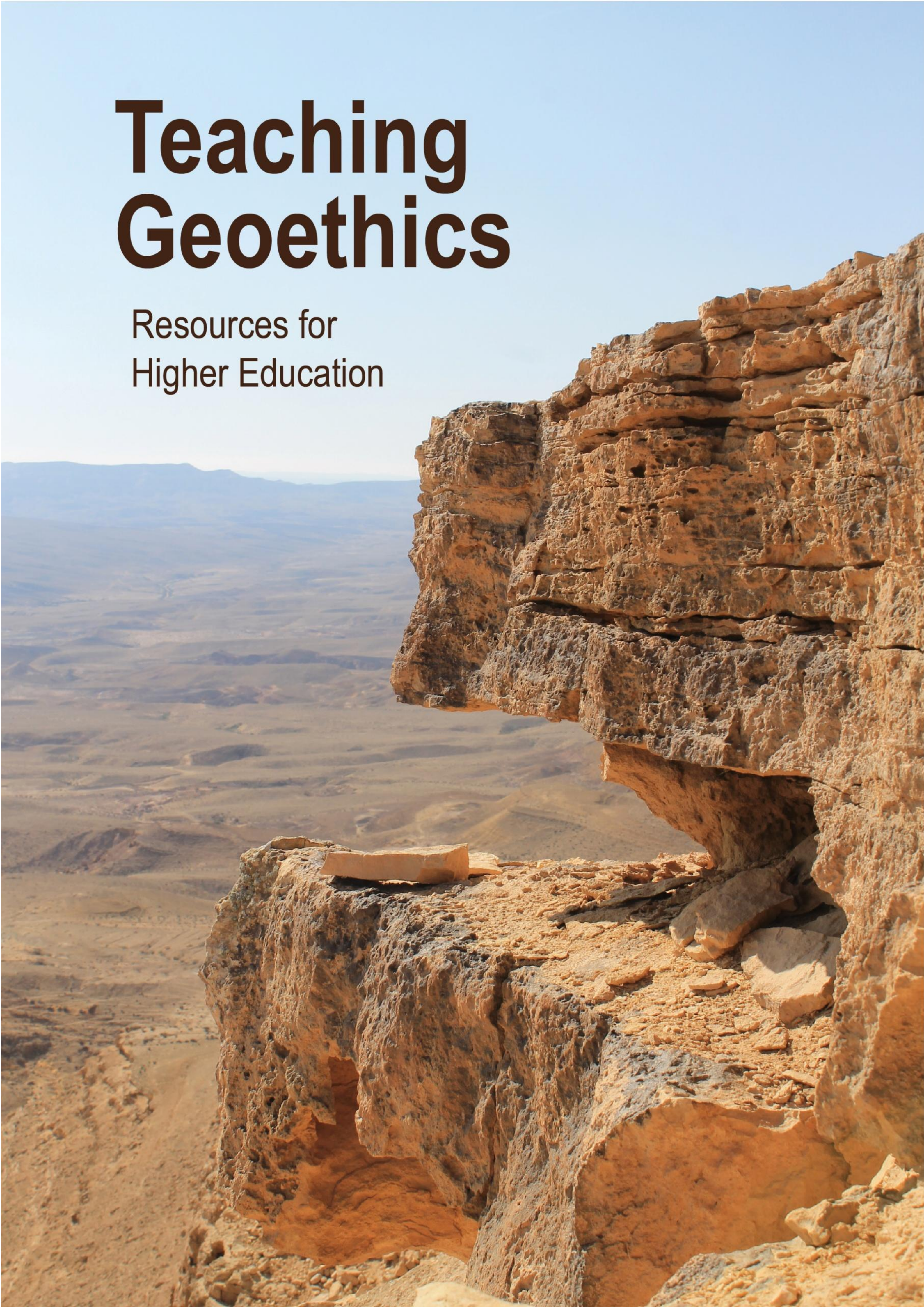
Teaching Geoethics

Resources for Higher Education



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CONTENT

PREFACE

The promotion of sustainable life involves respect and ethics for the Earth. Building sustainable societies requires responsibility in intervening in natural processes, building geoethics values and establishing a cultural and social awareness of citizens and science.

As we enter the second decade of the 21st century, the presentation of a book that brings forward experiences about education and teaching in the context of geoethics, in topics aligned with educational curricula themes (such as, for example, the role and ethical responsibility of society; geoethics in the context of geoheritage, the management of georesources, the increasing urbanization, georisks), represents a new paradigm in the debates involving the global environmental issues.

In the late 20th century, Donald Worster, in the 1992's book entitled *Nature's economy: a history of ecological ideas*, pointed out that the explosion of the first atomic bomb as a test in the desert of New Mexico, USA, and two months later, the reality of the explosion of the atomic bombs in Hiroshima and Nagasaki, marked the moment when humanity became aware of the possibility of the complete destruction of the planet Earth.

The scenario emerging global debates, since the late 1960s, showed that among the priorities for the 21st century, the major global environmental problems should be referring to ethical issues.

The exploitation and excessive use of the Earth system's georesources, which long ago extrapolated the planet's support capacity, involve not only the finite character of these resources, but the processes in an unsustainable production chain.

In Rio de Janeiro, in August 2000, the International Geological Congress put in its agenda the theme "Geology and Sustainable Development: Challenges for the Third Millennium", highlighting new roles and approaches of Geology in the 21st century.

Although concerns about human interference in the processes of terrestrial dynamics are recent in the political and environmental governance global scenarios, ethics in relation to the Earth is not recent, and may date back centuries before, when Antonio Stoppani (1824-1891) pointed out the "geological force " of humanity in the intervention on Earth processes, which leads us to the modern concept of the Anthropocene.

The beginning of the first decade of the 21st century demonstrated that the proposed ethics in relation to the planet should assume new priorities, which involve reflecting new values, behaviors and attitudes, pointed out by the International Association for Promoting Geoethics - IAPG.

In this book, geoethics themes are developed by researchers from different countries, cooperating to present a synthesis that is committed to the ethical, social, and cultural discussions on education, research and practice in geosciences. The role and social responsibility of geoscientists in the context of global debates on development and sustainability permeate the necessity to include training in geoethics within Higher education curricula.

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INTRODUCTION

Ethics is deemed an integral part of scientific research. In this sense, scientific training should be committed to fostering the awareness of ethical challenges and the importance of developing skills in dealing with these kinds of issues. The same idea is acknowledged in relation to promoting the science-society dialogue and the relevance to training, in the diverse areas of science, of developing abilities in this regard. The claims are particularly relevant at present, as new developments in science and technology deal with concepts and possibilities at the forefront of our concerns: from the life sciences, where the even the very notion of humanness is at stake, to the geosciences, where providing conditions for the operational sustainability of the earth system is broadly understood as imperative. The emergence of geoethics as a research and reflection field and the efforts in raising the awareness of the ethical aspects of the interaction of human activities with the Earth system are related to this concern; we can see the founding of the International Association for Promoting Geoethics in 2012 as a mark of the institutionalization of the field. Most of current advances in science somehow evoke the involvement of all of us citizens, our engagement to debate and take part in decision making processes. Moreover, most of the contemporary societal challenges entail contributions from different scientific areas and require multidisciplinary teams, including the social sciences and the humanities. Exploring this kind of collaboration seems also crucial as part of scientific training.

Ethics and the science-society dialogue are thus key and, in fact, interconnected aspects of the scientific practice. In the last decades, the relevance of this became well-present in the domain of science policy. In the European context, the program Ethical Legal and Social Aspects (ELSA) of science that emerged in the 1990s (Forsberg, 2015; Zwart & Nelis, 2009), and more recently the idea/practice of Responsible Research and Innovation (RRI), part of Horizon 2020 (European Commission—Directorate-General for Research and Innovation, 2013), are illustrative examples.

We might then ponder how does this articulate with the concept of value-free science, the idea that science in order to be objective must be free of the influence of any aspects other than the purely epistemic. As it has been noted (Jorge, 2014), this idea and the value-laden thesis might lead to a sensation of ethical completeness when doing science and to some difficulty in accepting the interpellation by society.

For better contextualization, let us look at the evolution of scientific knowledge production, of the relation science and society as well as of ways of addressing societal challenges. Analysing long-term developments of knowledge production in science, the scholar in science, technology and society studies Rip identifies the increasing importance of protected spaces (2018); these protected spaces, have material, socio-cultural and institutional aspects, became a functional requirement for doing science, have the effect reducing interference and variety and mean that productivity of scientific knowledge production is somehow based on exclusion. The opening up of institutionalized knowledge production and recontextualization of science in society has occurred in a variety of ways, from the last decades of the 20th century (Rip, 2018).

An extended responsibility of the scientists became clear in the wake of World War II. And adding to the institutionalization of knowledge production, the institutionalization of ethics emerged. The Nuremberg Code, following the so-called Doctors' Trial (see Shuster, 1997), then in 1964 the Helsinki Declaration adopted by the 18th General Assembly of the World Medical Association (WMA) and last amended in 2013 (WMA, 2013 [1964]), and more recently, in 2005, the Universal Declaration on Bioethics and Human Rights (UNESCO, 2005) are key regulatory documents which apply to research in the life and health sciences. The creation of ethics committees or institutional review boards is rooted in those guiding principles.

The existence of ethical constraint in scientific practice is well-acknowledged (Jorge, 2014). This is not a specific feature of research involving human participants, nor of animal welfare with regards to scientific experimentation. The biosciences provide other illustrative examples. Back in 1975, the Asilomar conference on recombinant DNA molecules (Berg, Baltimore, Brenner, Roblin III, & Singer, 1975; Berg & Singer, 1995) dealt with this. The aim of this conference, organized by a group of leading molecular biologists, was to assess the potential biohazards of the new technology and to establish guidelines to govern research the field. The meeting included not only experts in molecular biology but also other participants such as lawyers and members of the press. As noted by historian of biology and bioscience ethics expert Hurlbut, the meeting is remembered as *“a historical event that established the foundation for scientific self-regulation in an unknown and potentially dangerous domain”* (2015, p. 126). Although later criticized by not including the public, Asilomar is a precedent for the governance of emerging technologies.

Back to the aforementioned idea of RRI, it is time now to emphasize its ethics component – ethics as integral part of research, present throughout the whole process, from beginning to end, and as the means of achieving research excellence, in all areas of research and innovation, whether involving human beings, other living beings or the Earth system. The future of RRI as a practice implying all societal actors during the whole process of research and innovation has provided numerous discussions so far. Rip (2018), for instance, notes that even if the term might change, something will remain as the approach provides a social license to operate.

Our focus here is scientific training and how to address ethics in this context. This eBook well illustrates the present efforts in building a socially responsible and ethically committed future geoscientific community. The contributions offer a comprehensive approach to the teaching of geoethics: from designing the syllabus, to the theoretical framework underlying the developed materials, to issues of geoscience communication, to the analysis of specific cases within the diverse domains of the geosciences, and foremost to the materials provided. In a time of climate change, of geo-environmental issues and of global health threats, providing the kind of education that will enable a shift towards a more sustainable, healthier and equitable society is now, more than ever before, important. As noted by biophysicist Quintanilha, back in 1988: *“[w]e cannot abdicate our moral and social responsibilities. Science needs to be taught as an integral component of education of man at all levels. We need to know what science can or cannot do for us”* (Quintanilha, 1988, p. 151). Ethics (and geoethics) are part of this.

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Chapter 1

Geoethical syllabus and educational resources for Higher Education

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CHAPTER 1. GEOETHICS SYLLABUS AND EDUCATIONAL RESOURCES FOR HIGHER EDUCATION

SUMMARY

Geoethics is an emerging field in geosciences whose aims is the research and reflection on those values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system. The GOAL Erasmus+ project (2017-1-PTO1-KA203-035790) has been specifically focused to teach and promote geoethics. To do so, GOAL aimed at developing a geoethics syllabus, to offer a framework in addressing geoethical concerns, and to provide educational resources that can be used in Higher education to create awareness on the ethical and social implications of geosciences knowledge, education, research, practice, and communication. It focused on enhancing the quality and relevance of students' knowledge, skills and competencies. The project followed a contextualized approach in education supported by the case-based methodology and diverse strategies to elaborate teaching and learning resources. The creation of an international team network and subsequently the syllabus and educational case-studies intended to develop operational capacities to enforce the conceptual substratum of geoethics and to bring added values at a EU level to a specific target group of Higher education. To this aim, the research team, which integrated geoscientists and social scientists, developed various educational resources to assist the implementation of the syllabus in every country. Therefore, all educational materials are provided in English and videos and links are specially prepared to be understandable for Higher education students. The syllabus incorporates the following themes: Theoretical Aspects of Geoethics (foundations, definition, meaning and values); Geoethics and Georisks; Geoethics and Geoheritage; Geoethics in Mining; Geoethics in Water Management, and Geoethics in Education. Being the first international project funded on geoethics, its outputs are expected to be a step forward in the field and to promote new insights. Results achieved in the GOAL project will allow to international partners, as well as the geoscientific community, to set additional perspectives and seek new horizons in the field of teaching geoethics.

1 INTRODUCTION

The United Nations presented the new Agenda 2030 for Sustainable Development Goals (SDGs) in September 2015 (UN, 2015a, b). Given the importance of citizens' awareness in achieving the targets of the Agenda, particular attention has been given to education to achieve its goals. In particular, a key challenge was connecting the scientific comprehension and familiarity of the SDGs with the educational learning process. Part of this learning process is about recognising that geosciences knowledge understanding influences the economic growth and development of each country and thereby its cultural framework (Vasconcelos et al., 2016).
Equally, human activities increasingly interact with, and irrevocably modify, the Earth system, this implies the importance to study natural phenomena and dynamics as an integrated planetary system, in which human activities strongly influence this system (Angus, 2016). This has lead the geoscientific community to debate about the concept of Anthropocene, in order to understand if effects of human activities can be recognized and remain in the geological records for million of years, so that a new geologic epoch may be formalized. In any case, apart from the scientific discussion it is emerged the need for society to define a wiser, responsible, and sustainable way to assure life on Earth (Peppoloni et al., 2019; Vasconcelos et al., 2020). Human activities are underpinned world views, belief systems and values that are culturally defined, and which set the limits of geoscientific behaviours and practices. According to the International Association for Promoting Geoethics (2017), "*Geoethics consists of research and reflection on the values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system. Geoethics deals with the ethical, social and cultural implications of geoscience education, research and practice, and with the social role and*

responsibility of geoscientists in conducting their activities." Geoethics' may help to re-define behaviours, to increase human awareness for alternative ways of living or even to redirect economic models of growth and development (Peppoloni & Di Capua, 2016). Therefore, geoethics proposes a theoretical framework, approaches, and behaviours to contribute in achieving the SDGs. Nevertheless, geoethics is still an emerging field in geosciences (Bobrowsky et al., 2017) and demonstrating its value and utility in sustainability science still requires more concerted interdisciplinary and multidisciplinary efforts. According to Stewart (2016), it is clear that geoscientists need to cooperate with other scientific disciplines such as biology, zoology, ecology, agronomy and environmental sciences. This means that to fully appreciate the complexity of contemporary human-environment relationships, we must also draw from the social sciences (Bohle, 2019). After all many of the societal issues relating to the planet are not only concerned with the scientific understanding but *'... are about moral and aesthetic choices. They are about equity and ethics'* (Oreskes, 2004, p.381). Geoethics spans a continuum of concerns, from establishing clear and transparent professional codes of practice to global legal frameworks and governance around global environmental problems. Recognising this breadth of concerns, the international partnership of the GOAL project explored the potential to teach and educate to geoethics through innovative and creative approaches. To this aim project members from different countries brought expertise in overlapping interdisciplinary areas and discussed about ways and tools on how to educate to geoethics in more effective ways. Specifically, the project integrated researchers and practitioners with expertise and skills in theoretical aspects of geoethics, geosciences education, geoheritage, georisks, environmental sciences, and ICT for educational purposes. Results achieved in the GOAL project will allow to international partners, as well as the geoscientific community, to set additional perspectives and seek new horizons in the field of teaching geoethics.

2 THE OUTPUTS OF THE GOAL PROJECT

A globalized world asks for renewed sustainable development goals in terms of environmental, economic and social targets. This reiterates the relevance of geoethics since the latter highlights and discusses the value and the societal utility of concept like sustainability, adaptation, prevention, and education (Peppoloni et al., 2019). As stated by many researchers, numerous societal issues concerning the planet are not related to their scientific understanding but rather to ethical dilemmas (Marone & Peppoloni, 2017).
The GOAL project was an international partnership that leveraged synergies to achieve its main aim: to develop a transnational syllabus and corresponding educational resources, directed at the awareness and learning of geoethics in Higher education. The syllabus had to enhance students' knowledge, skills and competencies and had to be suitable for application in universities and other Higher educational establishments.

Apart from the syllabus, the Lithuanian team developed an online platform that was used by an international network formed by 24 researchers, from Portugal (coordinator country), Italy, Spain, Austria, Lithuania and Israel. The operational capabilities of this network, that connects knowledge from overlapping areas, such as georisks, geosciences education, environmental sciences, geoparks, geo- and palaeontological heritage, and informatics in education will benefit both the conceptual development and the overall framework of geoethics at EU level and in relation to a specific target group of Higher education.

The final aim of the GOAL project has been to create an eBook useful to learn main concepts of geoethics and some good practices in geosciences areas by following a geoethical approach. The eBook will help students and early-stage professional geoscientists to address ethical and social challenges in their profession.

2.1 The syllabus

The urgent need to create a geoethics syllabus for the formal Higher education curriculum emerges when considering the lack of students' awareness about this new disciplinary field. The integration of geoethics values, methods and applications as an integral part of the educational training will allow geoscientists *i*) to become more aware of their social role and scientifical and technical capability to intervene in the Earth system processes in a more responsible way, *ii*) to respect life on the planet in all its forms, and *iii*) to better serve society, looking at its safety and health (Bobrowsky et al., 2017). Moreover, knowing and applying geoethical values will imply practicing geosciences as an effort to accomplish the universal goals of the Education for Sustainable Development and to fully understand that careless actions by humans, interacting with the Earth system, can lead to irreversible consequences and threaten the survival of human life and many other species on the planet. An in-depth training in geoethics will help young and early career geoscientists to search for acceptable and responsible solutions in their geosciences activities and to understand the importance of accurately informing society about negative and positive repercussions of any possible intervention on natural environments (Bobrowsky et al., 2017). Communicating geosciences knowledge using appropriate language and methods is an important geoethical value, useful to make citizens capable of actively contributing to improve the quality and sustainability of human life on Earth.
The syllabus' structure was elaborated after a revision of available literature and the consultation of diverse international syllabi. This structure defines the rational, implementation, aim, objectives, skills, methodology and strategies, content, evaluation and references of each topic considered. Each topic is analysed within a curricular unit (see appendix 1). The topics were defined according to each team members' expertise and relevance in geoethics themes, issues, and dilemmas. They range in different aspects of interest for geoethics and highlights the ethical issues involved in human beings-Earth system interaction. Tables 1, 2, 3 and 4 present the topics explored in the GOAL syllabus by the different team members.

Table 1: Topics of the GOAL syllabus developed by the Italian team.

Geoethics: foundations, definition, meaning and values	**Geoethics and Georisks**
√ Three fundaments to start: – The origins of the geoethical thinking. – From ethics to geoethics. – The meaning of geoethics. √ The concept of responsibility: meaning and individual duties. √ The four geoethical domains: individual, inter-personal/professional, society, Earth system. √ The ethical reference system of geoscientists. √ Intellectual freedom: a pre-requisite for practicing geoethics. √ Geoethical values: ethical values, cultural values, social values. √ Codes of ethics and training in geoethics.	√ Definition of risk. √ Risk perception. √ The acceptable limit of risk. √ Fundamental elements in risk studies. √ Risk management cycle (preparedness, response, recovery, mitigation) and the concept of resilience. √ Building a risk reduction strategy: key-points and values.

√ Geoethics applied to geosciences: knowledge and skills of geoscientists, and themes of geoethics. √ The four main features of geoethics: actor-centric, virtue ethics, geoscience knowledge based, context-dependent in space and time. √ Key geoethics concepts: sustainability, prevention, adaptation, education. √ The Cape Town Statement on Geoethics. √ The Geoethical Promise**.**	√ Culture-based on facing the emergency and culture centred on prevention. √ Roles and responsibility of actors involved in the risk decision chain. √ Citizen science in georisks' management.

As founding members of the IAPG – International Association for Promoting Geoethics, the Italian team leaders developed the conceptual framework of geoethics (see Chapter 4 on Theoretical Aspects of Geoethics) that served as the foundation for the elaboration of the other syllabus topics and the educational resources. Since, they were also researchers in the Istituto Nazionale di Geofisica e Vulcanologia (Italy), they also had skills to explore the topic of geoethics in georisks management (see Chapter 8 on Geoethics and Georisks).

Table 2: Topics of GOAL syllabus developed by the Portuguese and Spanish teams.

Geoethics and Geoheritage	**Geoethics and Mining**
√ Definition of geoheritage and its different types of values. √ Natural and human-made threats to geoheritage. √ Fundamental elements in geoheritage management. √ Relation between geoheritage, public policies, and society. √ Importance of transnational regulations to guarantee the conservation of geoheritage. √ Influence of cultural and social setting on the restrictions related with collecting natural specimens. √ Best practices to avoid the over-artificialization of natural environments related with geoconservation actions. √ Compatibility between geoconservation and other types of land-use management.	√ Complexity in global (and local) markets of mineral resources. √ Environmental justice related to mining. √ Involvement of all stakeholders in mining projects. √ Public awareness of the importance of mineral resources for society. √ The relevance of well-informed citizens in the responsibility of the decision-making process. √ Responsible science communication to promote clarity and transparency in dissemination. √ Regulation and standards operation procedures internationally recognized in mining. √ White Paper on Responsible Mining.

Being two teams with members with different academic background, particularly in teaching and research in different geological areas, the Portuguese and Spanish teams devoted their efforts to bringing new ideas in exploring geoethics in geological and palaeontological heritage and in mining (see Chapter 5 on Geoethics and Geoheritage and Chapter 6 on Geoethics and Georesources).

Table 3: Topics of GOAL syllabus developed by the Austrian team.

Geoethics and Water Management
√ Human right to water and the United Nations Sustainable Development Goals (UN SDGs).
√ Environmental justice related to water.
√ Implications of climate change on water management.
√ Competing interests of different stakeholders concerning water and land-use management.
√ Coherent environmental policies as essential baseline to achieve societal goals related with water.
√ Transnational implications of large water-infrastructure projects.
√ Specificities related with groundwater management.
√ Personal daily behaviours and the influence on water consumption.

Focused in water management, and being experts in this area, the Austrian team presented some relevant aspects to explore geoethical dilemmas related to water and aligned it with United Nations Sustainable Development Goals (UN SDGs) (see Chapter 7 on Geoethics and Water Management).

Table 4: Topics of GOAL syllabus developed by the Israeli team.

Geoethics in Education
√ Educating students to become geoethically responsible citizens.
√ Outdoor experiences as an important source to develop geoethical awareness.
√ Responsibility to include geoethics concepts, values and principles in Higher educational courses.
√ Geoethics as an integral part of the professional training of gescientists.

The Israeli team integrated mainly Geosciences Educators from a Teaching Department and focused their work in presenting ways of implementing geoethical dilemmas in Higher education classes, enhancing the main importance of teaching geoethical principles and values (see Chapter 9 on Geoethics in Field-Trips).

All work undertaken to elaborate the different topics of the syllabus was conducted in such a way to allow the sharing of good practices among all team members. The different academic background of GOAL members, which ranged from geosciences to social sciences, allowed to establish intellectual synergies to contribute to a wider approach to geoethical issues.

2.2 The educational resources

Built upon a social constructivist approach and a case-based methodology, the GOAL educational resources bring to Higher education classes geoethical thinking, issues, and dilemmas. Written in English and provided with references that can be consulted by any student, early career scientist, and geosciences educator, the educational resources titles are presented in Table 5.

Table 5: Title of the educational resources and inherent syllabus topic.

Title of the educational resource	Syllabus topic
Introduction to geoethics: definition, concepts, and application.	Geoethics: Foundations, Definition, Meaning and Values
Geoethics and geological risks.	Geoethics and Georisks
A geoethical conflict in “Lo Hueco” fossil site.	Geoethics and Geoheritage
Good practices in the promotion of geoethical values in a UNESCO global geopark.	Geoethics and Geoheritage
Can we dare say modern society does not need mineral raw materials?	Geoethics and Mining
Earth system nexus human interaction: a geoethical perspective.	Geoethics and Geoheritage Geoethics and Water Management
Geoethical aspects of hydropower plants.	Geoethics and Water Management
Water – a geoethical perspective on one of humanities most valuable resource.	Geoethics and Water Management
Geoethics in education: from theory to practice	Geoethics and Education

These educational resources are related to the topics of the geoethics syllabus and were specifically developed to help professors and educators to start using the syllabus by including modules in their courses. All educational resources benefitted from the technical support of the Lithuanian team that made the editing of the video pills and took all the photos during project activities.

In a Social Constructivism-based educational approach, evaluation must be regarded as a way to assess students learning achievements so as to scaffold their learning process and allow them to overcome their biggest difficulties in engaging with the teaching methodologies and subject contents. It also gives professors a feedback of the strategies they are using to guide students in their problem-based or case-based learning. As such, the presentation of geoethics cases and its exploration in terms of values and principles that can be discussed and highlighted is the addressed proposal to evaluate students after exploring the educational resources.

3 CONCLUSIONS

The GOAL project contributes to an increased capacity of participants to design a syllabus and organize interdisciplinary educational activities related to teaching geoethics. It also provides ways to incorporate geoethical thinking into regular curricular units' academic courses, or by contributing to the creation of specific curricular units in Higher education. It promotes the enrichment of the specific disciplinarily knowledge with geoethical issues for of all the partner organizations. The GOAL project was developed to support innovation and creativity through inter- and transdisciplinary approaches. Results achieved go beyond the project partners and through the release of a dedicated eBook in the GOAL website (https://goal-erasmus.eu/) aim to reach the geosciences community worldwide. This will be also possible due to the fact that project partners have large network of contacts, at national and international scale, so being capable to easily reach potential interested researchers, professors, and educators of many countries. With other stakeholders of interest (NGO's dealing with education, environmental issues and sustainability; ministers; academics; educators; and representatives of student bodies), it also aspires to provide the base to develop ways for teaching geoethics worldwide.

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Chapter 2

Educational theoretical framework underpinning geoethical educational resources

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CHAPTER 2. THE THEORETICAL FRAMEWORK UNDERPINNING GEOETHICAL EDUCATIONAL RESOURCES

SUMMARY

Under a macroscopic scale, several learning theories are frequently cited to support educational curricula or guidelines to improve the educational systems. In the same direction, but on a microscopic scale, any educational mediation, as the teacher-learner relationship, should not be led without a prior and reflected analysis of learning theories. The understanding of the major learning theories is the first level to create a solid educational theoretical framework. The members of the Geoethics Outcomes and Awareness Learning (GOAL) Project, sensitive to this belief, developed a theoretical framework based on the *social constructivist* theory. This theory supports the teacher's action – as a learning facilitator and scaffolder of this process – and establishes the active and central learners' role in their educational development, in an intensely social and environmental immersed context. The GOAL's educational framework guided the syllabus and educational resources' development. These were designed later to Higher education courses, namely geosciences' ones. The learning and teaching methodologies and strategies implemented in GOAL's syllabus and educational resources are framed on an inquiry-based teaching approach. Regarding the multiplicity of scientific subjects covered in the GOAL Project – such as sustainable development, georesources exploitation, geoconservation or georisks, for example – and the inherent geoethical issues, the case-based methodology was selected and operationalized employing a plurality of teaching strategies. Since geoethics is a scientific area that mobilizes knowledge from geosciences, economics, philosophy, and sociology, this multidisciplinary scientific field fits perfectly with the establishment of dilemmas. Considering the case-based teaching methodology starts from cases, defined as a dilemma taken from real life and organized in the form of a case, learners are generally requested to collaborate. Distributed into small groups, the learners can explain their opinions and ideas, and evaluate each other's views. During the process, learners are challenged to examine the case. Merging their backgrounds and experiences, learners might arrive at a resolution for the original dilemma. The case's exploration usually finishes by a plenum debate – which could raise new dilemma(s). Subsequently, this teaching methodology promotes learners' collaborative and communication competences. Generally, the case-based teaching methodology can be employed to foster higher cognitive level questions, requiring greater knowledge and skills. Consequently, this methodology is adequate both to the GOAL's scientific content density and its application in Higher education.

1 INTRODUCTION

"There is nothing more practical than a good theory."

Kurt Lewis, 1952

The international project *Erasmus Plus GOAL – Geoethics Outcomes and Awareness Learning* (https://goal-erasmus.eu) – aims to create a geoethics syllabus and its educational resources (Vasconcelos et al., 2018) – see chapter 1. In the elaboration of any syllabus (and its educational resources), there must be a reliable theoretical framework. The development of the theoretical framework is essential for the successful application of products – both syllabus and educational resources –, according to the intentionality of why they were created. However, the supreme intentionality of these products, as almost all educational instruments, is to guarantee the learning of a certain scientific content. So, the GOAL Project's members considered it crucial to study the learning theories evolution, to entirely understand the learning process itself.

According to Schunk (2012), a theory represents a set of scientifically accepted principles that make it possible to explain a phenomenon or process. The results subsequent from scientific practice can be organized and systematized according to particular frameworks. Theories provide a theoretical background for the interpretation of observations – in this context, they emerge as an interface between research and educational practice. Schunk (2012, p.10) argues that without the theories, the results would be "*disorganized collections of data*" since researchers and experts would not have a context for interpreting the data underlying a theory. Consequently, we can assume that theories establish a direct relationship between scientific knowledge and practice. In this sense, it is pertinent to know several learning theories in order to select the one that would best satisfy the GOAL project's aim.

As the 19th century passed, several psychologists dedicated themselves to the study of human learning (Moreno, 2010). Simultaneously, several theories emerged trying to explain the learning process (Moreno, 2010; Schunk, 2012). The first theory developed was *behaviorism*. According to this theory, the learning process is observable as a change of behavior or response, with occurrence frequency, which happens mainly due to environmental factors (Moreno, 2010; Pritchard, 2017; Schunk, 2012). Burrhus Skinner (1904–1990) is one of the main authors related to this theory. According to this author, the learning corresponds to a constant change in an observable behavior. This change occurs as a result of an individual's interaction with the environment. In this theory, the external factor acquires high importance in the learning process, with the individual idiosyncrasies, beliefs, and previous experiences being ignored (Moreno, 2010; Schunk, 2012). *Behaviorism* had a dominant force in psychology in the first half of the 20th century, and the majority of the older theories of learning are behavioral (Pritchard, 2017; Schunk, 2012).

Conversely, *cognitivism* also emerged. According to this theory, the learning process corresponds to the acquisition of knowledge and skills, through the formation of mental structures, namely: "*its construction, acquisition, organization, coding, rehearsal, storage in memory, and retrieval or nonretrieval from memory*" (Schunk, 2012, p.22). These structures result from information processing with the individual's beliefs and experiences (Moreno, 2010; Pritchard, 2017; Schunk, 2012). From a cognitive perspective, the learning is characterized as an internal mental process, in which a relatively enduring change in mental structures occurs as a result of an individual's interaction with the environment (Moreno, 2010; Schunk, 2012). Jerome Bruner (1915–2016) is one of the main authors related to this theory. Another theory entitled *social cognitive* theory appears in the literature, associated with the author Albert Bandura (1925–). According to this theory, the learning process also results from the observation of other individuals or their behavior consequences. This theory defends that learning occurs even when there is no direct interaction with the environment (Moreno, 2010; Schunk, 2012). In this theory, the term "social learning" appears. Social learning, according to Bandura (2000), occurs when the individuals learn from observing the behavior of others or from seeing the environmental outcomes of the behavior of others. Because social learning happens from others preferably than from direct experience, it is also named indirect learning or observational learning.

In the latter 20th century, *constructivist* learning theories finally appear. At the core of these theories is the notion that learners actively build their knowledge, through their personal experiences with other individuals and with the environment (Pritchard, 2017; Simpson, 2002; Schunk, 2012). In the literature, two types of *constructivism* are raised: individual and social. *Individual constructivism* is mainly related to Jean Piaget (1896–1980). According to this learning theory, individuals have a natural tendency to search for understanding as they interact with the environment. Social interactions are not heavily emphasized.

The *social constructivism* is largely based on the work of Lev Vygotsky (1896–1934). The divergence between these two *constructivist* theories remains in the fact that *social constructivism* theory emphasized the social domain, having a significant and essential impact on the learning process (Adams, 2006; Pritchard, 2017; Schunk, 2012). The *social constructivist* theory will be discussed more prominently in the next section. Due to the characteristics and scientific content addressed by the GOAL Project, it will follow the *social constructivist* theory of learning. In this sense, given the modern society's educational demands and the international guidelines, the GOAL's educational resources will be developed following the inquiry-based teaching methodologies – which will also be discussed in the next section.

2 GOAL'S THEORETICAL FRAMEWORK: FROM EDUCATIONAL THEORY TO GEOETHICS TEACHING AND LEARNING

As mentioned previously, Vygotsky's theory (*social constructivism*) places more importance on the social environment as a facilitator of development and learning (Adams, 2006; Tudge & Scrimsher, 2003). In this theory, the interactions between interpersonal (social), cultural, historical, and individual factors are pivotal elements of human development (Pritchard, 2017; Tudge & Scrimsher, 2003). The interactions with other individuals and the environment improve the development process and promote cognitive growth, performing a significant function in the learning process. In the Vygotsky's theory, the learning process integrates the following steps (Figure 1): i) internalization; ii) mediation; iii) inner speech; iv) Zone of Proximal Development (ZPD) (Moreno, 2010).

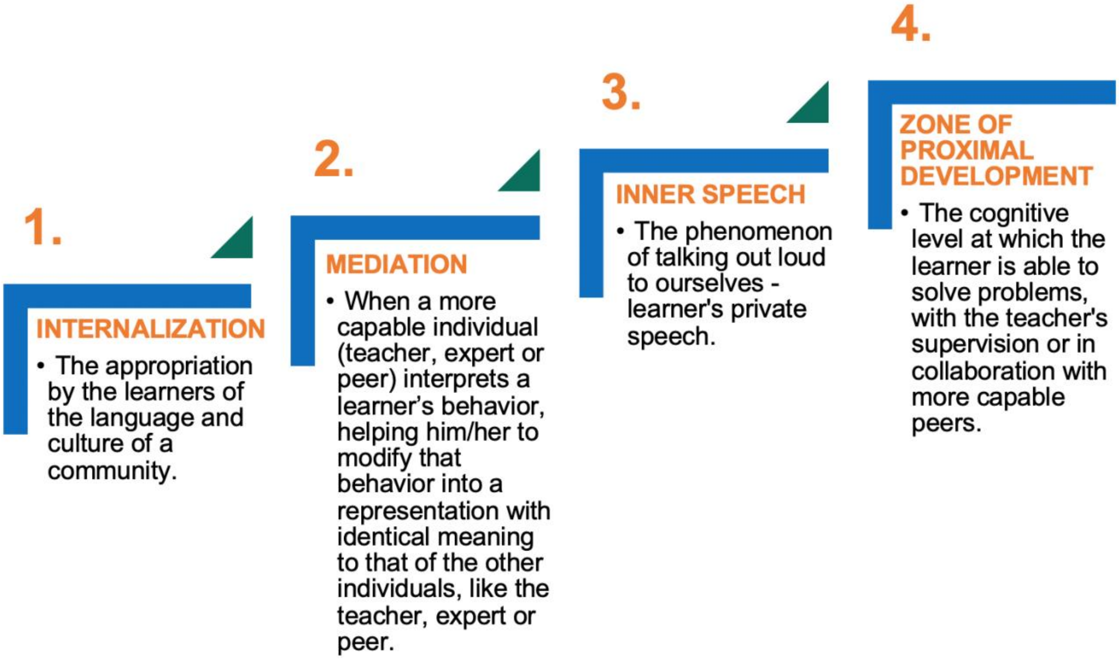

Figure 1. The learning process of Vygotsky's theory (*social constructivism*)

A fundamental concept in Vygotsky's theory is the zone of proximal development (ZPD). The ZPD (Figure 2) is defined, by Vygotsky (1978), as "*the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers*" (p.86). So, the ZPD represents an individual's possible learning under certain and appropriate educational conditions (Adams, 2006; Pritchard, 2017; Puntambekar & Hübscher, 2005). Through the ZDP, the teacher (or experts and peers) and the learner collaborate on a task that the learner could not accomplish independently – due to the difficulty level of the task. Learning is then a collective process. In this process, individuals with more knowledge or skills (experts or peers) share them to achieve a task with the individuals (learners), who exhibit a lower level of knowledge or skills (Bruner, 1984) – scaffolding. This concept is defined as the process of tasks' control, adjustment, and mediation, according to the level of the learning (Puntambekar & Hübscher, 2005; Wood, Bruner & Ross, 1976). This scaffolding process has five main functions, as stated by Schunk (2012, p. 246): "*provide support, function as a tool, extend the range of the learner, permit the attainment of tasks not otherwise possible, and use selectively only as needed*".

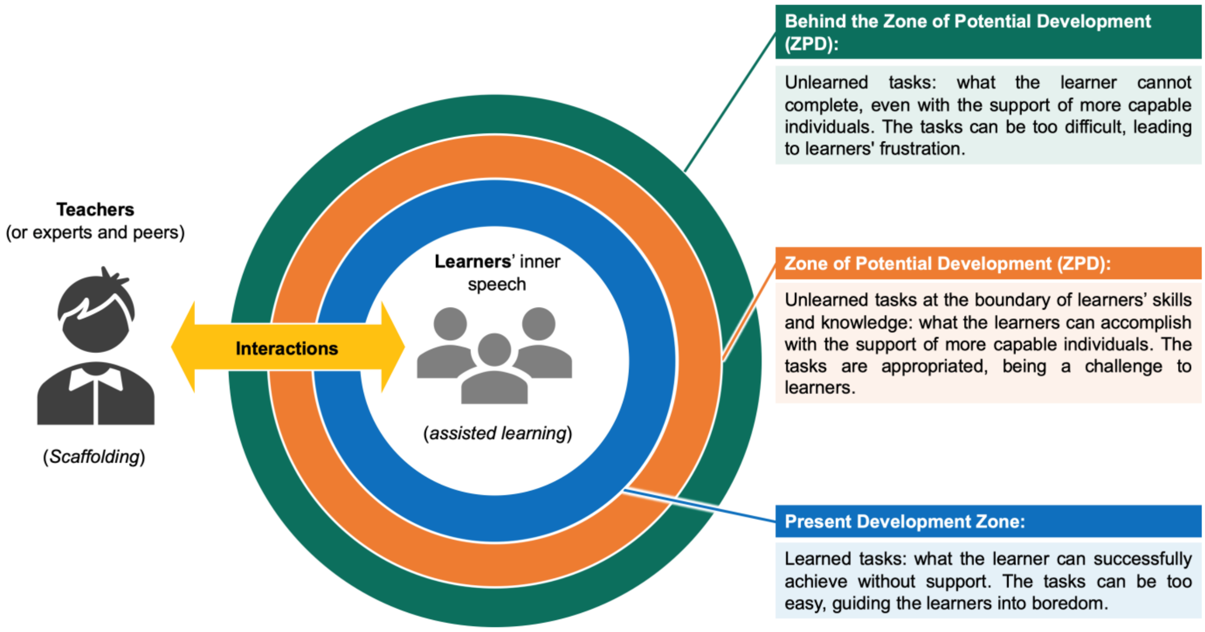

Figure 2**.** The Zone of Proximal Development

Another term linked to *social constructivism* theory is "reciprocal teaching". This term comprises an interactive dialogue between a teacher (or experts and peers) and a small group of learners. Reciprocal teaching comprises social interaction and scaffolding as learners gradually develop skills. This aims to promote understanding through summarizing, generating questions, clarifying, and predicting. Firstly, the teacher (or experts and peers) guides the groups by, for example, summarizing the content of the text, proposing questions about the main ideas of the educational resources and tools, clarifying particularly difficult portions of the text, and predicting possible resolutions for the tasks. Once the entire method is understood by the learners, the teacher gradually turns the responsibility of following tasks to the learners. The teacher's responsibility is to scaffold learners with suggestions and feedback during the process (Brill, Galloway, & Kim, 2001). The teacher (or experts and peers) resumes to reduce his/her involvement with the group and eventually intervenes only to tutor the learning process. The teacher-learner relationship following an inquiry-based teaching methodology is similar to the relationship previously explained. In Vygotsky's theory, there is another relevant notion – "self-regulation". This involves the coordination of mental (cognitive) processes such as planning, synthesizing, and forming concepts, in order to be able to control every learning aspect, from planning to evaluating performance afterward (Moreno, 2010; Schunk, 2012). One of the ways to bring *social constructivism* to the geosciences' classroom, can be through the application of the inquiry-based learning methodology.

The inquiry-based learning methodology's main goals are: i) to have learners understanding; ii) to infer general principles or theories; iii) to apply them to new situations. In the classroom, the inquiry-based learning starts from a disturbing question or problem directed to learners. Then, they have to formulate hypotheses, collect data to test their hypotheses, draw conclusions from their tests, and reflect on the original question and their thinking process. The responsibility of the teacher (or experts) is to guide learners' thinking and to monitor the learning progress (Moreno, 2010). Although, there is a propensity to interpret inquiry-based learning as a new and innovative methodology or a recently invented approach to science education, this has been part of the educational framework since at least the middle of the 19th century. The ideas underlying the inquiry-based learning are coined to John Dewey (1859–1952). He was the first educational psychologist to introduce them as a method in which teachers ask students to answer a thought-provoking question or problem, in his book entitle "*How we think*" (1910) (Lashley, Matczynski & Rowley, 2002).

Nevertheless, learning is an idiosyncratic process and a natural process – it is an instinct (Orion, 2017). As an instinct, the urge to learn is triggered by a stimulus or need. The initial learning' stimuli are emotional' ones – for example, interest, curiosity or relevancy. Consequently, according to Orion (2017), every teaching process should begin with establishing learning environment and sequence that will stimulate the learner's interest and curiosity and ignite the learning instinct.

2.1 GOAL'S educational methodology: the geoethical dilemmas underpinning by the case-based teaching

Case-Bases Teaching (CBT) is a methodology grounded on inquiry-based teaching and relies on the potentialities of reflection, critical-thinking, group discussion, opinion-forming and argumentation. The context is what makes CBT unique and a methodology able to form active citizens (Darling-Hammond & Hammerness, 2002). Analyzing specific cases, learners develop the capacity of recognizing patterns and improve problem-solving skill though several real scenarios. These later should be based on data from scientific research and studies (Anderson & Schiano, 2014; Moreno, 2010; Vasconcelos & Faria, 2017).
It all began in 1870, on Harvard University (USA). Professor Christopher Langdell (1826–1906) used it on laws classes. This new methodology raised interest but only 50 years later was applied to business courses. A program dedicated to the cases' development in diverse disciplines was one of the boosters of CBT. In 1985, also in the Harvard University, the Medical School began to employ this methodology to teach students how to diagnose patients. The development of the "New Pathway" curriculum is considered a revolution in medicine teaching, and students began to gain an active role on their own learning process (Garvin, 2003). A good example, known by the majority, is the TV show "Dr. House", where the main physician led students through real cases for diagnostic and treatment practice. From Harvard, CBT spread all over the world. In science education there are some reports of the firsts CBT uses in the 1940's (McNaught, Lau, Lam, Hui &. Au, 2005). It is still an underused methodology in science classes, even though it showed proof of enhancing learners' engagement and in theory to practice transposition. It happens because the context given by the cases work like mental anchors making it easier for learners to relate and apply previous concepts (Anderson & Schiano, 2014; Garvin, 2003; McNaught et al., 2005).

Under the *social constructivist* theory of learning, CBT requires an environment rich in social interactions. This way, group work is a key for the success of the intervention. *Social constructivism* relies on collaborative work and group discussion, which is adequate to the reflection about scientific and ethical problems (Brady, 2020; Keffer, 2003; Garvin, 2003; McNaught et al., 2005). Thus, students learn not only from the teacher but also with their colleagues, maximizing the completeness of the learning process. Besides, they develop interpersonal skills that are valuable for their future (Garvin, 2003; Moreno, 2010).

The CBT uses the Socratic methodology, in a way that questions and answers are the usual process to analyze, reflect and debate the cases' possible resolutions (Anderson & Schiano, 2014; Garvin 2003). Time is an important aspect in science education through the curricula, as such, this method can be a good criterion to conduct the teaching process. Nevertheless, it is important that learners be aware that they must not be afraid of asking naïve questions, they are important as well, and sometimes concern theoretical basis comprehension problems. Besides the questions included in the case, space can be given to new questions raised by learners. Also, there are no wrong answers or perfect solutions (Center for Teaching and Learning, 1994; Garvin, 2003).

Cases allow teachers (or experts) to verify if learners are capable of transposing concepts that were studied before into the practice. Theoretical concepts are the base for a successful CBT's class. This way, they must not be left aside, and teacher should always assure the concepts were previously understood by learners (Center for Teaching and Learning, 1994; McNaught et al., 2005). Aware of this fact, GOAL experts developed a first educational resource, underpinned on CBT, concerning all theoretical framework needed to understand and practice a geoethical approach. The knowledge developed through this educational resource will be later applied to real and practical situations, in eight cases developed on GOAL, where the theoretical concepts are used to solve ethical problems.

As cases mostly portrait real situations it is easily understandable that more than one field of knowledge is required for its resolution. CBT does not consider the boundaries between different disciplines. It can focus on a specific scientific subject, but more than one field of knowledge incorporates the learning process (Center for Teaching and Learning, 1994; Yadav, 2007). As such, learners are confronted with a real interdisciplinary task that will require to comprehend that the reality is complex, and solutions entail several approaches. Being geoethics an interdisciplinary field of knowledge, it makes it suitable for CBT application. Also, geoethical problems contain a multitude of natures, which demands concepts from diverse disciplines.

CBT classes develop through several phases that begin with cases presentation and analysis and ending with class discussion and practical conclusions and things to improve in the next class (Figure. 3). This method is attributed to Langdell, the first Professor that developed and used CBT. After analyzing the case, learners, gathered in small groups (four to six elements), proceed to brainstorming, discussing and reflecting on the case. The next phase includes the formalization of learning objectives – these can be defined previously by the teacher and discussed with the learners on this moment. Then learners must prepare the dissemination of new findings, including their answer to the proposed questions of the case and following the procedure described on it. The subsequent mission is to share results with the other groups and teacher on plenum debate. Finally, and thinking of future CBT classes, learners and teacher should focus on points to improve based on the present case (Brady, Russo, Dieterich & Osborne, 2020; Vasconcelos & Faria, 2017). This way, it is possible to trace an evolution during several CBT classes and even address competencies that were, for some reason, less worked in the present class.

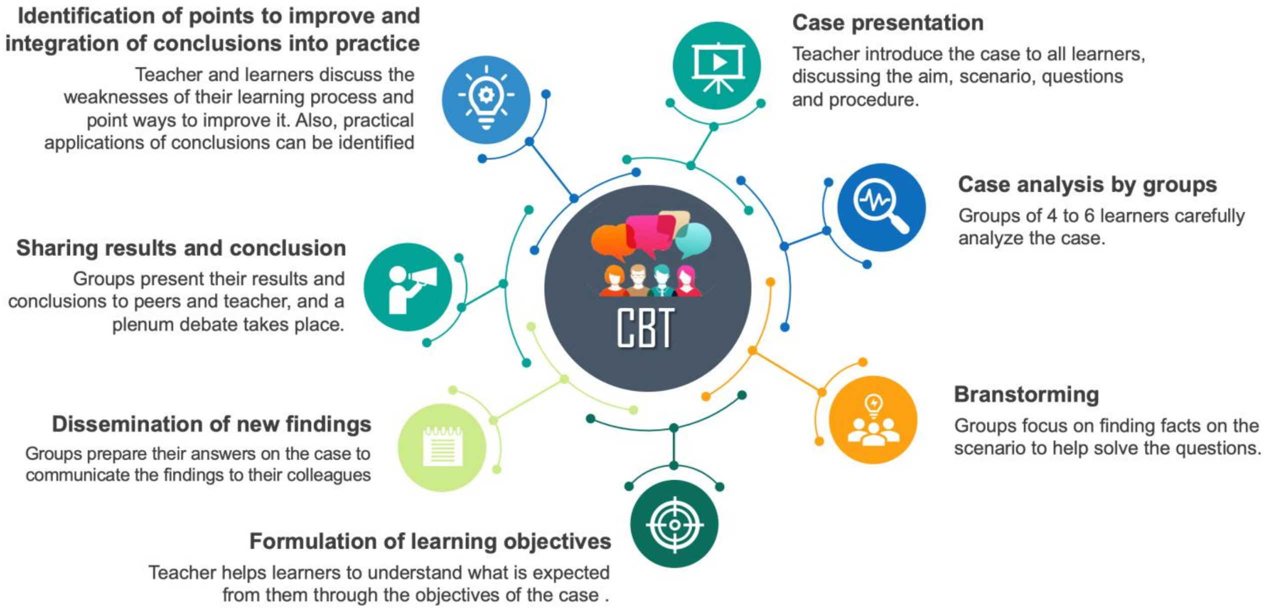

Figure 3**.** Case-Based Teaching (CBT) methodology model

Another important aspect to clarify is the role of teacher and learners. Being a *social constructivist* methodology positioned on inquiry-based teaching, CBT is centered on the learner and the teacher assumes a facilitator role (Vasconcelos & Faria, 2017). Learners must have an active and self-regulated role to develop the knowledge, and personal and interpersonal competencies expected from the application of the case. Moments of analysis, questioning, reflection, debate, argumentation and opinion-forming are essential for learners' development of knowledge, competencies, and accomplishment of cases' objectives. The learning-process occurs mostly on a social basis and, sometimes, on an individual sphere. Teacher promotes interactions between peers, like debates and questioning, guiding learners through the objectives they are expected to achieve. Also, teacher should guarantee that

learners are focusing on the right problems and concepts, ensuring the completion of the aim of the case (Brady, 2020; Moreno, 2010; UNESCO, 2016; Vasconcelos & Faria, 2017).
Moreover, application of CBT on ethical cases, like geoethical ones, centers on the use of reasoning. Cases have solutions that require complex reasoning from learners, so this cognitive process has normative guidelines that path the way to good or valuable actions – when ethical decisions take place (Keffer, 2003; McNaught et al., 2005). CBT, when applied in a proper way, allows learners to perform intricate and contextualized thinking process, even similar to experts, which is a valuable aspect concerning the resolution of geoethical problems mostly requiring an interdisciplinary approach. The probabilities of a successful development of ethical perspective, and consequent actions, improve if a specific context is given, for example through a dilemma (Keffer, 2003). Dilemmas are problems with no unique solution. Their solutions are multidisciplinary and different solutions prioritize different aspects. This way, learners develop competencies for decision-making, learn how to balance positive and negative impacts and understand that there are no perfect solutions (Moreno, 2010). Reasoning should be grounded on rules and principles that guide the actions of society. It is important not to forget that rules and principles come from generalizations based on previous conflict resolutions. As such, in some cases studied through CBT, problems can be raised when these generalizations do not fit the scenario reality or even some rules or principles conflict. Therefore, a balance must be found, some principles and rules can be prioritized, and alternative solutions can be suggested focusing on different approaches of the conflict. It is when they are confronted with real life problems or dilemmas that theoretical concepts are put to the test. Studies show that when confronted with real cases, people – even experts on philosophical ethics, professional ethics and philosophers – tend to change their perspective and discourse towards the equivalent decisions (Keffer, 2003).

Being geoethics a discipline that deals mostly with abstract concepts, a practice application of these concepts is essential to ensure a good learning and operationalization of geoethical approaches. The expression of ethical values – like respect, transparency or cooperation – can be better understood if learners are confronted with situations in which these or other values may be at risk, when certain decisions are made. The abstract knowledge can be made more concrete if applied on real challenges society faces. With cases based on research integrity and professionalism on geosciences practice, geological risks management, georesources management, geoheritage valorization and conservation, water management and geosciences education, GOAL Project addresses a broad scope of thematic related to multiple challenges in geosciences, as well as relevant problematics for the accomplishment of the 2030 Agenda sustainable development goals.

3 GOAL'S EDUCATIONAL RESOURCES: A WAY TO BRING GEOETHICS INTO GEOSCIENCES' CLASSROOMS

Besides the geoethical syllabus – see chapter 1 –, the GOAL Project's members created eleven geoethical educational resources (https://goal-erasmus.eu/educational-resources/), which can be employed together or separately. Due to the multiple scientific backgrounds of the GOAL's members, the educational resources were produced comprising geoethical issues in a wide range of geosciences' subjects.
To introduce the learners to the fundamental geoethics theoretical aspects, illustrating its main characteristics, the educational resource entitled "*Introduction to geoethics: definition, concepts, and application*" was created by Silvia Peppoloni and Giuseppe Di Capua, from Italian team (Appendix 2 or available here). The same authors to provide an overview of geoethical aspects and implications in georisk management produced the educational resource "*Geoethics and geological risks*" (Appendix 3 or available here). The geoethical values' promoting related to human interaction with the Earth system, through reflection on natural resources exploitation, geoheritage importance and conservation, and the need for geoscientists to raise public awareness of their work, was accomplished by the production of the following educational resources: i) "*Earth system nexus human interaction: a geoethical perspective*" by Cristina Calheiros, Nir Orion and Clara Vasconcelos, from Portuguese and Israeli teams (Appendix 4 or available here); ii) "*Can we dare say modern society does not need mineral raw materials?*" by Clara Vasconcelos, Tiago Ribeiro and Alexandre Lima, from the Portuguese team (Appendix 5

or available here); iii) "*Good practices in the promotion of geoethical values in a UNESCO Global Geopark*" by José Brilha, from Portuguese team (Appendix 6 or available here); iv) "*A geoethical conflict in "Lo Hueco" fossil site*" by Daniel DeMiguel, Beatriz Azanza and Guillermo Meléndez, from Spanish team (Appendix 7 or available here); v) "*Geoethical aspects of hydropower plants*" by Guenter Langergraber, Sebastian Handl, Susanne Schneider- Voß and Markus Fiebig, from the Austrian team (Appendix 8 or available here); vi) "*Water: a geoethical perspective on one of humanities most valuable resource*" by Sebastian Handl, Guenter Langergraber, Susanne Schneider-Voß and Markus Fiebig, from the Austrian team (Appendix 9 or available here).

Finally, to address the scientific subjects referred, by bringing them to the real world, through an approach supported by field trips, three educational resources were produced by Nir Orion and Ron Ben-Shalom, from Israeli team (Appendix 10 or available here): i) "*Integration of geoethical aspects of georesources within field trips of Earth sciences academic courses*"; ii) "*Integration of geoethical aspects of georisks within field trips of Earth sciences academic courses*"; iii) "*Integration of geoethical aspects of geoheritage within field trips of Earth sciences academic courses*".

These eleven educational resources are closely related to the five major geoscientific domains present in the GOAL Project' syllabus, as illustrated in Figure 4.

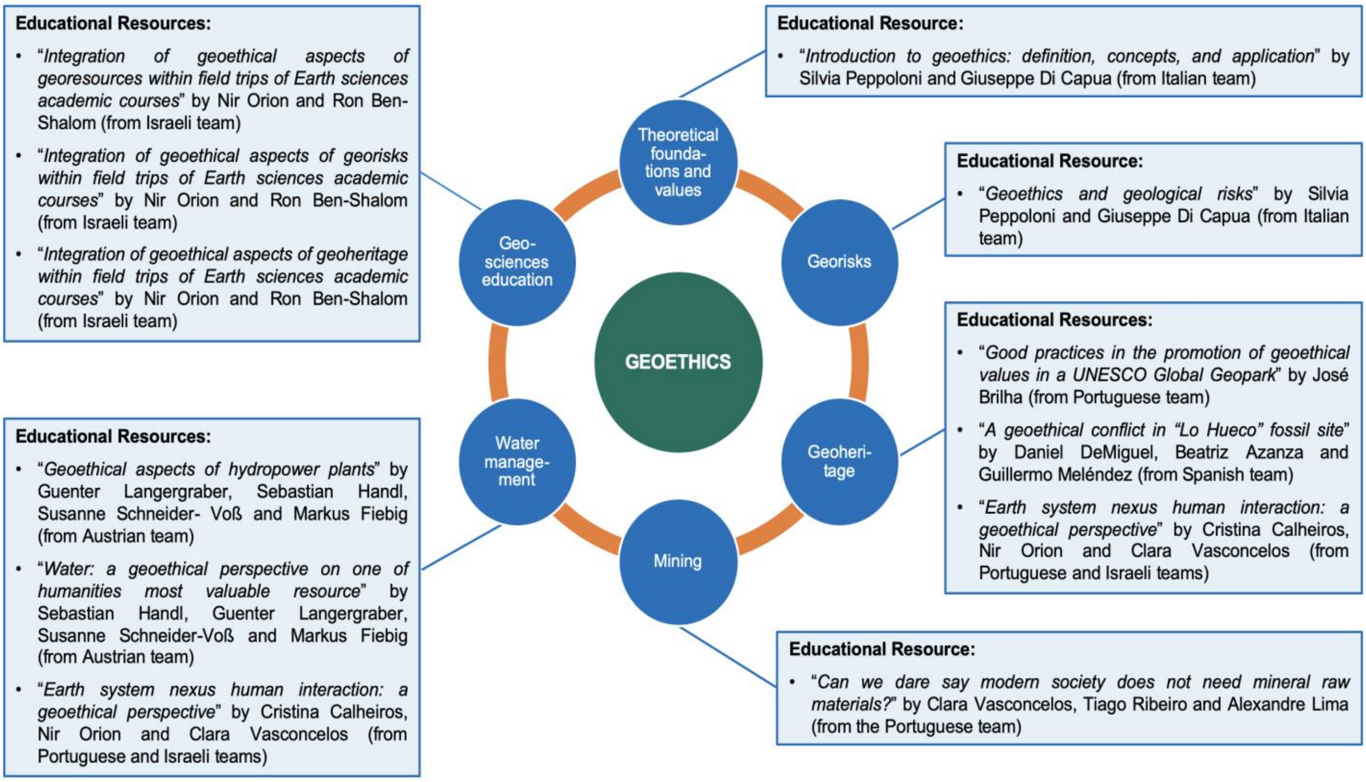

Figure 4. GOAL Project' scientific domains and its educational resources

These educational resources are vehicles for the geoethics' integration in the Higher education geosciences' classroom. The GOAL's members expected, with these educational resources, to enhance geoethics, as a geosciences' discipline.

4 CONCLUSION

As previously discussed, geoethics is a very prolific interdisciplinary field for conceiving dilemmas that mobilize higher cognitive level knowledge and develop competencies. However, its inclusion in science education cannot be carried out in a decontextualized mode or without a properly defined theoretical framework. As learning is more significant when learners' have a context in mind, in the case of geoethics it is no different. In this sense, the GOAL Project, brought together the efforts and approaches of a multidisciplinary and international consortium, in order to create educational instruments scientifically validated and structured according to the best educational practices available. With the elaboration of a syllabus and more than a dozen educational resources, the GOAL Project stands out for its originality in approaching geosciences education, bringing the social sciences for geosciences practices. The synergy between the GOAL members' knowledge and its relevance to the education of 21st century citizens, combined with the challenges that society faces, are elements that enhance geoethical discussion and reflection.

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Chapter 3

Social responsibility and ethical attitude on the media

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CHAPTER 3. SOCIAL RESPONSIBILITY AND ETHICAL ATTITUDE ON THE MEDIA

SUMMARY

Geoethics is a rather new field of research that lies at the intersection of several disciplines. Combining insights from economics, sociology, philosophy and the understanding of the Earth system, geoethics aims at finding the foundational values of appropriate behaviour and practices when human actions intersect with the Earth system. Geoethics researchers have been able to formulate these values and articulated them within four levels of responsibility: (i) responsibility towards the self, (ii) towards the colleagues, (iii) towards the society, and (iv) towards the Earth system. In order to educate more aware, active and responsible geoscientists, training in geoethics should become an essential feature of every undergraduate and postgraduate curriculum in geosciences. By understanding the delicate role played by geosciences professionals, who, thanks to their knowledge and expertise, are trusted as special informer and educator of the general public, this chapter aims at presenting the ethical values and the appropriate and most effective line of behaviour that geoscientists should follow when advising communities. In order to do so, in this chapter it will be firstly presented a brief overview on geoethics. Secondly, it will be introduced and discussed the ethical principles that should guide geoscientists when engaging in science communication. Thirdly, it will be shown the web platforms that geoscientists would have at their disposal, together with the skills that they should develop to appropriately exploit them. Finally, examples of best practices would be provided from the communication activities carried out throughout Erasmus+ KA203 project GOAL – Geoethics Outcomes and Awareness Learning.

1 INTRODUCTION

Today, geoscientists have to face a very large spectrum of issues that may go beyond the range of their academic field. As exponential population growth proceeds sustained, it is expected that the Earth will be inhabited by almost 11 billion people by 2100 (Roser, 2019). This startling growth entails several alarming concerns, that touch a wide arrange of academic fields. Complications related to human actions upon the planet (such as greenhouse gas emissions, water scarcity, food security, excessive energy demand and others), require a communal effort. Researchers claimed that the solutions to these challenges lie at the junction of four basic endeavours (Mogk et al., 2018):

1. Knowledge of the Earth system and how it operates
2. Understanding of changing social and cultural value systems
3. Comprehension of economic realities
4. Awareness of philosophical approaches addressing human actions that generate negative catastrophic and irreversible impacts on human existence and on ecosystems

In this scenario, geoscientists definitely play a prominent role, as they have competence and experience to better understand the Earth system, its elements and dynamics. However, despite their very important function, young geoscience students are still unprepared to face some of the ethical challenges that their future job might present them.

In order to educate more aware, conscious, ethical and responsible geoscientists, training in geoethics have to become an essential feature of every geoscience curriculum. Geoethics has been defined as "*research and reflection on the values which underpins appropriate behaviours and practices, wherever human activities interact with the Earth system. Geoethics deals with the ethical, social, and cultural implications of geoscience knowledge, education, research, practice and communication, and with the social role and responsibility of geoscientists in conducting their activities"* (Peppoloni & Di Capua, 2017, p. 2). This wider frame of research is aimed at creating professional figures that better understand their social responsibilities. The inclusion of geoethics in the educational system would result in a stronger ethical commitment from the geosciences community, which would ultimately recognize the crucial role that new generations of geoscientists will play in the near future and prepare them to become "moral agents". They will be committed to transfer to society not only scientific knowledge on the Earth but a new, more comprehensive and ethical understanding of the planet (Peppoloni & Di Capua, 2016; Peppoloni, Bilham, & Di Capua, 2019).

Geoethics comprehends a quite large and diversified group of responsibilities and principles better summarized under four categories or, as they are called in other cases "levels of ethical conduct" (Mogk et al., 2018; Peppoloni & Di Capua, 2016):

1. Responsibility towards the self
2. Responsibility towards colleagues
3. Responsibility towards society
4. Responsibility towards the Earth system

The first category deals more with personal and "reflective" responsibilities. Since geoscientists often have to face personal questions, problems and dilemmas, the first level of conduct should lead them towards the formulation of unavoidable ethical questions. It is important to stress the fact that there are not always right or wrong answers to certain ethical issues. However, a responsible geoscientist should always question his/her line of behaviour, asking himself: "what are the personal ethical attributes of my profession?".

The second "level of conduct" develops in a consequential manner regarding the previous one. It is still strictly related to the profession of geosciences, but this time it moves the focus from the person to the whole category of professionals and it covers the right line of behaviour that a geoscientist should pursue when contributing to the geosciences community. Regarding responsibilities towards the colleagues, a geoscientist should ask himself: "what are the ethical practices that I should comply with when working with my colleagues?".

The third category is the one that will be mostly discussed in this chapter. It deals with the ethical values affecting geoscientists behaviour when engaging with non-scientists (e.g., politicians, journalists, communities, etc.) and it is mostly concerned with communication. This is a rather delicate issue, as nowadays the widespread diffusion of information technologies often simultaneously disseminates misinformation and lowers the quality and the ethical practices of journalists, in general, and science journalists, in particular (Foresta Martin & Peppoloni, 2017). When engaging in communication with non-specialists, the geoscientist has to face several ethical dilemmas and critical choices, and he/she should always ask himself: "what is the proper line of behaviour that I should pursue in order to communicate geosciences research results in a professional, ethical, comprehensible and effective manner?".

Finally, the last level of conduct is an even broader category that includes one of the biggest challenges of this century: our relationship with the planet. Geosciences have also other inherent values that go beyond their scientific and technical information. Besides ethical values, geosciences also entail cultural and social values that geoscientists should transmit in their communications (Peppoloni & Di Capua, 2016). Terms like geodiversity, biodiversity, sustainability and prevention are not mere "cold" scientific words. They imply a larger group of ideas and feelings that are associated with us and our relationship with the planet that we inhabit. As geoscientists have to provide good stewardship of the Earth based on their knowledge, they need to ask themselves: "how my actions are going to affect the environment and more in general the planet? What can I do to preserve and enhance its geodiversity and biodiversity?".

As now it has been presented a general view of the issues addressed by geoethics, we can move further and start delving deeper into the topic of this chapter. By understanding the delicate role played by geoscientists, who, thanks to their knowledge and expertise, are trusted as special informer and educators of the general public, this chapter aims at presenting the ethical values and the appropriate line of behaviour that geoscientists should follow in communication practices, and it will mainly discuss the communication activities carried out in the Erasmus+ KA203 project GOAL – Geoethics Outcomes and Awareness Learning – which will be presented as examples of best practices. The communication carried out in GOAL project will be put in the wider context of ethics in science communication, as a general framework guiding geoscientists decisions when carrying out public engagement activities.

2 SCIENCE COMMUNICATION IN GEOETHICS

Among the several responsibilities of geoscientists, geoethics claims that they should "engage in science communication and education" (Peppoloni & Di Capua, 2016). As this responsibility is enclosed in the third category of ethical conduct, this means that the goal of a geoscientist should be directed towards society, by sharing and popularizing the results of geosciences in order to promote geoethical values, while, at the same time, presenting the scientific uncertainty of the same results.
This is not an easy task. Today's widespread diffusion of communication technologies has accelerated the circulation of information and increased their speed. As scientific news spread faster than ever, their quality and accuracy have often lowered. The phenomenon of "Web Churnalism" (the production of "copy and paste" articles in the media without the exertion of proper verification) is an unhappy example of this alarming trend (Foresta Martin & Peppoloni, 2017). It is in a context like this, that geoscientists must reclaim their role and pay particular attention to the ethical value of their communication.

However, there is also a specific need for the development of valuable communication skills. Today, geoscientists are not trained to communicate effectively to the public (Liverman, 2008; Solarino, 2014). Such requirements call for a two-pronged action. From one side, geoscientists should be made aware of the ethical implications of science communication, while, from the other perspective, they should also be trained to use effectively the current media tools at their disposal. These two actions are closely related, as by understanding the ethical implications of their communication activities, they would know how to apply them to the actual context, thanks to their new acquired communication skills.

This section will deal with these two actions. Firstly, it will discuss the ethical role played by geoscientists when engaging in science communication. This is a particularly important part, as, from time to time, it appears a tendency to perceive science communication as inherently ethical and morally right. A similar bias is usually inferred when appealing to the notion of "scientific objectivity" and the idea that "more knowledge is better than less knowledge" (Medvecky & Leach, 2017). However, it will be suggested that, in order to transform geoscientists in "moral agents", the delivery of scientific knowledge is not enough. As they should also promote ethical, social and cultural values that may foster positive change within the larger society, geoscientists must be aware of the ethical implications of their communication activities. Secondly, it will be presented some simple tips and advices on how to use effectively today's communication technologies. As suggested above, this is also a quiet important element of geoethics training. In order to communicate effectively, to engage the public and attract its attention, it is essential to know the differences between good and bad communication and to know how to properly use communication technologies.

2.1 Ethical role of communicating geosciences

What makes science communication ethical? Instead of establishing a discussion about what is wrong and what is right, thus moving this chapter in a realm that goes far beyond its original scope, we should start by addressing this question from the perspective of geoethics.
As said before, geoethics is not merely concerned with the spread of scientific knowledge for knowledge's sake. It aims also at sharing values that may foster positive change and good stewardship of the Earth. This is where levels of conduct three and four interact. In order to be ethical, geoscientists should promote scientific knowledge and geoethical values at the same time.

But, how can they do that? It is important to stress the fact that every communication activity is different. Since communication does not take place into a void, geoscientists should always be aware of the context of communication. For this reason, some evidenced the weakness of applying deontological and utilitarian ethics to science communication, as they universalize rules of conduct and adopt them “algorithmically” to every situation, ignoring its unique features (Stefanovic, 2015; Thompson, 2018). For instance, one could say: “it is very important to present scientific facts in the most rigorous way as possible”. A deontologist, who would find this proposition correct, would then decide to universalize it and apply it in every context. However, a geoscientist who would decide to present his research results to a general audience, using a specific, rich and complex vocabulary, as rigorous as it may be, would completely lose the attention of the public. In such a case, the rigorousness must be always accompanied to clarity, and the clarity will depend from the context to which the geoscientist refers, from the level of understanding of the audience.

Because of this, others suggested the adoption of “reflexive ethics” in science communication (Medvecky & Leach, 2019). This last category is different from deontology and utilitarianism, since it does not impose rigid rules of conduct that must be followed without blinking an eye. It provides a set of guidelines that has to be analyzed in context. It is called “reflexive ethics” because the attention is moved from the action to individual’s reasoning, who must decide how to act *in context*. Reflexive ethics can be successfully applied to geoethics, as also its values can be seen as ethical guidelines that needs to be applied in context. As a matter of fact, scholars claim that teaching geoethics should aim at developing questioning and reflection skills based on contextual simulations of ethical dilemmas (Mogk et al., 2018).

According to Medvecky and Leach (2019), reflexive ethics can be further divided into two categories: principlism and relational ethics. The former has been successfully applied to medical and bioethics, while the latter has been devoted to the analysis of ethics involved in different kind of relationships (e.g. client-professional relationship, communicator-public relationship, gender relationship, etc.). Within the field of science communication, these two scholars applied both theories to formulate their proposal of science communication basic principles: *Utility, Accuracy, Kairos* and *Generosity*. They will be now presented and analyzed specifically in the field of geoethics.

2.1.1 The four principles of science communication

As described previously, within reflexive ethics, principles do not act as fixed rules, imposing to strictly adhere to them. They are not deontological rules, but they are designed to promote reflection on the (communicative) action that is going to be taken. This does not mean that they are made to be broken, but that any geoscientist involved in communication has to be aware of these principles and take decisions that are based on careful ethical analysis. The four principles that are going to be discussed do not have a hierarchical order and one does not necessarily excludes the others, but, in some cases, they do not work in accordance. When carrying out public engagement, it is the job of the geoscientist to decide, according to the context, which of the four principles has to prevail over the others.

The first principle is *Utility,* which can sound obvious, since any type of communication must serve a purpose and “be useful”. However, in this context, it may refer to something that sometimes people tend to ignore. Within a science communication activity, the principle of *Utility* requires a geoscientist to take into consideration the value of the communication and “*its capacity to empower all involved, to enrich the lives of all involved, to lead to better social or individual outcomes*” (Medvecky & Leach, 2019, p. 88). In other words, when carrying out a science communication activity, a geoscientist should consider the usefulness of the information delivered, but not in a narrow sense, since whether something is useful or not is inherently subjective. For instance, small details of a presentation which could produce enjoyment, might be regarded as trivial or “useless” for a specialist, while people from the audience might find them intriguing or simply fun. This aspect should not be dismissed, as the enjoyment induced might be “useful” in captivating audience’s attention and bring geosciences closer to the public. Thus, anything that helps the geoscientist deliver his/her message effectively might be considered “useful”. For instance, storytelling has been often suggested as a useful technique for carrying out science communication activities (Priest et al., 2018; Joubert et al., 2019) and, regarding geosciences, some researchers have even delineated the “typical plots” of this field of study (Philips, 2012).

The second principle is called *Accuracy* and it could appear partially in contrast with the first. *Accuracy* requires communication to be the most accurate and close to truth as possible. This does not mean that any kind of simplification is excluded a priori, but it advises geoscientists to

be careful before applying any deviation from veracity and scientific rigour. For instance, as *Utility* may suggest to a geoscientist to make use of storytelling in its discourse, *Accuracy* would immediately tell him/her to be careful and to not compromise truth to attract the audience. As this example shows, when put in context, these principles manifest the delicate equilibrium on which science communication is based. A geoscientist should be trained to take care of the utility of what he/she is communicating, and at the same time to not disregard the accuracy of the information transferred to the public. Moreover, *Accuracy* also requires geoscientists to be very careful before claiming something to be true. As absolute truth is impossible to reach (Marone & Peppoloni, 2017), *Accuracy* would demand a geoscientist to be honest and present the uncertainties of his/her results, as geoethical responsibilities already indicate.
Kairos, the third principle, is more abstract than the previous ones. Ancient Greek used to distinguish between quantitative and measurable time (*Chronos),* and qualitative and opportune time (*Kairos)*. *Kairos* refers to "the right time". In this case, it means "the right time to say the right thing" and it covers many aspects connected to communication and time. From one aspect, it is about the right time of delivery, being aware of the proper *time* needed to present the discourse and give enough *time* for the others to understand the information and have enough *time* to act accordingly to that information. It is especially important when presenting results to policy makers or after disastrous events (e.g. earthquakes, floods, etc.), when there is an urgent need to know how to act and the population needs to be helped and in case reassured. But *Kairos* is also related to the time of communication technologies. Presenting results in front of an audience or showing them through a Youtube video are quite different way of delivery and, thus, have different *Kairos*, since people approach them in distinct way. Moreover, people are reached in quite diverse times through one medium or another and geoscientists should also take in consideration this aspect, when deciding which media to be used.

Finally, the fourth and last principle is *Generosity*. This principle is directly related to relational ethics, as, in fact, it draws attention on how stakeholders engage in the communication. When thinking in terms of *Generosity*, geoscientists should ask themselves which kind of relationship they should engage with their public. *Generosity* asks to geoscientists to take a strong commitment with the people they are informing, a commitment to pay attention to the needs of the audience, their demands and to acknowledge other people's knowledge, ideas, experience and aspirations as worthwhile. In other words, geoscientist should engage the public with a sense of *humility* and a desire to better understand also other points of view. In the spirit of the third level of conduct enunciated at the beginning of this chapter (responsibility towards society), this a very strong and important commitment that does not only effectively improve communication, but it also enhances the sense of humanity and kindness that geoethics aims to enforce.

2.2 What media should geoscientists use and how should they use them?

In the last years, traditional media have been supplanted by the Internet, as it has already become the most prevalent source for information (if not the unique one in some cases) for many people, especially students (Solarino, 2014). The outstanding spread of Information and Communication Technologies (ICTs) has, from one side, provided almost instant access to an incredible amount of knowledge, while, on the other hand, it has enlarged the demand for fast and accessible content, often causing a downfall in accuracy and veracity of information (Foresta Martin & Peppoloni, 2015). For this reason, geoscientists have the responsibility to carry out communication activities through Internet media and actively engage in science communication, even if this does not mean they all have to become science communicators. But for those who are directly engaged in communication activities, it indispensable to increase their skills in this field. The Internet provide a vast spectrum of channels for communication. Geoscientists have to know these channels and possess the adequate skills to manage them successfully. The effective use of these tools may not only counteract the negative effects of "Fake News", "Web Churnalism" and other unethical practices, but it may also improve significantly science communication by making it more interactive, pervasive and exciting (Rayies & Deepika, 2014). For instance, by using blogs or websites*,* geoscientists may share very easily and without any intermediary their knowledge. Moreover, as blogs include features such as comments and embedding of videos and links, they could bring the public closer to geoscientists, providing a stronger sense of cooperation and attachment. In this realm, the principle of *Generosity* plays surely an important role in establishing a good relationship between the geoscientist and his/her public. Geoscientists who decide to make use of blogs for their science communication, would need a solid background in writing skills for online content, as they cannot write blog articles in the same way they write scientific papers. In this sense, geoscientists need to learn how to become in part journalists and start to treat their content almost as a newspaper article, establishing a dialogue between the principles of *Utility* and *Accuracy*. Moreover, some basic skills of web design might be needed. Although building a website has become much easier today, thanks to the latest content management systems (CMS), such as Wordpress, Joomla or Wix, some web design skills are necessary in order to make a page recognizable among the other billions accessible on the web.

For what concerns social networks, the situation changes remarkably. Facebook is still the most popular social media platform, but this does not mean that geoscientists should not consider to use also other platforms for their science communication, especially if they want to reach different kind of audiences. Twitter, for instance, is commonly used by influential people and it is generally perceived as “more serious” than other platforms (Rayies & Deepika, 2014). On the other hand, geoscientists aiming to attract a younger public should consider using Instagram, as it is more popular among teenagers (https://www.omnicoreagency.com/instagram-statistics/).

All of these social media require particular digital skills to be used effectively. Among the 6 categories of digital skills elaborated by researchers (van Dijk & van Deursen, 2014), the most relevant for our case are *Communication Skills* and *Content Creation Skills*. These categories comprehend a wide arrange of specific skills, but two in particular serve specific purposes within social media. These are: (i) the ability to attract attention online, and (ii) the capacity to construct online profiles and identities. Both skills are essential in order to use social media features at their full potential, but they are not so easy to acquire. They would develop through a long process of trial and error. Nonetheless, a good way to start should be to learn how to use productively pictures and graphic editor programs (e.g. Photoshop, Illustrator and other Adobe packages). The power of the image should not be ignored, since it has been proven that geological phenomena can produce powerful aesthetic impressions in the observers (Kim, 2015). A knowledgeable geoscientist, skilled also in the use of cameras and graphic editors, may capture beautiful images of geological phenomena in order to attract attention on Instagram, a social media in which pictures play a prominent role, or on his own blog.

Finally, another platform that geoscientists should consider to use is Youtube. Obviously, also in using this platform, specific skills are needed, especially video production ones. However, what has been said previously for social media should also be taken into consideration when carrying out science communication through Youtube. To attract attention and create an online identity on Youtube, geoscientists might make use of powerful aesthetics images, coupled with storytelling. Audiences on Youtube tend to create a strong connection to the youtubers they like, more than on other social media, creating a sense of familiarity. This happens because youtubers communicate in a very familiar tone, establishing close relationships with their audiences. This fact has been proven by a study comparing scientific Professional Generated Content (PCG) with User Generated Content (UGC) on Youtube (Welbourne & Grant, 2015). This research shows that, although PGC is superior in number, its popularity is way lower when compared to UGC. One of the reason is that UGC foster meaningful connections with the viewer. Moreover, as UGC is usually delivered by just one person, people tend to trust them more. On the contrary, as PCG is generally developed and presented by more experts, people do not have time to build any meaningful connection.

One last consideration is related to *Kairos*. As we understood that saying things at “the right time” is a very important requirement for ethical and effective science communication, it is essential for geoscientists to commit themselves to life-long learning activities in order to always be updated on the last developments in their fields. This requirement is also among the ethical responsibilities promoted by geoethics (Peppoloni & Di Capua, 2016) and it would fall under the first category of responsibilities (“responsibility towards the self”). However, as we can see from this example, these categories tend to overlap. In fact, in this case, a geoscientist committed to life-long learning does not only prove his devotion to the profession, but, thanks to his continuous studies, he can also deliver up-to-date information to his/her public and, as *Kairos* requires, “say the right thing at the right time”.

Finally, it is also important to take into consideration the pace of content delivery, especially for Youtube videos. Studies has shown that slow speaking rates improve comprehension, while, on the other hand, faster rates of speech improve the persuasiveness of arguments and increase audience focus (Welbourne & Grant, 2015). In this scenario, it is up to the geoscientist to decide.

3 GEOETHICAL COMMUNICATION IN PRACTICE: GOAL PROJECT

GOAL – Geoethics Outcomes and Awareness Learning is an international project funded by the European Commission through the Erasmus+ program. The project lasted for almost three years (31/12/2017 – 30/08/2020) and its main purpose was to establish an international network of experts to develop multimedia educational material (of which this eBook is an example) for strengthening geoethics concepts at higher education level.
Materials were discussed and developed during four workshops held at the partners' premises in Italy, Portugal, Austria and Israel (for more information: https://goal-erasmus.eu/).

Among the different activities that have to be carried out throughout a project period, a very important one is dissemination, which consists in "sharing research results with potential users" (https://ec.europa.eu/research/participants/docs/h2020-funding-guide/grants/grant-management/dissemination-of-results_en.htm). It is another way of describing communication activities (or, at least, some of them). Since GOAL was focused on geoethics and aimed at the diffusion of geoethical concepts and values, its communication activities can be included as a prominent example of science communication applied to geoethics. Thus, GOAL's website, educational material and video production will now be analyzed to show how the theoretical framework highlighted in the previous sections can be translated into practice.

3.1 GOAL's website

Starting from the website (https://goal-erasmus.eu/), the first thing that visitors see when accessing GOAL's homepage are wide pictures of natural landscapes shot in the six countries involved in the project. Below the pictures, a brief description of the project's objectives is shown.

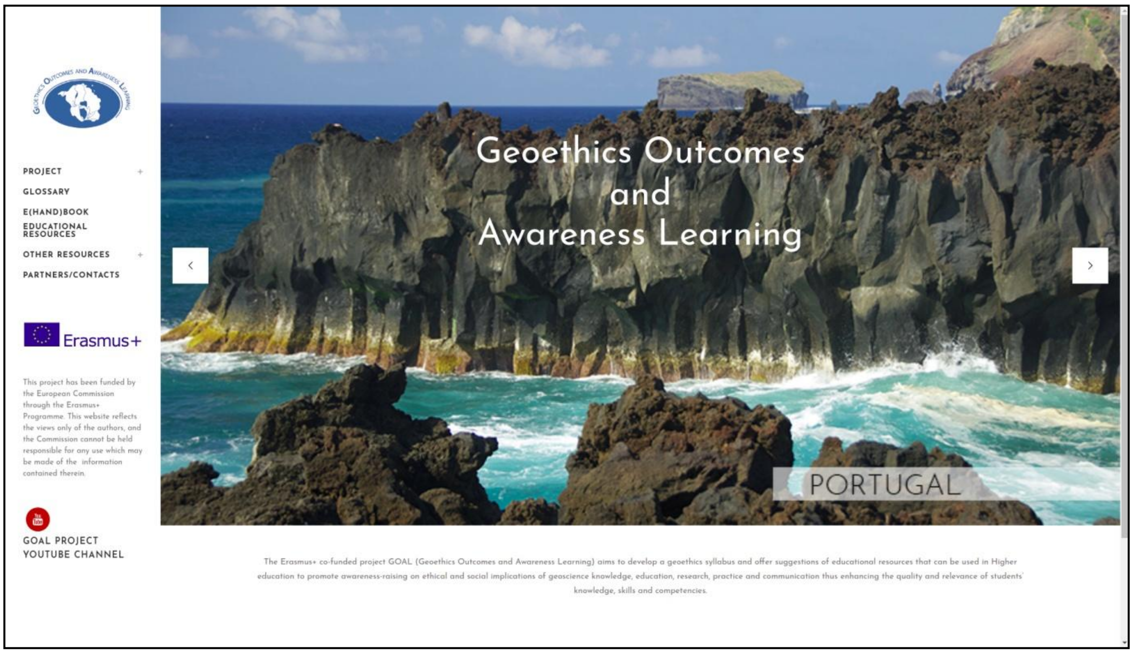

Figure 1. GOAL Homepage

These images "set the scene" for the content. Through the homepage, people who access the website immediately know the essential information of the project (what is about, which countries are involved) and, even without reading, visitors instantly understand that it is about geosciences, as these informations are mostly conveyed through images. As a matter of fact, throughout the whole website, the text has been shortened as much as possible. In this way, visitors do not get tired - when surfing through the pages.

Another relevant aspect of the website is its layout, which respects a fair simple rule: "Less is more". There is no need for elaborated graphics or a wide range of colours. The website is clean and simple to navigate and it uses the same colours of the project's logo, showing that it has been built in a coherent way.

Respect of the "less is more" rule can also be seen when analyzing the information uploaded on the website. There is nothing more than the essential, which is presented in a professional captivating graphic. This aspect does not only establish a user-friendly navigation, but it also shows to be in line with the ethical principles of *Utility* and *Accuracy*, since only the content relevant for the audience is uploaded and delivered in a precise way.

3.2 Educational resources

On the website, particular attention has been devoted to the *EDUCATIONAL RESOURCES* section. It has been highlighted on the menu bar and, together with the *E(HAND)BOOK,* stands out in comparison with all the other links. This did not happen by chance. In fact, as GOAL's educational material and eBook represent the main outcomes of the project, they should be highlighted and easily accessible to everyone.
In the *EDUCATIONAL RESOURCES* (https://goal-erasmus.eu/educational-resources/) page, visitors can access to the material developed during the project lifetime through several links, providing PDF documents. Graphically, these documents stay coherent with the website, since they apply the same colours and simple appearance. However, what is most relevant in this case are the actual texts and, in particular, how they are delivered.

The topics are rather clear: they all deal with different aspects of geoethics (e.g., water management, geological risk, the link between human interaction and the Earth system, etc.). But, from the point of view of science communication, what is really interesting is how they are developed. First of all, as they aim to reach a widest audience as possible, all the documents do not exceed 5/6 pages, since too many of them would discourage possible readers. Secondly, the content is presented in a very simple way and, as the website, they make large use of pictures. The first page, present the whole argument in a snapshot, so that the user could understand immediately what is going to read, while the following pages develop the content making use of different techniques. For instance, some of the educational resources respect the typical canon of scientific papers, but others are narrated with the adoption of storytelling (https://goal-erasmus.eu/wp-content/uploads/2019/08/GOAL_Earth-system-nexus-human-interaction_a-Geoethical-perspective2.pdf) or even comics (https://goal-erasmus.eu/wp-content/uploads/2019/10/CLARA_TIAGO_LIMA_GOAL_CASE.pdf). All these different kinds of narratives arise from decisions taken by individual experts who put in dialogue the principles of *Utility* and *Accuracy* and decided which was the best option according to the situation.

3.3 Video production

Finally, the last part of GOAL's communication that we are going to analyze is the Youtube channel and the video pills uploaded on the website. These videos usually feature one of the experts presenting a topic related to geoethics, most of the time in a natural background. It goes without saying that, as for the website, especially in the Youtube channel images play the central role. However, one of the most important issue with Youtube videos is *Kairos*, "the right time". Youtube videos cannot be too long, otherwise the interest of the viewer would be lost immediately. As a matter of fact, Goal's videos do not exceed 20 minutes. Secondly, we should pay also attention to the way the content is delivered. There is not wide use of technical terms and presenter talks at slower pace, in order to maximize the attention of the viewer.

4 CONCLUSIONS

The challenges of the 21th century are extremely wide and complex, so complex that cannot be tackled from just one perspective. This is one of the reasons teaching geoethics is very important. It puts people in touch with this immeasurable bond, it shows how humans and the environment are strictly linked and it provides guidance on the best way to act in order to strengthen and protect this connection.

Geoethics and its values are too much important to not be shared with the larger society. Because of this, we claimed that geoscientists have to be engaged in science communication activities as much as possible. Moving from these considerations, this chapter explained the ethical role of geoscientists in communication activities and the principles they should follow when communicating. We suggested the principles of *Utility, Accuracy, Kairos* and *Generosity*, as elaborated by Medvecky and Leach. Following that, it has been provided a brief overview of the principal web media for science communication, together with some of the skills that are required in order to use them effectively. Finally, the last section proposed the previous information into a practical context, discussing the communication carried out during Erasmus+ KA203 – GOAL project – Geoethics Outcomes and Awareness Learning.

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LINKS

GOAL's Youtube Channel: https://www.youtube.com/channel/UCK3zFumsKpROp151ro6zaGw

GOAL's Website: https://goal-erasmus.eu/

Chapter 4

Theoretical aspects of geoethics

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CHAPTER 4. THEORETICAL ASPECTS OF GEOETHICS

SUMMARY

A wide overview on the current state of research on geoethics with a focus on its philosophical, theoretical, and social aspects is provided in this chapter, aimed at creating a conceptual substratum capable to develop an organic and coherent geoethical thinking. Definitions, concepts, values, online resources and tools described in the next pages are necessary as an introduction to geoethics. The content of this chapter should be used as a base to be incorporated in geosciences courses. Two “ad-hoc” video-pills and the Cape Town Statement on Geoethics should be considered integral part of this chapter in order to get the essential elements of theoretical aspects of geoethics and a synthetic description of the difference between ethical issues and dilemmas.

1 INTRODUCTION: THREE FUNDAMENTAL QUESTIONS

Humans are capable of modifying natural environments, and in virtue of this capability they have an ethical responsibility towards the planet. Indeed, studying and managing the Earth system, exploiting its georesources, intervening in natural processes are actions that involve great responsibilities towards society and the environment, of which perhaps geoscientists are not sufficiently aware. Only by increasing the awareness of this responsibility, can geoscientists work with wisdom and foresight, and respect natural processes and dynamics existing in nature while guaranteeing a sustainable development for future generations. In order to define acceptable solutions to current anthropogenic global changes, geoscientists need to take into proper consideration the ethical and social aspects involved in geosciences issues.
Geosciences (or Earth sciences) are a wide set of scientific, basic and applied, disciplines (including engineering disciplines) whose aims, methods, tools are used by geoscientists to investigate the Earth system in order to understand its composition, structure, forces, processes, dynamics, cycles, resources, evolution, at various scales and in different spatial and temporal intervals.

The expression “Earth system" is here referred to physical, chemical, biological Earth’s constituents and their interacting processes and cycles on both the Earth surface and its interior, capable to transform and/or transfer matter and energy throughout the whole system in ways that are governed by the laws of conservation of matter and energy. The Earth system consists of geosphere (the solid Earth), atmosphere, hydrosphere, biosphere, anthroposphere (including the technosphere).

Geosciences analyse the interaction between Earth constituents, the relationships between the planet Earth and other celestial bodies, the influence of human activities on the geological deposits, processes, dynamics, and the ecosystem. Geosciences investigate both abiotic and biotic phenomena, the active and passive interaction between biological and a-biological processes and dynamics (e.g. corals and coral reefs, or biological matter and oil formation), how animal and vegetal life, and humans can determine or influence rock and geologic deposits formation and modifications. Geosciences studies use direct and indirect methods to make observations and get data, and through models geoscientists provide deterministic or probabilistic scenarios to forecast the spatial and temporal occurrence and evolution of physical, chemical, and biological phenomena.

Geoethics was born to define a conceptual substratum of categories, to be used as framework of reference for geoscientists, to help them develop a new way of thinking and interacting with the Earth system. Geoethics widens the cultural horizon of geoscience knowledge and contributes to orient scientists and society in the choices for a responsible behavior towards the planet.

At the present, geoethics is recognized as an emerging field in geosciences, but until 2012 geoethics was still in its early stage, with fragmented and discontinuous initiatives.

This means that it was necessary to start to give a theoretical structure to geoethics, to assure its scientific credibility, supported by a solid conceptual substratum, by answering essentially to the following questions:

1. What is geoethics?
2. What is the geoscientist's responsibility?
3. How can geoscientists serve society?

2 THEORETICAL FRAMEWORK

2.1 From ethics to geoethics

Practicing geosciences has important implications in ethical and social terms, and geoethics can be a way for society to approach the global problems affecting the human interaction with the Earth system in a more responsible way, without prejudices and ideological constraints. This implies geoscientists being aware of their ethical and social responsibility and role within society.
Unfortunately, training designed to increase this awareness does not yet exist and cultivating geoethical thinking is usually delegated only to personal initiative. Concretely, universities should train young people to develop critical thinking in geosciences, providing them with conceptual tools, useful to give a satisfactory answer to the following basic questions:

- When I am faced with a professional problem, on which elements can I base my decision?
- What is right to do and why?
- And how?

This is the ethical issue, and it implies a conscious choice between different options in problem-solving.

"*Ethics reflects on the conduct of humans and the criteria on which to evaluate behaviours and choices, in order to identify the "true good", including the means to achieve this goal. Ethics is intended to clarify, for a given circumstance, what to do and how to do it, taking into account the consequences of that act. Its function is to guide humans when they need to make a choice, by providing them with a framework of reference values, shared by the social group to which they belong, that can lead to the good, or to what is most useful to the individual or society. With regard to a profession, we can define ethics as the identification of duties and rights that regulate a professional activity by members of a social group, who possess specific technical-scientific knowledge, as well as methods and tools for its application.*" (Peppoloni & Di Capua, 2018, p. 1).

Regarding ethical aspects applied to research and professional activities the following definitions should be known (Di Capua, Peppoloni & Bobrowsky, 2018):

Research integrity: it is a set of ethical values, deontological duties and professional standards on which a responsible and correct conduct is founded by those who perform, finance or evaluate scientific research as well as by institutions that promote and realize it. The application of the values and the respect of deontology and professional standards guarantee the quality of research and contribute to an increase of reputation and public perception of science, with important repercussions on the scientific community and society.

Professional ethics: it encompasses the personal and corporate standards of behavior expected by professionals belonging to a professional community.

In the field of geosciences, the more specific term "geoethics" is used to frame the ethical problems related to the geosciences research and practice, and it includes aspects related to research integrity and professional ethics. Ideas that underpin the conceptual foundations of geoethics can be traced back to the eighteenth and nineteenth centuries when anthropogenic impacts on nature began to be recognised and documented (Peppoloni & Di Capua 2012; Bonneuil & Fressoz, 2013; Lucchesi, 2017; Lewis & Maslin, 2018). In the early ‘90, the word “geoethics” began to be used to define the ethical and social implications of geosciences (Cronin, 1992; Savolainen, 1992; Peppoloni & Di Capua, 2015a).

The word “geoethics” is the union of the prefix “geo” and the word “ethics”. An in depth etymological analysis highlighted that the word “ethics” has a double meaning: on the one hand, “ethics” contains a sense of belonging of each human to the social dimension of existence; on the other hand, “ethics” is related to the individual sphere of human behaviours.

In these both existential conditions (social and individual) the etymological root of the word “ethics” points out human beings’ responsibilities towards oneself and towards the social community to which they belong (Peppoloni & Di Capua, 2015b).

The prefix “geo” clearly refers to the “Earth”. But its ancient Sumerian base “ga” contains a deeper meaning, that is “home, dwelling place”. So “geo” is not simply the Earth, but more specifically the place where humans dwell and where future generations will dwell. So, geoethics means responsibility towards the Earth and future generations (Peppoloni & Di Capua, 2015b).

Based on these considerations, geoethics has been defined as “*the research and reflection on the values that underpin appropriate behaviours and practices, wherever human activities interact with the Earth system*” (Peppoloni & Di Capua, 2017, p. 2). This definition proposes an analytic approach to reality, focusing on the need to identify values on which to base the growing interaction between humans and the Earth system.

A second part of the definition states that “*Geoethics deals with the ethical, social and cultural implications of geoscience education, research and practice, and with the social role and responsibility of geoscientists in conducting their activities*” (Peppoloni & Di Capua, 2017, p. 2). It emphasizes the centrality of geosciences as a body of technical-scientific knowledge to correctly manage this interaction. In particular, geoscientists are asked to assume the ethical responsibility to use their knowledge for the benefit of society.

2.2 The four domains and areas of application of geoethics

In geoethics the concept of responsibility is central (Bobrowsky, Cronin, Di Capua, Kieffer & Peppoloni, 2017). The responsibility expresses the commitment to answer to someone (individuals, institutions, organizations, society in general) for one’s own actions and their potential consequences. Responsibility implies the obligation to satisfactorily perform or complete a task that has a consequent “penalty for failure” (Peppoloni & Di Capua, 2018). With reference to the scientific community, a potential failure should not only be intended from a legal point of view (for example: if calculations to make a slope stable are wrong owing to negligence and a disaster occurs, scientists will pay for the consequences), but also in terms of loss of credibility, trust or reliability, or an impairment of the relationship with colleagues and stakeholders. After all, it is the failure of the scientific and cultural role of geoscientists to help society in facing geological problems, that is, definitely, the loss of the reason for being geoscientists (Peppoloni & Di Capua, 2017).
Taking responsibility means to act rationally and coherently with respect to the purpose attempted, but also to consider the impact one’s choices have on one’s own credibility, and/or colleagues, and/or society, and/or the natural environment. Responsibility means to answer for one’s own actions and being competent to execute the actions requested and/or to solve a specific problem. Responsibility is a prerequisite to establish ethical best practices, activities, and working capacity building (Peppoloni et al., 2019).

Geoscientists can act at various scales and in different working environments, and therefore they have to deal with diverse ethical levels of interactions, starting from the correctness and honesty of individual behaviours, which necessarily influences the working experience as well as the following interactions with colleagues, society and the environment.

The goodness of a behaviour is measured based on values. These values refer to four geoethical domains discussed in the following: individual, inter-personal, societal, and environmental (Peppoloni, Di Capua & Bilham, 2019).

The geoscientists' responsibility can be referred to these four domains:

- the responsibility towards oneself (individual domain) in conducting the own work to the best of own ability. This implies to apply appropriate research methods, verify the sources of information, report findings and interpretations fully and objectively, assure ongoing professional training and the continuous improvement of geological knowledge lifelong, always maintaining intellectual honesty at work, avoiding conflicts of interest that could compromise the trustworthiness of own work;
- the responsibility towards colleagues (inter-personal domain), to cooperate with a respectful and honest attitude, with the common goal to find solutions to problems. This includes to respect others' ideas, diversity of perspectives, expertise and methods, foster the mutual understanding, accept a fair debate with hypotheses and theories that disagree, share information and data, be respectful of the intellectual property;
- the responsibility towards society (societal domain) that geoscientists have the duty to serve in order to allow its development and assure its safety. To achieve those goals, it is fundamental making data and results of own studies public, easily accessible and user friendly with explanatory information targeted to the population, transferring advanced knowledge to industry and authorities, collaborating in the training of technicians' and professionals' skills, participating in educational campaigns for the population, increasing the synergy with government agencies and local administrations through the development of operational protocols;
- the responsibility towards the Earth system (environmental domain). Geoscientists have the knowledge, expertise, professional and cultural sensibility to help protecting natural environments, to use prudently georesources favouring as much as possible a sustainable and responsible management, to enhance the scientific, educational, cultural and aesthetic dimension of the bio- and geodiversity, to entrust it to future generations.

These four domains of the geoethical analysis represent a helpful framework to motivate geoscientists to develop a responsible approach to increase the awareness of their individual and social responsibilities towards their working environment, society and the Earth system.

Geoethics applies to the entire range of geoscience fields, such as: responsible/sustainable use of georesources; geo- and anthropogenic risks reduction and prevention; management of the land, coastal areas, seas and open oceans; socio-environmentally sustainable supplies of energy; pollution and its impacts on health; climate change studies and adaptation; research integrity and deontology; literacy and education in geosciences; geodiversity and geoheritage protection and enhancement; forensic and medicine geology (Ellis & Haff, 2009; Fressoz, 2012; Peppoloni & Di Capua, 2012; Gundersen, 2017; Lollino, Arattano, Giardino, Oliveira & Peppoloni, 2014; Peppoloni, Bobrowsky & Di Capua, 2015; Wyss & Peppoloni, 2015; Bohle, 2016; Vasconcelos, Torres, Vasconcelos & Moutinho, 2016; Peppoloni, Di Capua, Bobrowsky & Cronin, 2017; Stewart & Gill, 2017; Arattano, Peppoloni & Gatti, 2018; Meller et al., 2018; Bohle, 2019a,b; Orion, 2019; Peppoloni et al., 2019).

2.3 Key-points of the geoethical thinking

Talking about geoethics is possible only by referring to human behaviours. So, geoethics implies an anthropocentric perspective, having human agent's responsibility as ethical criterion to guide ow actions. Humans have the power to choose, more or less consciously, between different options. The definition of geoethics proposes humans, who are themselves part of nature, having the role of rational conscience of the Earth system architecture (Peppoloni & Di Capua, 2017).
Geoethics requires conscious and responsible geoscientists to be applied. They possess the scientific and technical knowledge to understand the best way for humans to interact with the Earth system. And even if this knowledge is not perfect, thus fallible, always subject to possible changes and improvements by definition, as any other empirical science, geoscientists have the responsibility to provide excellent science (Marone & Peppoloni, 2017).

The importance of the concept of responsibility implies the need to define the perimeter of the geoscientist's action and therefore to identify the role that a geoscientist must play in the decision-making chain. Regarding this aspect, a paradigmatic example is the "L'Aquila earthquake-case" (Cocco et al., 2015). In the judgment at first instance, seven scientists were convicted for negligence in the seismic risk assessment, after the city of L'Aquila had been destroyed in 2009 by an earthquake and three hundred people died. The lack of clarity on the role of the various actors involved (decision-makers, scientists, mass-media and population) led to a confused message to citizens about the risk they were running and about the preventive actions to be adopted. But with the third and final judgement, six out of seven scientists were acquitted, and this made it clear that negligence cannot be attributed to scientists who only had the role of "scientific advisors" and not of decision-makers. So, the distinction of the roles is fundamental.

2.4 The values of geoethics

Once the role of geoscientists has been defined, the need to identify reference values arises, values able to guide choices and behaviours, appropriate for each situation. The ethically correct solution to a problem will not be the result of a simplistic choice between right and wrong. In fact, preliminarily it is necessary to discuss and fix reference values on the basis of which it is possible to discriminate correct/acceptable decisions and choices from incorrect/unacceptable ones.
Three groups of values have been proposed, as useful references to establish a correct/acceptable relationship between geoscientists, society and the Earth system (Peppoloni & Di Capua, 2016; Peppoloni et al., 2019):

- Ethical values: they concern both the individual and social sphere of geoscientists, and include honesty, awareness, integrity, transparency, reliability, competence, respect, reciprocity, courtesy, sharing, cooperation, inclusivity, multidisciplinarity, safety.

- Cultural values: geosciences are capable of influencing current and future ways of thinking about the Earth system. The geoethical thinking enhances cultural values such as geodiversity, geological landscape, geoheritage to strengthen the relationship between communities and the land they inhabit, and considers those values also under a socio-economic perspective (as well as ecological and geological). Geoparks and geotourism, that represent a synthesis of those values, can become a modern economic opportunity for a country's sustainable development.

- Social values: geoethics can support society in facing global challenges, such as climate change adaptation, the search for new sources of energy and the best management of the current ones, the need for a sustainable approach to the environment, the defense against geo-hazards and the promotion of preventive approaches to georisks management, and the development of a society of knowledge. From the geoethical perspective values such as sustainability, prevention, adaptation, and geo-education are social values, capable to influence the societal vision of future decades. "Sustainability" has a double social value: in the near term it consists of developing strategies and technologies for reduced use of energies and minerals, and to encourage the percentage increase of renewable energies; in the long term, it consists to building a new model of economic development for societies that aims to give new generations the possibility of discovering and exploiting other ways to produce energy and use natural resources. In fact, a sustainable world is also economically beneficial to society as a whole. Geoethics can help define the threshold of a sustainable human living. The development of a "culture of prevention" in the society is the way to improve the resilience of human communities (namely their ability to anticipate, avoid and/or respond to an event. This includes the capacity to restore the material, cultural and spiritual conditions existing before an event and to prepare for and respond to future events in a more effective way), on the basis of scientific information and data provided by geoscientists. "Adaptation" refers to the ability of a social group to modify its organization, modes of production and consumption, interests, objectives, network of external relations and the ways in which it interacts with its environment for response to a change. Natural systems change irreversibly, given their interconnection and complexity, determined by non-linear system dynamics that do not allow the complete restoration of previous conditions. This implies the need for human communities to develop strategies and actions to adapt to natural and anthropogenic changes, so as to guarantee their survival. "Geo-education" has the goal to train young people and to transfer geologic knowledge to the public.

Through geo-education geosciences assume a fundamental role in building a knowledgeable society, by raising awareness about how the Earth system operates and evolves.

2.5 Codes of ethics and ethics of responsibility

The translation into practice of geoethical values is represented by codes of ethics/conduct, which prohibit wrong practices and foster correct ones, and legal framework to manage human processes and interactions within society. Codes are a very useful tool to prevent, monitor and control inappropriate practices and policies. But their adoption is not always sufficient to increase the ethical level of a scientific and professional community at an acceptable level. “Bad practices”, “unethical behaviors”, “research misconduct” or “conflicts of interest” continue to threaten the credibility of geosciences community.
The observance of ethical practices included in the codes should not be confused with the essential ethics education and training that each geoscientist should receive in the Higher education to assimilate ethical values and reach a higher level of integrity within the professional community. It is essential to embody the value before the code, to make sense of an ethical action. To encourage ethical behaviours in geoscience community, young and early-career geoscientists should be motivated in respecting professional codes. This means that teaching geoethics should be introduced in Highr education curricula (Peppoloni & Di Capua, 2017).

2.6 Intellectual freedom as fundamental prerequisite for geoethics

Geoethics implies a conscious and rational way of acting, being based on responsible behaviours and a scientific approach to problems. An ethical decision can only come from a responsible choice, but without intellectual freedom ethical decisions are problematic. Intellectual freedom is a fundamental pre-requisite for acting ethically. Without resorting to extreme cases, even harassment, bullying, discrimination, conflicts of interest, pressures at work threaten the serenity of the working environment and more generally they inhibit the freedom of choice. A respectful working environment is fundamental to maintain a high level of professionalism and to assure an ethical conduct while practicing geosciences. Harassment (from psychological to sexual) and discriminations offend the dignity of the person, and seriously undermine not only integrity and credibility of the geosciences community, but also the quality of the scientific results. These kinds of behaviours prevent individuals, driven by fear of punishment or retaliation, from taking ethical decisions.

2.7 Ethical issues and dilemmas

An ethical issue presupposes the existence of a choice at least between two alternatives, one of which is the best option, taking into account the reference system of individual, social, scientific, economic and cultural values in which a geoscientist is acting, assuring an accurate knowledge of the problem to be faced and an adequate competence for its resolution. If one option is clearly better than another, then the decision to be taken could be relatively simple. But often geoscientists are in front of ethical dilemmas: so a “perfect” choice is not possible, but rather different options to be followed exist, all with inevitable negative impacts on society or the environment (Marone & Peppoloni, 2017; Bohle & Marone, 2019).
In this case, which is the best choice to be taken from an ethical point of view? On what do geoscientists base their choices?

A real ethical dilemma implies a problematic solution: in fact, it doesn’t have a “perfect” solution, but rather the most acceptable one concerning a specific context.

Moreover, if a geoscientist usually makes choices trying to look at the most acceptable solution (that means the one with the best consequences, or at least not the worst ones), sometimes bad consequences must be carefully evaluated and eventually accepted.

In any case, not always it is a duty of geoscientists to take a final decision about a specific matter. In fact, often the decision on the feasibility of a geological intervention in an area can depend not only on scientific and technical considerations, but also on political issues. In this case, geoscientists have the social role to provide decision-makers with all the exhaustive elements to take a decision as sustainable as possible for that societal and environmental context. This means that a geoscientist is ethically obliged to properly inform those who are really in charge of the decision-making process, and surely a solution or at least an orienting suggestion or an expert advice are expected from geoscientists.

If geoscientists are facing a geoethical dilemma, their first professional attitude should be to accept they cannot offer a unique right solution, but options and potential outcomes and scenarios. Geoscientists' duty is to explain the choices and the consequences of choosing each of them, avoiding making the mistake of considering geosciences knowledge as a universal law, thinking they might solve an ethical dilemma by using categories like "right" or "wrong". Geoscientists can suggest ethical choices by justifying them adequately from a scientific and technical point of view, and by clearly indicating pros and cons of the choice they are proposing, including when possible a cost/benefit analysis even in societal and environmental terms, taking into account also the probabilities of occurrence of the perturbations induced in the considered system, and the quantification of the epistemic uncertainties of their models.

Making technical-scientific choices under uncertainty inevitably implies accepting compromises, trying to find a balance between different factors. So, there is no "absolute good", even in geoethics. There is only a "good" choice/decision/practice that is related to the circumstances and social, economic, and cultural contexts in which geoscientists are operating. In practical terms, certainly geoscientists' decisions should consider scientific and technical aspects, as well as economic and temporal implications (for example lesser costs or shorter feasibility time). But at the same time, they should take into account the greater social benefit their choice can entail. Finally, geoscientists will take care of environmental aspects, by choosing interventions that respect as much as possible natural dynamics.

In this perspective, a careful and rational analysis of a problem to be solved must lead to that point of equilibrium, in which the sum of the positive effects is optimized. This would be the way to take a choice ethically sustainable for the human community and the environment involved, based on identified common values, shared by all those who will be involved in the consequences (positive or negative) of that choice. The geoethical approach is based on adopting an inclusive approach in problem-solving and to share responsibilities with all stakeholders.

This implies the importance to work with local communities and stakeholders to determine where there is reasonable alignment of values (economic, social and ethical values) and opportunities for collaborative action that will create sustainable benefit for all parties.

Those reference values should take into the due account different cultural, economic and social contexts and backgrounds, existing in different parts of the world. Just as an example: a dam can strongly impact on a natural habitat, but at the same time it can ensure protection from floods and water supply for thousands of people. Similarly, in developed countries it is common to consider mining a threat to human health and nature, but mining is surely an opportunity for development of economically depressed areas, capable to bring benefits, jobs, facilities and infrastructures to the local population. Positive and negative aspects should be considered at the same time, and also from different perspectives: in the short and long term, or on a small and large scale.

The aim of a geoethical analysis is to find an acceptable solution, a compromise solution, not limited in time, based on scientific but also economic and social considerations, discussed among parties and shared. It is evident that geoethics means not only to define standards and procedures, but also to constantly search for universal values to be shared, because probably a technical solution alone is not enough to solve complex problems: real progress is possible when the practical action is accompanied also by an ethical reflection on the value of that action (Peppoloni et al., 2019).

2.8 Why do we have to act (geo)ethically? Geoethics as an advantage

In order to favour the spread of (geo)ethical behaviours and practices in the geosciences community, advantages in acting ethically should be highlighted and fostered.
It becomes central to educate to understand the advantage of following ethical rules and best (geo)ethical practices. Conducting geosciences activities in a responsible way means to be able to find wiser and cheaper technical solutions, it means to win the trust of the client/population and earn professional/scientific credibility and respectability. At the same time it is important to create cultural, social and legal conditions, so that there is no advantage for scientists, companies or single professionals to act unethically, because of the negative repercussions on their reputation or in terms of penalties. This doesn't mean to minimize the intrinsic value of an ethical action, but its beneficial aspects should also be emphasized while teaching geoethics.

2.9 Teaching geoethics

The practice of geosciences often places scientists in front of situations for which there are no unique solutions. This implies that decisions related to geoscience matters having (geo)ethical and social repercussions depend on different elements. In particular:

- the framework of reference values existing in the contexts in which geoscientists are operating;
- the level of knowledge, scientific and technical preparation and updating of scientists and professionals;
- the degrees of freedom geoscientists have, depending on whether they work (industry, research field, governmental bodies);
- the efficaciousness of their interaction with other professional figures;
- the perception of the social utility of their actions.

Given the complexity of the issues, it is clear that the ethical dimension in geoscience cannot be entrusted only to the individual sense of responsibility, but it is necessary to develop this dimension in the academic context (Bobrowsky et al., 2017).

Introducing students and early-career geoscientists to geoethical thinking means transferring to them the values that are behind the concreteness of their scientific action. Geosciences are based on experience, this implies that the reference values of geoethics, that must accompany the practice of geosciences, should be constantly defined and verified in the light of the concreteness of practical results.

2.10 Resources

Understanding geoethics and adopting geoethical thinking should be favoured by resources able to transmit essential reference elements about theoretical framework of geoethics.
To this aim two video-pills and the Cape Town Statement on Geoethics (Di Capua, Peppoloni & Bobrowsky, 2017) are considered complementary resources to this eBook.

2.10.1 Video-pill: "Introduction to geoethics: definition, concepts, areas of application"

In this video-pill definition and meaning of geoethics from a philosophical point of view and its themes are provided. The concept of responsibility its application to the four domains of human interactions in the geoethical analysis, and the areas of application of geoethics are discussed.
It is highlighted the need to define shared values for taking ethical decision and three groups of geoethical values are proposed: ethical values, cultural values, social values.

It is emphasized the importance to translate into practice those values through codes of ethics/conduct and by teaching geoethics.

2.10.2 Video-pill: "Ethical issues and ethical dilemmas"

This video-pill is focused on the difference between ethical issues and dilemmas. The ethical issue is related to the problem of the choice between two alternatives: in this case one choice is better than the other one. The choice will be based on a specific reference system built on social, scientific, economic, cultural, and personal values and beliefs. Taking a geoethical decision needs accuracy of knowledge on the problem, both in technical and scientific terms, and assuring an adequate competence for its resolution. In the case of ethical dilemmas, a choice between different options, all with inevitable negative impacts on society and/or the environment, and with no right solution in absolute terms, but only with acceptable solutions has to be faced. The video-pill discusses matters such as the acceptance of the consequences of the choices, the necessity of compromises, geoscientists' duty and their attitude in facing geoethical dilemmas.

2.10.3 Cape Town Statement on Geoethics

The Cape Town Statement on Geoethics (CTSG), released officially in October 2016 by the International Association for Promoting Geoethics (IAPG), is a document that defines the conceptual framework for the study and application of geoethics. The CTSG is structured into different sections. The "Preamble" indicates the overarching objective of the statement. The "Introduction" outlines both, the context in which geoscientists are now operating, and the premises for following a geoethical approach. In the section "Definition of Geoethics" the formula (originally proposed by Peppoloni & Di Capua, 2015) is included. The section "Purpose" delineates the scope of geoethics, and why it is essential for the geosciences community and society. The purpose to embrace geoethics is to improve the quality of research and professional work and the credibility of geoscientists, to foster excellence in geosciences, to guarantee sustainable benefits for communities, to protect local and global environments, and to ensure the conditions for a healthy and prosperous development of future generations. In the section "Fundamental Values of Geoethics" a set of geoethical values are listed. They regard both the individual and the social sphere of geoscientists, in relation to the four ethical domains to be considered in the geoethical analysis. The section "Geoethical Promise" contains the Hippocratic-like oath for geoscientists, originally proposed by Matteucci, Gosso, Peppoloni, Piacente & Wasowski (2014), and slightly revised. The section "Final Statement" closes the document, underlying future environmental and social challenges, encouraging geoscientists to raise their responsibility, and strengthen the credibility of geosciences in order to secure societal trust. The final statement stresses the importance (and necessity) of the document for the geosciences community in the light of anthropogenic global challenges. The CTSG has the goal to encourage a more responsible behaviour in geosciences research and practice. It addresses firstly the geosciences community, but has important significance also to society as a whole, as it synthesizes some values that should guide human actions with respect to the Earth system. The CTSG is a reference document for the international geosciences community and is supported by 22 organizations (http://www.geoethics.org/ctsg). The CTSG is translated into 35 languages (Peppoloni, 2018: http://fliphtml5.com/gqru/ttwl), so that people can share universal values of geoethics and strengthen a common identity within the social diversity.

Cape Town Statement on Geoethics

Preamble

The concepts, values and views on individual responsibilities of geoscientists, expressed in the "Cape Town Statement on Geoethics" reflect an international consensus. The statement aims to capture the attention of geoscientists and organisations, and to stimulate them to improve their shared policies, guidelines, strategies and tools to ensure they consciously embrace (geo)ethical professional conduct in their work.

Introduction

Geosciences have major impacts on the functioning and knowledge-base of modern societies. Geoscientists have specific knowledge and skills, which are required to investigate, manage and intervene in various components of the Earth system to support human life and well-being, to defend people against geohazards and to ensure natural resources are managed and used sustainably. This entails ethical obligations. Therefore, geoscientists must embrace ethical values in order best to serve the public good.

Geoethics is an emerging subject, which promotes a way of thinking and practicing geosciences, within the wider context of the roles of geoscientists interacting with colleagues, society and the planet.

Only by guaranteeing the intellectual freedom of researchers and practitioners to explore and discover in the Earth system, is it possible for geoscientists to follow ethical approaches in their work. Likewise, only by increasing researchers' and practitioners' awareness of the ethical implications of their work is it possible to develop excellent geosciences to serve society and to reduce the human impact on the environment.

Definition of Geoethics

Geoethics consists of research and reflection on the values which underpin appropriate behaviours and practices, wherever human activities interact with the Earth system.

Geoethics deals with the ethical, social and cultural implications of geosciences knowledge, education, research, practice and communication, and with the social role and responsibility of geoscientists in conducting their activities.

Purpose

Embracing geoethics is essential: to improve both the quality of professional work and the credibility of geoscientists, to foster excellence in geosciences, to assure sustainable benefits for communities, as well as to protect local and global environments; all with the aim of creating and maintaining the conditions for the healthy and prosperous development of future generations.

Fundamental Values of Geoethics

- Honesty, integrity, transparency and reliability of the geoscientist, including strict adherence to scientific methods;
- Competence, including regular training and life-long learning;
- Sharing knowledge at all levels as a valuable activity, which implies communicating science and results, while taking into account intrinsic limitations such as probabilities and uncertainties;
- Verifying the sources of information and data, and applying objective, unbiased peer-review processes to technical and scientific publications;
- Working with a spirit of cooperation and reciprocity, which involves understanding and respect for different ideas and hypotheses; Respecting natural processes and phenomena, where possible, when planning and implementing interventions in the environment;
- Protecting geodiversity as an essential aspect of the development of life and biodiversity, cultural and social diversity, and the sustainable development of communities;
- Enhancing geoheritage, which brings together scientific and cultural factors that have intrinsic social and economic value, to strengthen the sense of belonging of people for their environment;
- Ensuring sustainability of economic and social activities in order to assure future generations' supply of energy and other natural resources.
- Promoting geo-education and outreach for all, to further sustainable economic development, geohazard prevention and mitigation, environmental protection, and increased societal resilience and well-being.

Geoethical Promise

The adoption of the following Hippocratic-like oath (the "Geoethical Promise") by early-career geoscientists is proposed, to promote respect for geoethics values in geosciences research and practice:

I promise…

… I will practice geosciences being fully aware of the societal implications, and I will do my best for the protection of the Earth system for the benefit of humankind.

… I understand my responsibilities towards society, future generations and the Earth for sustainable development.

… I will put the interest of society foremost in my work.

… I will never misuse my geoscience knowledge, resisting constraint or coercion.

… I will always be ready to provide my professional assistance when needed, and will be impartial in making my expertise available to decision makers.

… I will continue lifelong development of my geoscientific knowledge.

… I will always maintain intellectual honesty in my work, being aware of the limits of my competencies and skills.

… I will act to foster progress in the geosciences, the sharing of geoscientific knowledge, and the dissemination of the geoethical approach.

… I will always be fully respectful of Earth processes in my work as a geoscientist.

I promise!

Final Statement

It is essential to enrich the roles and responsibilities of geoscientists towards communities and the environments in which they dwell, as well as paying attention to each scientist's individual conscience and relationships with colleagues. Human communities will face great environmental challenges in the future. Geoscientists have know-how that is essential to orientate societies towards more sustainable practices in our conscious interactions with the Earth system. Applying a wider knowledge-base than natural sciences, geoscientists need to take multidisciplinary approaches to economic and environmental problems, embracing (geo)ethical and social perspectives. Geoscientists are primarily at the service of society. This is the deeper purpose of their activity.

In the coming years, especially when addressing matters like energy supply, use of geo-resources, land management, pollution abatement, mitigation of geo-risks, and climate change adaptation and mitigation, ethical and social issues will be central in scientific discussion and in public debate. In addition, handling large quantities of data, science and risk communication, education strategies, issues of research integrity, anti-harassment and anti-discrimination policies, gender balance and inclusion of those living with disabilities will be major topics for geoscientists.

Raising the (geo)ethical awareness and competences of the members of the geosciences community is essential, also to increase trust and credibility among the public. This can best be achieved in the near future by two means: by promoting more effectively existing guidance such as codes of ethics/conduct and research integrity statements; and by introducing geoethics into geosciences curricula, to make geoethics a basic feature of the training and professional activity of geoscientists.

3 CONCLUSIONS: MAIN CHARACTERISTICS OF GEOETHICS

The 'geoethical thinking' can be located within broader societal concerns about the responsible conduct of science and the science–society interface (Bohle & Di Capua, 2019).

Initially developed as professional ethics (deontology) inside geosciences (Peppoloni & Di Capua, 2015a; Wyss & Peppoloni, 2015; Mogk, 2017), and to frame inquiries on the responsible behaviour of professionals in geosciences and the societal relevance of geosciences (Peppoloni et al., 2015; Gundersen, 2017; Peppoloni & Di Capua, 2018; Bohle & Di Capua, 2019), geoethics is increasingly recognised as an emerging subject that goes beyond professional boundaries to inform human agents' actions and societal decisions as a whole (Bobrowsky et al., 2017; Peppoloni et al., 2019), with well-established conceptual foundations and a developing framework for its practical application across a growing range of geosciences disciplines and sectors for assuring sustainable, safety and health conditions to human communities and protecting biotic and abiotic entities (Peppoloni & Di Capua, 2017; Peppoloni et al., 2019).

The concept of responsibility is a central pivot in geoethics: the human agent sits at the centre of an ethical reference system in which individual, interpersonal/professional, social and environmental values coexist, underpinning their responsibilities at these four levels (named "the four geoethical domains") (Peppoloni & Di Capua, 2015b; Bobrowsky et al., 2017; Peppoloni & Di Capua, 2017; Peppoloni et al., 2019).

The four fundamental characteristics of geoethics can be summed up as follows:

a) human agent-centric,

b) shaped as virtue-ethics,

c) geosciences knowledge-based,

d) with space-time context-dependent approaches.

Geoethics is a virtue ethics, placing at the forefront individual, responsible action based on the adoption of societal and professional reference values. Its development and application are led by scientists for the benefit of society, within a pragmatic, open and continuous revision process. Geoethics is grounded on geosciences knowledge to assure an informed and conscious approach to problems related to human-Earth system interaction. Geoethics is context-dependent in space and time and so ethically sound choices may differ for similar ethical dilemmas: geoethics is shaped and informed by a strong awareness of the technical, environmental, economic, cultural and political limits existing in different socio-ecological contexts (Peppoloni et al., 2019).

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Chapter 5

Geoethics and geoheritage

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CHAPTER 5. GEOETHICS AND GEOHERITAGE

SUMMARY

There has been little discussion about the relationship between geoethics and geological heritage, probably because both topics are relatively new in geosciences and still little understood. Here we provide a short overview of the relevant concepts of geodiversity, geological heritage and geoconservation. Palaeontological heritage is specially highlighted, as fossils are probably among the most threatened elements and need additional, more effective protection measures. Furthermore, we present some ideas to promote awareness and reflection in students and pre-professional training of geoscientists around some themes that directly link geoconservation principles with geoethical issues.

1 GEODIVERSITY, GEOHERITAGE AND GEOCONSERVATION

1.1 Background and main concepts

Geodiversity can be defined as "*the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landforms, topography, physical processes), soil and hydrological features. It includes their assemblages, structures, systems and contributions to landscapes*" (Gray, 2013, p.12). This term was introduced in the first years of the 1990 decade but, after 30 years, it is still generally unknown by the majority of the society. Brilha et al. (2018) make a review of this concept and show how geodiversity is connected with other natural systems and, in particular, how it is determinant to guarantee human sustainability based on the use of extractable and non-extractable natural resources (Figure 1).

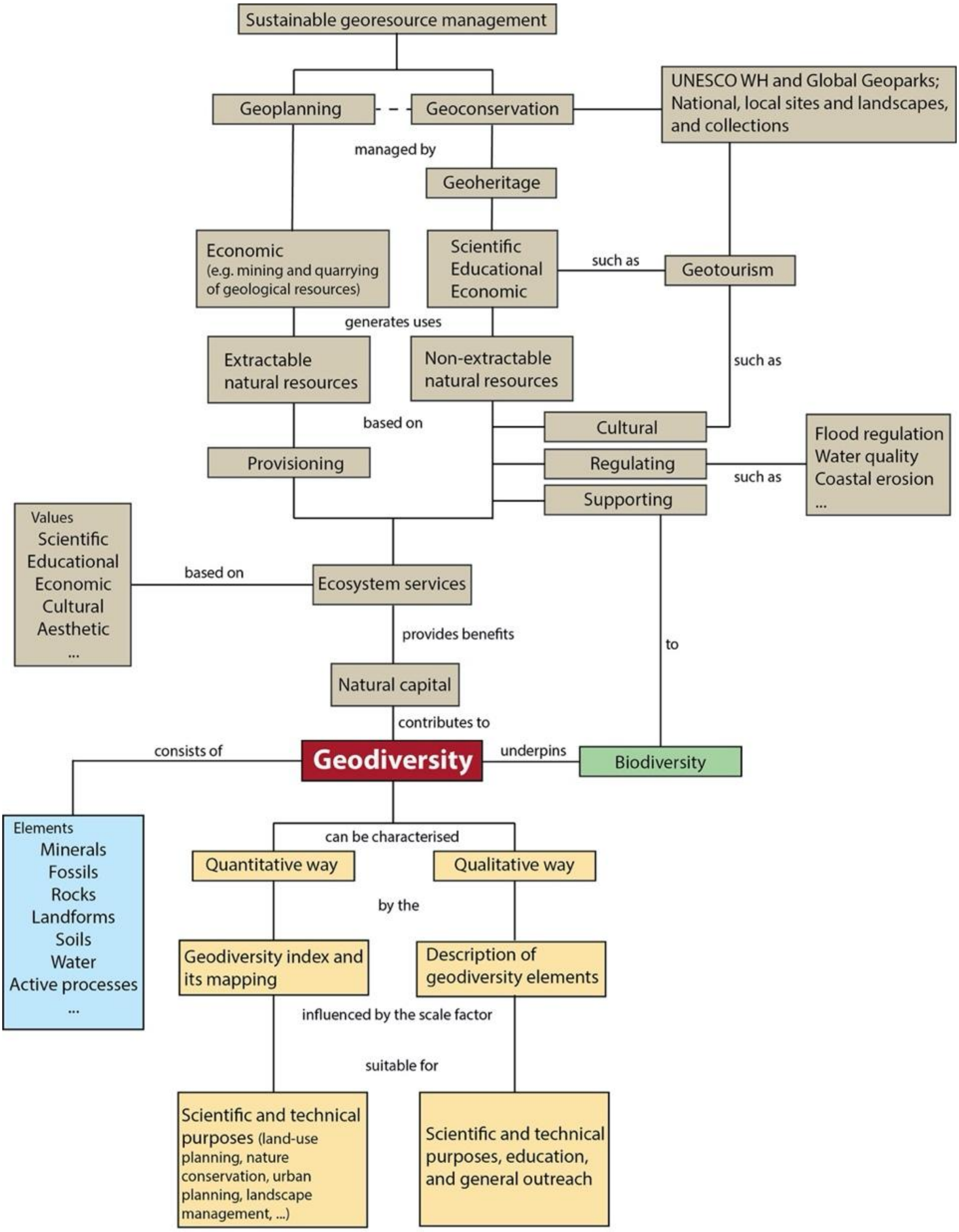

Figure 1. Network of definitions and relationships starting from the concept of geodiversity (Brilha et al., 2018, p. 20)

The smart use of geodiversity elements by the society demands a solid knowledge of how Earth systems work. To obtain scientific data that allow geoscientists to know better our planet, it is essential to guarantee access to geological materials (minerals, rocks, fossils, soils, landforms) with some special characteristics. In many domains of geosciences, some of these data are obtained directly in the field. In other domains, samples are collected for further analysis in the laboratory. However, in both cases, geological sites that are object of study must be preserved as evidence of the history of the planet, thus allowing the advance of geosciences (Figure 2). These places are known as geosites and the set of geosites in a given territory constitutes its geological heritage (*in situ*) (Brilha, 2018, in press).

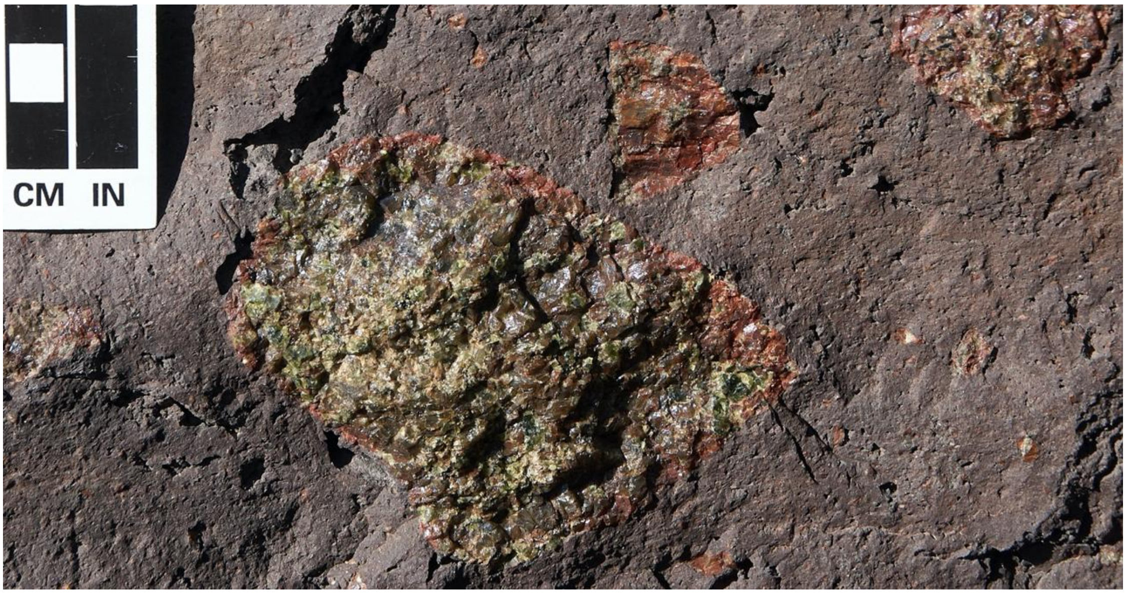

Figure 2. Olivine-rich xenoliths in basaltic rocks. Samples from this outcrop have high scientific value because they provide important geochemical data to understand volcanic processes (Lanzarote Island, Canary Archipelago, Spain). Photo by J. Brilha

Geological samples organized in scientific collections available for scientific research are also part of the geological heritage (*ex situ*) (Figure 3).

Figure 3. Ammonite specimen in a scientific collection, an example of *ex situ* geoheritage (Natural Sciences Museum, University of Zaragoza, Spain). Photo by J. Brilha

All these special *in situ* and *ex situ* geological features should be kept in the best possible conservation status and must have some characteristics that differentiate them from other similar geological features. The scientific relevance of a geosite is also attested by national and international publications directly related to its geological value.

In addition to scientific use, geological sites may have other types of sustainable use. It is the case of an educational use, when geodiversity elements can be easily understood by students of different school levels, in addition to have a good accessibility and safety conditions for students and teachers (Figure 4).

Figure 4. Basalts with columnar jointing as an example of geological site with high educative value (Iceland). Photo by J. Brilha

In other sites, geodiversity elements are natural attractions that can be used for the promotion of leisure and tourist activities. For a recreational and tourist use, the aesthetic and cultural values of these elements are particularly relevant (Figure 5).

Figure 5. The aesthetic value and uniqueness character of Iguaçu waterfalls justify the high touristic visitation of this geosite (Brazil/Argentina). Photo by J. Brilha

The vast majority of geodiversity elements with no scientific value but with other type of values are designated as geodiversity sites but this does not imply that they should not be protected and valued following geoconservation strategies (Brilha, 2018).

1.2 Why do we need geoconservation?

Geoconservation aims at the protection and management of geosites and geodiversity sites, including the management of geological collections. There are specific methods to promote geoconservation, namely the inventorying and quantitative assessment, statutory protection, conservation, promotion and interpretation, and monitoring of sites (Brilha, 2018).
Geoconservation measures are needed because many geological sites worldwide are under threat due to several anthropic factors:

i) *Cultural and science illiteracy* – Decision-makers and the society in general have a very low awareness about geology and the importance of geodiversity elements for the natural capital, ecosystems services, and human well-being. Therefore, public decisions towards geoconservation tend to be delayed or completely overlooked.
ii) *Unsustainable mining* – In spite mining of mineral and energy resources is absolutely vital for the human development, unsustainable mining may put many relevant geological sites at risk.
iii) *Urban development* – The rapid expansion of cities towards rural areas due to the human population growth and migration from the countryside to urban areas is responsible for the destruction of many geological sites.
iv) *Deficient statutory protection* – Without a solid statutory protection at the international, national or local levels, the preservation of geological sites is fragile and frequently inconsequent.
v) *Inefficient administration* – A public administration without trained staff, a solid geoconservation strategy and proper funding, the vulnerability of geoheritage increases in many countries.
vi) *Smuggling and illegal collecting* – Fossils, minerals, and rocks are being stolen from many countries feeding international smuggling networks that provide huge benefits to speculators.
vii) *(Some) scientific research* – There are geosites strongly affected by deficient scientific sampling procedures that do not take into account the different types of values of some outcrops.
viii) *Unsustainable tourism and leisure activities* – Mass tourism in areas with fragile geological features (for instance, caves, soft and unconsolidated substrates, rare fossils) can negatively affect many geological sites.

Geoconservation should be also considered an applied geosciences (Henriques et al., 2011). In fact, mainly during the last two decades there is a growing volume of scientific knowledge developed using specific methods. In addition, there are research schools and teaching that produces master and PhD theses, discussion among experts in scientific events of all types, and publication of peer-reviewed papers in dedicated indexed scientific journals. All these characteristics are typical of any other geosciences.

2 PALAEONTOLOGICAL HERITAGE

Among the different elements of geodiversity, fossils are particularly affected by many of the threats mentioned above. Accordingly, the palaeontological heritage is here highlighted as it demands strategic and more effective protection measures.

2.1 Generalities about fossils and palaeontological heritage

Fossils are any evidence (remains, impressions, moulds, casts, traces, biochemical molecules, etc) of once-living organisms from a past geological age that are preserved in the materials of the Earth's lithosfere (i.e., they are mostly found in rocks with a sedimentary nature). They represent a relevant component of geodiversity with the unusual capacity to connect people with our natural environments and also, importantly, with our origins and past. Fossils inform about the environment where past organisms have lived and, together with their surrounding environment of deposition (usually, the environment of accumulation of the sediments corresponding to the rock in which fossils are found), give palaeontologists a fuller understanding of the history and evolution of the life on our planet.

Given the exceptional nature of the process of fossilisation, a fossil is, by definition, a unique or rare and non-renewable natural object and, as such, a highly valuable asset (Henriques & Pena dos Reis, 2015). However, in all fossils we can find the convergence of three different histories: *i*) Since a fossil is the evidence of a once-living organism, it is the result of an evolutionary history and, as such, it informs about the past life on Earth and the relationships with current biodiversity. *ii*) Since the humankind forms part of this evolutionary history, fossils inform as well about our own history as living beings (hence, the evolutionary anthropology or the study of humankind from a palaeontological perspective receives a lot of attention), but also about our changing role in nature and our relationships with Earth. *iii*) Since a fossil is the result of a fossilization process (a complex natural biological and geological process), it has also its own geological history that could be different of the rock containing it and that still continues while it is not removed from the site. Palaeontology, or the study of fossils, is then placed at the intersection among geological, biological and archaeological/anthropological disciplines. The palaeontological heritage shares, therefore, common characteristics with both our natural and social/cultural/historical heritage (despite ongoing debate among some geo-researchers), and cannot be interpreted or studied without this synergetic perspective. In common with the natural heritage, fossils are formed in and by nature; while the obvious link with the social/cultural/historical component is the popular fascination of fossils that lead to collection of these elements for hobby (Alcalá & Morales, 1994).

It is also important to underline that fossils are an evidence of the evolutionary theory, which can raise conflicts with religious beliefs (science vs. religion) because they are real evidences of past life and extinctions. Due to these singular features, it has been argued that palaeontological heritage can be a separate entity from geoheritage, despite fossils are geodiversity elements (Meléndez & Soria-Llop, 2000).
The scientific value of fossils is due both to the fossil itself and the rocks containing it. Then, the term palaeontological heritage refers to both a "set of rocks containing fossils, the palaeontological sites, and all the fossils extracted from them". In this sense, it is comparable to other geoheritage such as the mineralogical and the archaeological heritage.

2.2 Management of palaeontological heritage

Fossils are valuable objects that offer some type of benefit and are of interest to society. There is a plethora of reasons that attract people to fossils (which is particularly evident for dinosaurs and anthropoid primates) which, on one hand, can contribute to promote learning for students and public in general (since they explain something amazing) but, by the other hand, may result in a direct, serious impact and a hazard for the integrity of the fossil record. There is a long and complex process from the discovery of a fossil in the field (which requires actively searching likely deposits and careful excavation of the fossil) to its incorporation into a collection and use in exhibition and dissemination, that can be synthesised as follows:

1) finding --- 2) extraction --- 3) preparation/conservation --- 4) collection management --- 5) study/publication --- 6) exhibition --- 7) dissemination.

Usually, only macrofossils (i.e., fossils that are visible at the naked eye) are used for exhibition, while both macro- and microfossils (i.e., fossils that can only be seen with a magnifying glass or a microscope) are equally relevant to the scientific knowledge and research (Figure 6).

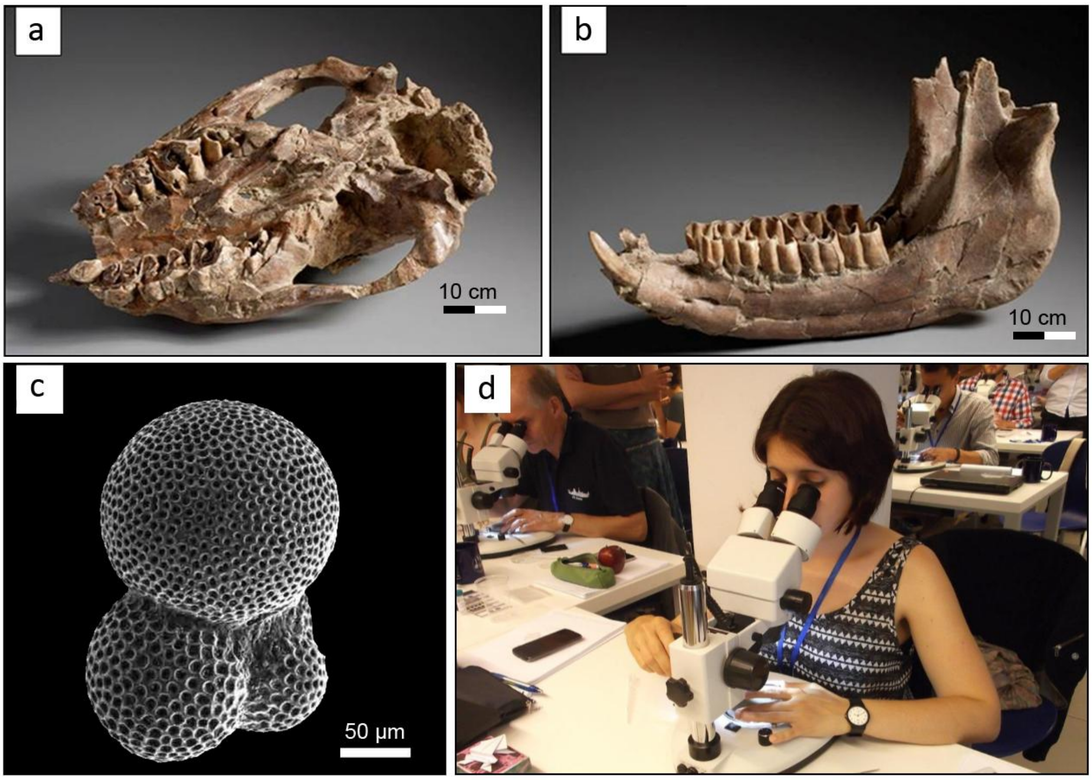

Figure 6. a) Skull (MPZ-2006/285) in ventral view and b) complete jaw (MPZ-2006/6) of a middle Miocene (~12 million years) rhinoceros *Alicornops simorrense* as an example of macrofossil. Images provided by the Natural Sciences Museum, University of Zaragoza, Spain. c) Specimen of a planktonic Foraminifera *Eoglobigerina* (Arenillas & Arz, 2013, p. 164) and d) micropalaeontologists at work

A palaeontological site is a particular location (or group of nearby occurrences) in which fossils (of any type and concentration) are present (Alcalá & Morales, 1994). It is evident that not all fossil occurrences are palaeontological heritage, such as not all paintings are art nor all the territory of a country can be declared as geoheritage. This is clear in the case of microfossils, as they are components of many sedimentary rocks (Figure 7). Microfossils have been neglected in geoconservation, but type-localities and stratotypes that are formally defined on the basis of microfossils are relevant components that need to be considered as palaeontological heritage as well.

Figure 7. Microfossils (alveolines) in limestones. Photo by J. A. Arz

In a first step, palaeontologists have to decide which fossils and sites have the sufficient importance to be considered as palaeontological heritage and, once decided, how to manage them in the proper way. There are three different groups of criteria that may help to resolve this task (Alcalá & Morales, 1994):

i) *Scientific criteria* – Nature of fossils (fossils of exceptional importance); geological age of the rocks; type localities (i.e., those from which certain species have been first recognised and formally defined); degree of preservation; association with archaeological remains; diversity of fossils (for example association of plant and animal remains); taphonomic (i.e., the process leading up to preservation or fossilisation) information; bio/chronostratigraphical relevance (sites which date important geological formations at international level); wider geological interest; and level of knowledge (sites that have provided new knowledge about a particular topic).
ii) *Socio-cultural criteria* – Fragility; geographic location; vulnerability to damage; historic value; educational interest (a criterion of special relevance to this chapter as it informs about the potential of a site for use in education); touristic interest (similar to the previous); and complementary value (sites in places already protected for other reasons).
iii) *Socioeconomic criteria* – Urban value (sites in urban areas potentially available for development); mineral value (sites associated with mineral exploitation); public works (sites linked with works); and economic value.

Note that many of these criteria might create various ethical conflicts and consequently are directly related to geoethics. For example, public works (especially for transport, water and power), mining activities, engineering projects, etc. can destroy sites of relevant importance to palaeontology, but they can also allow the discovery of new fossil occurrences. Also, conservation is needed to protect fossils and sites from loss and destruction through illegal sampling and also to regulate the selling and exportation of fossils.

In terms of regulations, and because palaeontological heritage is considered a type of heritage in many countries, there are legal measures for a correct protection and management of fossils and palaeontological sites. These laws vary widely from country to country, with some governments being less strict than others (Wimbledon & Smith-Meyer, 2012). A relevant difference among countries concerning fossil collecting is the private or public ownership of the surface and underground.

3 GEOETHICAL ISSUES RELATED WITH GEOHERITAGE

It is evident from all the above that geoheritage offers great opportunities to provide education of geosciences for the benefit of citizens and also to promote a reflection on a plethora of aspects. Thus, geoparks, geosites and museums, among other resources, can be successfully used as tools to support geoethics learning and facilitate student training. However, the inventory, conservation, and management of geoheritage raises some geoethical issues that are still poorly addressed in the literature. Some of these issues are briefly presented in the following paragraphs, with the purpose to trigger reflective learning and not to give a final answer to some of the dilemmas.

3.1 Illegal collecting of geological specimens (fossils, minerals, meteorites)

In recent years, the popularity of fossils (and minerals to a lesser extent) as collectible and commercial items has significantly increased. Most probably, this is in part attributable to the growing prominence of dinosaurs in movies and TV shows, as they are attractive and fascinating elements for the public. As a result, commercial collections have dramatically increased, creating competition for scientific collectors, although the commercial appropriation of fossils and minerals is illegal in many countries.
Commercial collecting raises therefore many ethical issues and has a detrimental effect on both education and science, as fossils, minerals and meteorites are irreplaceable educational and scientific objects. Picking up small fossils or minerals, or invertebrate fossils, seems harmless enough, but, should amateur collectors be allowed to collect them? And what about professional geoscientists?

For instance, the increase in the economic value of fossils has limited the possibility of public museums and educational centres with tight budgets acquire fossils for their collections. Concerning science, the irresponsible sampling of geological specimens by amateurs and collectors has led to a scientific loss of valuable specimens. The sampling of fossils without following a correct (scientific) protocol contributes to a permanent loss of information of the surrounding environment of deposition and the geological context, many times of much more interest for palaeontologists than the fossil by itself.

It is therefore crucial to promote sound criteria to assist geoconservation actions and determine what regulations are needed for the inventory, evaluation, conservation, valuation and monitoring of the palaeontological heritage. Public administrations in charge with the management of geoheritage should be assisted by geoscientists, particularly when they have a lack of staff with proper training (Alcalá & Morales, 1994). Some regional administrations in Spain are a good example of management as they have already included a professional palaeontologist in their regular staff.

3.2 Smuggling of geological specimens versus economic revenue of deprived communities

Another perspective concerning illegal collecting of geological specimens is related with economic and social issues in local communities. In some countries, the collecting of minerals, fossils and meteorites is a source of income for many poor families in rural areas. Without alternatives, this activity is the only resource available for non-educated people and with guarantee of a regular income flow.

In many places, like in the Tafilalet region (Morocco, North Africa), the search and massive digs of fossils for commercial purposes is leading to the destruction of sites and specimens

(Gutiérrez-Marco & García-Bellido, 2018). However, this is not all bleak and the same trade of fossils can bring a benefit for science, as there are thousands of new findings (especially marine invertebrates such as trilobites and cephalopods) thanks to massive exploitation of fossiliferous layers, which allow a better understanding of taxonomic, taphonomical and palaeoecological aspects of past organisms.

3.3 Selling of fossil replicas: fakery or handcraft

Many fossil groups are very limited in the number of specimens and therefore it is not possible to have them in museum collections all over the world. For such groups, the production of replicas is an excellent solution. In several natural history museums, the fossil exhibition is almost entirely based on replicas, particularly in what concerns complete skeletons of dinosaurs or other complex, heavy animals.

The production of replicas can be seen under three different perspectives:

i) As an *educational and scientific resource* – When the availability of real fossils is limited and expensive.

ii) As a *handcraft* – When artistic fossil recreations are produced and sell as any other economic activity (Figure 8).

Figure 8. Traditional selling of minerals and fossils in Morocco. The “giant ammonite” on the right can be considered an example of local handcraft. Photo by J. Brilha

iii) To *simulate true fossils* with a clear purpose to deceive (particularly non-expert) buyers.

Countries where fossil fakery is common include USA, Colombia, Peru, Russia, Germany, France, and (especially) Morocco (with marine trilobites) and China (with *Archaeoraptor* being one of the most conspicuous recent fossil fakes).This practice has a negative impact on both science and society, as many of the fake material can be difficult to identify as such (sometimes even to experts) and is sold at higher prices to museums and educational institutions where it is exhibited as a real fossil (Budik & Turek, 2003).
The production of fossil replicas with a licit aim may decrease the pressure on limited outcrops and can constitute an economic alternative for local populations.

3.4 Mining and development works: a threat or an opportunity

Mining and urban development can lead to the destruction of many geological features with scientific, educative, and touristic values. Sometimes, mining companies are interested in exploring a certain area where geoheritage has been already identified, causing significant impacts on this natural heritage.
However, mining activities and public works give access to rocky massifs where new geological occurrences with geoheritage relevance may be identified. Mining of fossiliferous formations is, quite frequently, a source of new fossils that can lead to the identification of new species. The same happens with mineralogical heritage. Many mineral samples with scientific value are only available because mining exploitation brought those samples to the surface. The truth is that without mining, many important mineral and fossil specimens would remain completely unknown for science.

The palaeontological site of Lo Hueco (in Central-East Spain) is a good example of potential conflict between infrastructure development and preservation of palaeontological heritage (see Educational Resource). This site yielded in 2007 an enormous and unusual concentration of Late Cretaceous dinosaurs (70-80 million years) (Ortega et al., 2008; Barroso-Barcenilla et al., 2009) thanks to the works carried out for the construction of new high-speed railway. There were no signs of any fossils in the surroundings, but a new palaeontological heritage came to light. Fortunately, the railway works stopped for a while to facilitate the identification, documentation and protection of fossils. After this research, it was possible to introduce a modification in the construction works of the railway in order to protect the site. This was an exceptional example of cooperation between the company ADIF (Administrador de Infraestructuras Ferroviarias) and the palaeontologists, with mutual benefit for the government, the society and the conservation of this heritage.

3.5 Mineral and fossil shows: an educational occasion or an incentive for smuggling of geological specimens

Mineral and fossil fairs/shows/festivals are organised all over the world. Some of them have already a worldwide recognition, such as the Tucson Gem and Mineral Show which gather each year around 4000 trade companies in Arizona, USA. Smaller events are frequently organized by universities and museums, with the participation of professional sellers that display fantastic specimens and, of course, with the purpose to do business (Figure 9).

Figure 9. Example of vitrines showing several samples of minerals in a fair (left; Photo by J. Brilha) and a replica of *Tarbosaurus* skull from Mongolia in a shop (right; Photo by B. Azanza) to sell

While these events may have an educational character, raising awareness of the public for a usually less known natural world and eventully stimulating young people to follow a geoscientific career in the future, one should question about the provenience of all the samples displayed in these events.

Were they collected following the national legislation in each country? The local collectors in remote areas and many times in poor countries were they properly paid for their work? Are there fossil and mineral sites with high scientific relevance being lost due to overcollecting to feed the international market? Are countries aware that their natural heritage is going out of the country? Do these countries collect taxes as they do for any other commercial activity?

These are just some of the issues related with fossil and minerals shows that should be discussed under a geoethical perspective.

3.6 Location of vulnerable geosites: reveal or keep secret?

There is increasintg interest on geotourism, both by promoters and visitors (Dowling, 2011). In spite it is not restricted to geoparks, the strategy of the 147 UNESCO Global Geoparks is strongly supported on geotourism. Geotourism promotes the visit to geological features, not only focused on geological interpretation but also on the links that can be established between these features and biological and cultural character of communities. Geological sites with high aesthetic value, good accessibility and safe visiting conditions can be converted into touristic attractions with high potential to generate an economic activity.
What about if a geological site with high geotourism potential is vulnerable due to an intrinsic fragility of the geological element or due to possible physical degradation caused, intentionally or not, by visitors?

Should a manager open a certain geological site to visitors when it is not possible to guarantee its conservation? Fossil sites are a good example of this dilemma. Many fossils sites have the potential to attract visitors but, without proper conservation measures, these visitors may collect and vandalise fossils, contributing to the loss of the site value and consequently to a decrease of the number of visitors.

In geological sites, there is always a risk that tourists collect and take fossils, rocks, minerals, etc. What about if this activity is allowed in informal sites or fossil parks where visitors appreciate the opportunity to "act like a palaeontologist" (Figure 10)? Despite fossil parks may have an educational character, one should question about the ambiguous message that is being presented concerning geoconservation.

Figure 10. Invertebrate fossils on the surface can be easily collected by visitors. Because fossilisation is a continuous process, once fossils are freed from the rock they are more susceptible to be incorporated in future rock bodies by current geologic processes (for instance, they could be dragged, damaged and deposited in other place by a flooding) if they are not collected. Photo by N. Kelpšaitė

3.7 Artificialization of show caves: a way to promote visitation or a loss of value

Karst caves are one of the most popular nature attractions in the world. The underground environment raises a great curiosity among children and adults due to uncommon landforms such as stalactites and stalagmites. During the 20th century, many caves were heavily developed to receive a growing number of visitors. Quite frequently, these development works have introduced a great disturbance in the natural environment, with significant changes in the accessibility and visiting conditions, such as paved trails, artificial lightning (sometimes very colourful), music and even some artificial structures such as benches and stairs, not rarely implying destruction of some natural features (Figure 11).

Figure 11. Cacahuamilpa Cave, the most visited cave in Mexico, discovered in 1883 and with about 350.000 visitors per year (Palacio-Prieto & Gómez-Aguado de Alba, 2014). Photos by J. Brilha

Nowadays, this type of development in caves is not acceptable, mainly because it introduces dramatic changes in local biodiversity.

The challenge for managers of modern show caves is the following: should the cave be prepared to receive different types of public, children, adults and senior citizens, people with disabilities, allowing all the society to have an underground experience? Or should the cave be kept in the most natural state possible but limiting its accessibility to just a fraction of possible visitors. While the former implies an artificialization of the cave, the latter gives a more realistic feeling to visitors and cause much less impacts in geodiversity and biodiversity.

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Chapter 6

Geoethics and georesources

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CHAPTER 6. GEOETHICS AND GEORESOURCES

SUMMARY

Georesources are linked to all kind of objects in human society. The human being has evolved over time. Early in its development, it took advantage of georesources that were within its reach to improve its living conditions. When he was a collector and therefore nomad, he changed the landscape in a very light and even imperceptible way. But even then, he started using tools from geological resources, the most famous being the use of flint. At that time, man begins to change his environment. The Stone Age allows man from the Palaeolithic to continuously evolve in knowledge until the Neolithic. But there is a technological leap when it realizes that it could use metals to its benefit. The use of copper, from the metallurgy of various minerals, whether in ornaments or in tools, it was then widespread, for example, in Europe. Mining is related with civilization since ancient times. In that way started the geoethics in the use of geological resources. The Europeans seems to think that should the mining be operated only on development and third world countries, and not mined in the first world countries, or not mined at all. So, how can society evolve towards a more sustainable way of life, where resources are consumed sparsely, if most citizens are not aware on the raw material cost of their consumption habits? It becomes clear that in order to achieve the most desired sustainability an effective investment in education for the geosciences is needed.

1 PUBLIC AWARENESS OF THE IMPORTANCE OF RESOURCES IN SOCIETY

The current dichotomy between environmental protection and the material comfort societies achieved in the last fifty years is probably one of the most interesting paradoxes of modern-day economies. The progressive relocation of industrial production to east, and consequent dislocation of the labour force from physical tasks to services and white-collar jobs, has moved societies away from the economic activities that have underpinned development: the exploitation of natural resources. At the same time, particularly in highly developed countries, the mediatisation of concepts such as "clean energy" and "sustainability" has created movements that oppose any extractive operation; and the false perception that it is possible to produce goods and energy in a "clean" manner, as if there were not always impacts of some kind. This perception is aggravated by the fact that most of the population is concentrated in cities, where products arrive clean, packaged and ready to be consumed. However, the reality couldn't be more different.
In fact, all everyday objects are somehow linked to the exploitation of a geological resource. And all, without exception, have some kind of impact on the planet. A few examples with day-to-day objects is enough to make a case.

In the composition of something as simple as toothpaste, there is, amongst other elements, sodium fluoride, calcium carbonate and silica. Sodium fluoride - the famous fluorine - is obtained by neutralizing hydrofluoric acid, a by-product obtained during the production of phosphate fertilizers which in its turn is made by processing fluorapatite - a mineral that occurs as common accessory but not processed, for example, in the Panasqueira Mine (a tungsten mine operating since 1896 in Portugal). In the crystalline form, this mineral is quite coveted by collectors. Calcium carbonate is obtained mainly from grinding calcite, the mineral that forms all limestones and marbles in the world, which due to its low hardness allows for a "mild abrasion". Silica may be present in the form of micas. These are part of the largest class of mineral constituents of rocks, silicates, and allow shimmer to be added to the paste. In fact, micas are so important that they are used in soap, make-up, creams and almost all products made by the cosmetic industry.

When cooking food, the most obvious geological resource is natural gas, extracted from the subsurface using complex resource-consuming techniques and infrastructures. A glass ceramic hob for example is made from a mixture of lithium - present in igneous rocks called pegmatites, of which Portugal currently has the largest resource estimates in Europe - silicon - extracted mainly from sands and quartzite rocks - and aluminium oxides, under which there is a copper coil, a metallic mineral usually extracted mainly from chalcopyrite ores such as those mined at the Neves-Corvo Mine also in Portugal.

Regardless of the mean of transportation used, they are all built with a multitude of metals, and powered by fuel or electricity. The first is obtained by refining oil, extracted from reservoirs in various geological environments, and the latter needs batteries in which elements such as lithium, nickel, aluminium, manganese, copper, graphite, and cobalt are present. The electrical energy to move these vehicles is most likely produced by burning coal, gas or, more recently from renewable sources. These too involve the exploitation of geological resources.

Solar panels are made almost entirely of pure silicon. They are manufactured by processing quartz sands or pure quartz to extract silicon, which is subsequently treated with phosphorus or boron - becoming a semiconductor - to which a layer of titanium dioxide is applied. All of these elements are of course extracted from minerals.

Wind turbines are made of metal alloys and their blades are made of plastic reinforced by fiber-glass, which is made using silica-rich sands, kaolinitic clays (similar to those used in porcelain), fluorite and other minerals.

From the examples above it becomes clear that all objects without exception, are made from finite natural resources. In fact, and according to the UN, the material footprint (MF) per capita in the EU (the quantity of raw materials required to meet the consumption) is around 25 tonnes, one of the largest in the world. Despite this, most of the public is not aware of the extent to which they are directly connected to geological resources. Most of this dissonance is related to misconceptions about the subsurface and on the aforementioned social distance between production and consuming locations.

Several studies have evaluated the public perceptions of subsurface hydrology (Gibson et al., 2016), unconventional hydrocarbon extraction (Williams, 2014); nuclear waste storage (Corner et al., 2011); carbon capture and storage (CCS) (Oltra et al., 2010) and geothermal drilling (Dowd et al., 2011) and found that laymen have a very different conception of the subsurface when compared to that of the geological community. They also found that most peole consider that geological interventions below ground might be causing damage to the subsurface which they perceive as a pristine region they'd wish to remain 'naturally untouched' or not 'unnaturally disturbed' (Stewart & Lewis, 2017).

This panorama poses a clear problem: how can the public make informed decisions - which impact on their safety, economic independence, jobs creation amongst other issues - on the several geo-related issues (water management, resource extraction, CCS, energy etc.) if they do not understand how deeply connected to the geosphere their lives are? Also, how can we as a society evolve towards a more sustainable way of life, where resources are consumed sparsely, if the majority of citizens is not aware on the raw material cost of their consumption habits?

It becomes clear that in order to achieve the most desired sustainability an effective investment in education for the geosciences is needed.

2 CLARITY AND TRANSPARENCY IN MEDIA DISSEMINATION (REGULATED SCIENCE COMMUNICATION) TO WELL-INFORM CITIZENS

As mentioned, it is imperative that citizens become aware of the importance of geosciences, particularly resource exploitation, play in their collective life. In order to achieve this, several communication levels need to be considered.

The first is related to corporate communication. When compared to other major industries, such as the pharmaceutical or the health industry, the georesources industry, particularly the mining industry, does not communicate as effectively, suffering from a negative public perception.

It is undeniable that this negative image is in part related to several misconducts which have led to serious environmental and social damages in different parts of the globe, including Europe where today the regulatory framework is tight. However, it is also related to the poor geosciences education of the general public and with the factors pointed out in the previous section. In fact, the European Commission considers that the most important barrier for the development of mining projects in Europe is not related to technology or access to funding but related to the negative public opinion that might block these projects.
The consequences of this negative perception, fed in part by fears based on the way the industry performed in the beginning of the 20th century, can have serious economic impact on companies looking to operate in a certain region. This is particularly true for Small and Mid-Sized Enterprises which, although cheaper to manage in terms of operational costs, are often pressured to present results in shorter timeframes. It is therefore of paramount importance that companies exert proactivity in communicating objectives, methods, risks and potential benefits of their operations. This should be done early in the exploration phase by experts from both the communication and the technical realms.

The second level is related to the media and their crucial role in transmitting information to wider audiences. In this sense, and although it has never been so easy to obtain information as it is nowadays, both science and the media are going through a crisis of trust and constant discredit. The fact that a lot of the information is scattered, confusing and often wrong only contributes to this.

Research from the Reuters Institute for the Study of Journalism found that "47% of people say they go directly to the websites of broadcasters or newspapers for their news, but online, people increasingly find news via the various search (20%) and social media (25%) services offered by US-based platform companies like Google and Facebook." The role of social media is particularly relevant as this is a source of unregulated and uncontrolled information where fake news and pseudo-science are commonplace. A survey conducted by the Pew Research Centre in association with the John S. and James L. Knight Foundation, found that the majority of U.S. adults - 62% - get news on social media, and 18% do so often. These numbers clearly demonstrate the importance of investing in science communication through both traditional and social media.

The third level is related to the domain of science communication itself. Although, as demonstrated above, exploitation of georesources is highly dependent on stakeholders approval and a positive public perception, which in its turn is highly influenced by the way communication is conducted, most geosciences university degrees do not have modules related to science communication. As a consequence, very few (if any) geoscientists are amongst the most popular scientists in the world and geosciences are often associated with the "dirty industries responsible for climate change and planetary degradation". In the long term the effect of this lack of an effective geosciences communication strategy will have a serious negative impact over the georesources industry, increasing upfront costs to obtain the social license to operate and even leading to the failure of new projects.

3 THE RELEVANCE OF WELL-INFORMED CONSENT FROM THE CITIZENS TO USE THE SITE FOR MINING

Apart from the legal and regulatory framework companies have to comply with in order to operate a legitimate business, there is another type of "license" that is becoming more and more important. It is called Social Licence to Operate, or SLO. To put it simply it refers to the level of acceptance or approval granted to a company by various stakeholders, particularly local communities, who may be affected by the company's activities. It is considered to have evolved from the broader notions of "corporate social responsibility" and its first uses were in reference to the mining and extractive industries in the 1990s.
SLO is an abstract concept as it is related to an intangible license, not granted by means of a document, but by a tacit contract made with the stakeholders, primarily local, who legitimize, accept and allow a certain company to operate in their region.

The SLO is made up of three components: legitimacy, credibility, and trust (Ethics Centre, 2018) which cannot work individually but need to be conquered as a whole.

Legitimacy: the extent to which an individual or organisation abides with the norms of the community, be they legal, social, cultural, formal or informal in nature.

Credibility: the individual or company's capacity to provide true and clear information to the community and fulfil any commitments made.

Trust: the willingness to be vulnerable to the actions of another. It is a very high quality of relationship and takes time and effort to create.

Other related factors such as transparency, accountability, clarity about benefits, remedies and adequate due diligence also play a very important role. Amongst them is one that is becoming more and more important: consent. It is now clear, particularly from the examples related to mining exploration activities in several European countries, that without consent of local stakeholders, companies' activities will be severely hindered, potentially leading to economic losses.

Morrison (2014) points out that the social licence can never be self-awarded. Instead he considers that for the SLO to be obtained, the organisation should gain sufficient trust and legitimacy within the community so that it obtains its consent. He also argues that business themselves cannot be the entities that determine the prevention or mitigation measures they should engage in order to mitigate environmental or social risks. Even when the procedures and actions are clearly determined by law, the stakeholders and rights-holders have to be involved in order for the process to be legitimate.

Due to its characteristics, intimately related to public perception and to a certain extent, collective emotions, it is much easier to lose an SLO if one of the three essential components aforementioned is lost. In fact, there are many examples of where the social license has been lost. These range from oil & gas operations in the Niger Delta or the Gulf of Mexico, mining operations in Brazil, nuclear power plants in Europe amongst others.

In sum, obtaining an SLO is a continuous process of negotiation, where it is essential that the organisation looking to obtain it, is aware of the potential socio-environmental impacts (positive and/or negative) of its operations and engages in an open dialogue with the several stakeholders in order to build relationships based on trust, mutual respect and understanding.

Communication with stakeholders should not only be a way to obtain the SLO. It should also be an educational process aiming to change future generation's perceptions on geosciences and the extractive industry.

When approaching the community and other stakeholder's during the development of a mining project, the most common identified mistakes are:

- Underestimating the importance of communication during the early stages of a project (exploration) leading to a delayed engagement with the stakeholders
- Lack of a communication plan
- Lack of staff training and awareness to the communication strategies
- Use of evasive strategies to communicate
- Unclear speech
- Lack of information at the moment of engagement
- Use legal arguments instead of diplomacy
- Condescending approach and the assumption that the stakeholders will not understand the basic scientific concepts.

When analysing the stakeholders position relative to the companies proposals, the most common challenges - which may be enlarged by simple mistakes or failure to implement the best practices - are:

- Stakeholders demanding to be informed since early stages on every step of the project and how will the areas be affected. Although legitimate, this can be a challenge if the company cannot provide a full plan at a very early stage, a common situation particularly in frontier areas.

- Stakeholders focusing mainly on the negative impacts of the project but without factual understanding of the level of risk. This is a common situation particularly if there are small but active groups against the project which can lead to a generalized negative opinion.

- Lack of understanding of the different phases and technical details of a project. As an example, confusion between exploration and exploitation phases, their methods and impacts, are common.

- Lack of adequate media coverage. Due to the lack of expertise in scientific and technical issues in the media outlets, it is common for media coverage on georesources themes to be inadequate. It is common for the approach to be made from an environmentalist point of view without adequately addressing, for example, the differences between "hazard" and "risk" or the particularities of different geological contexts (e.g.: mining of massive sulphides does not carry the same risk for water contamination has mining for lithium pegmatites).

These challenges, that cannot be ignored by the operating companies, can be aggravated if, as previously mentioned, the communication strategy is not adequately structured and if the companies cannot provide information validated under international standards or failed with commitments or statements. However, it is possible to minimize communication risks and improve social acceptance, by using very simple principles:

- EDUCATE - Transmit the message without confrontation, using adequate communication techniques and experienced staff.

- INCLUDE - Always include the stakeholders in the several stages of a project, explaining all facts with clarity and in a language that laymen can understand. The fact that some data needs to remain confidential should be a matter of special attention in order to avoid the perception that companies are hiding information.

- FOLLOW - Create a communication model with follow-up tools, to measure and assess stakeholder's acceptance.

- UNDERSTAND - Before addressing negative opinions and statements, companies and regulatory entities should try to look at the challenges from the stakeholder's position. This creates empathy and promotes impartiality.

Stakeholder's management is not always a field of technical expertise and depends a lot on personal ability to communicate. For that reason, training is the most effective tool to help the technical teams and management to better communicate.

4 SOCIAL RESPONSIBILITY BEFORE, DURING AND AFTER A MINING PROCESS

Mining should be thought as an integrated project that includes many different phases:
Exploration: any new project should deploy an integrated programme of non-invasive innovative remote sensing (ex. Satellite and airborne LiDAR), geophysical exploration (ex. georadar methods), and 3D modelling technologies to reduce explorations costs, increase the chances of discovery, identify potential deposits and extensions of known mineralisations under cover. This

strategy will increase investors' confidence in project viability and reduce environmental impacts.
Exploitation: through optimised workflows a new project should examine the role that a mobile and centralised ore processing can play in capital cost reduction. Novel ways for optimising extraction techniques such as using 3D high resolution X-Ray imaging of ore, should be considered.

Remediation: it should start during the exploration phase, effectively increase during exploitation, and should be intense when mines close. If needed, remediation should continue after closure to ensure that the areas affected by mining activities are, as much as possible, returned to their initial state.

It should also be thought of in the most sustainable way possible.

Sustainability: A key part of any mining operation is the environmental sustainability of the operation from exploration to exploitation and remediation. As an example, landscape remediation should use state of the art test mine facilities in order to find the best solutions to minimize environmental impacts and technological solutions for mining of small and complex mineral deposits, including dealing with mine waste and the rehabilitation of former mining sites. Thus, it particularly addresses the challenges of industrial viability and environmental impacts.

In addition, the exploitation of indigenous resources significantly contributes to environmental sustainability of mining projects as the impacts can be monitored throughout the mining lifecycle. This can be used to provide end-users with environmental traceability of the raw materials used in their consumer products.

According to GTK (Geological Survey of Finland), mining operations impact the natural environment, economy and social structure of the region where they occur. The goal of sustainable mining is to minimise the adverse environmental and social impacts in all stages of the operations. At the same time, the operations strive to maximise social and local benefits.

Minimising the adverse environmental impacts requires developing and testing better control and measurement methods that take into consideration the special characteristics of mining operations and the local natural conditions. Maximising the societal, economic, social and cultural impacts in a sustainable way requires research, communication and methods that allow broad-based community participation. Participation is especially important on the regional level, because that way the corporate social responsibility of the mines can be executed locally in the best possible way.

This will enable Small and Medium-Sized Enterprises (SMEs) to engage with stakeholders and prepare sustainable post-closure plans to maximize the benefits to local communities. The socioeconomic studies assess the community perceptions regarding mineral exploitation and enhance a sustainable development after closure.

5 REQUIRED GEOETHICAL PROCEDURES IN THE MINING SITE

For Arvanitidis et al. (2017) responsible mining concerns the principles and ethics of sustainable development applied to the exploration, exploitation and use of economic mineral resources. In this concept the entire value chain -from initial studies, exploration, extraction, to processing, refining, waste management, mine closure and rehabilitation - is included.
Responsible mining is about actual commitment to managing the economic, social and environmental challenges related to mineral resources development and building a system capable of ensuring/promoting responsible extraction of minerals while developing a proper alignment of the corresponding benefits at local, regional, national and global scales. It relates to building trusting and transparent relationships with society, particularly with the stakeholders directly affected by the exploitation activities. This allows a fruitful involvement of local communities and government authorities in the creation of sustainable benefit for all parties. It is a way to minimize and mitigate environmental impacts related to water, biodiversity and land.

In fact, new mining needs to be highly innovative in bringing together all aspects of the mining life-cycle, from exploration, and processing, environmental management and remediation, to socio-economic aspects. This was rarely done in the past, particularly by SMEs. However, linking these several aspects is essential for a joined-up approach to resource exploitation in the 21st century.

Results of H2020 projects like FAME (https://cordis.europa.eu/project/id/641650), IMPACT or INTRAW (https://cordis.europa.eu/project/id/642130) will be very important to SMEs, allowing them to explore and identify new ore reserves, develop and enhance their mining facilities, helping them to foster programs focused also on small mining, increasing their business competitiveness and sustainability.

Any geoethical code applied to a mine site (or exploration area) should be applicable to the entire organization, locations, partners, employees and suppliers. Main ethical principles drive from the respect for the Law and its enforcement, for conventions and for the use of Cautionary Principles in all actions that may cause public or environmental damage. Constant stakeholder consultation and focus on continuous improvement needs also to be taken into account

The application of the geoethical code should translate into procedures that converge into a comprehensive Code of Conduct, which can be provided to anyone involved, and that defines detailed guidelines covering:

Innovation - where everyone is incentivized to appreciate and share new ideas and creative solutions; to question what is done and why; seek ways for improvement; and to consider error as an opportunity; to be aware and follow the market development in order to anticipate actions; and to develop personal skills in order to ensure high performance;

Team spirit - promoting cooperation as a means to continually improve as a group, encouraging enthusiasm sharing of skills and knowledge; being receptive to new ideas and accept feedback from others in the work place, actively listen and participate with others in a constructive and genuine manner;

Honesty - Treating people equally at all times, being consistent between actions and words, seeking win-win situations at all times, developing a culture of trust and responsibility in carrying out the functions and relationships with others;

Focus on results - Rising to challenges and feel supported to overcome obstacles to achieve ambitious goals, proactively plan, analyse, anticipate obstacles, propose and implement corrective actions, participate and promote the cooperation of everyone in search for new solutions that exceed the expectations of "stakeholders", ensuring results are obtained legally, ethically and with the highest quality.

It is also paramount that all entities involved establish the attitudes and commitments that have to be respected and improved along the value chain with regards to:

Child Labour -Companies should be active in not allowing any kind of child labour throughout the value chain. Per definition "child" is any person under 15 years old (or 14, as applicable local laws), below the age of completion of compulsory schooling or under the age for employment in the country concerned.

Forced and Compulsory Labour - Assure the contractors and suppliers do not employ forced or compulsory labour or work in degrading conditions.

Health and Safety - Assure that all applicable requirements for health, safety and the environment, are complied with throughout the whole chain of supply.

Freedom of Association & Right to Collective Bargaining - Assure that through the supply chain all the parties involved recognize and respect the rights of workers and the exercise of legal rights of free association. Suppliers must also respect the legal right of workers to collective bargaining; Discrimination - all the parties involved along the supply chain must ensure that hiring, salary, benefits, advancement, termination and retirement are based on ability and not on beliefs or any other personal characteristic.

Disciplinary Practices - all the parties involved along the supply chain must treat all employees with dignity and respect. A workplace free of harsh and inhumane treatment, harassment or sexual abuse, physical punishment or torture, physical coercion or verbal abuse and any threat of such treatments should be ensured;

Work schedule - all the parties involved along the supply chain must comply with applicable laws on working hours and public holidays at the place where they perform the activity. The regular working week, not including overtime, shall be as defined by law, and should not exceed 48 hours. All work in extraordinary hours must be voluntary, except in extraordinary circumstances if voluntarily agreed and / or through collective bargaining. These situations should not exceed 12 hours per week.

Remuneration - workers should be paid at least the minimum wage required by law and all legal benefits should be respected. In the event of overtime employees should be paid at the overtime rates that are legally required, or, in countries where such legislation does not exist, at least the equivalent rate to their normal hourly wage.

Management Systems - the contractors should favour suppliers that maintain management systems that integrate the requirements of this Code of Conduct for Suppliers and to ensure compliance with applicable laws and continuous improvement.

Any requirements of A Code of Conduct are minimum requirements. Therefore revision and adoption of new measures to ensure high standards and transparent operations are key to success.

6 REGULATION AND STANDARDS OPERATION PROCEDURES INTERNATIONALLY RECOGNIZED IN MINING

Almeida et al. (2014) refers that there are two internationally recognised systems for classification and reporting of reserves and resources of solid minerals: the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) group, and the United Nations Framework Classification (UNFC). Despite a common perception that these are in competition, they are in fact closely linked and address different sets of requirements. The CRIRSCO standards, which include PERC (Pan European Reserves and Resources Reporting Committee), JORC (Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves), and the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) standard among others, were developed for public reporting by companies listed on stock exchanges, to provide a consistent terminology as well as quality assurance in company estimates of mineral resources and reserves. The underlying objective is protection of the public (in this case investors) by ensuring that the reports produced use consistent terminology and core content so that they can be understood, and that those who prepare public disclosure reports are competent to do so and are prepared to take personal responsibility for their own work.

These Best Practice Guidelines for Mineral Processing (BPGMP) supplement the CIM Exploration Best Practices Guidelines and the CIM Estimation of Mineral Resources and Mineral Reserves Best Practice Guidelines (2003), which are referenced in NI 43-101 and recognized internationally. The BPGMP provides guidance specifically for those Qualified Persons (QP) using mineral process information when preparing mineral resource and mineral reserves and preparing supporting documentation under NI 43-101.

7 HEALTHY AND SAFETY IN WORKABLE MINING AREAS

In most of the present active mining sites in Europe, the health and safety best practices set very high standards, goals and levels of awareness. These are defined in a way so that all operations become dependent on the achievement of maximum levels of safety to all workers and environment. To achieve such high levels of safety, training, formal application of technical procedures and internal communication are essential.

On Exploration activities, standards are often bellow desired, and major companies are raising the levels on less advanced projects. Demand for new materials and big market changes are taking the companies to work around mine sites and mining installations. These include mining works comprising of shafts, galleries and open pits. By-products from the mines are also common features and may include waste and ore piles and tailings ponds. Depending on the age of the mine infrastructure such as old buildings and old machinery may exist.

With time, in future inactive areas of mining operations Nature will begin the process of reclaiming these sites deteriorating buildings making them unsafe to enter or work near them. The weather will corrode metallic objects making them dangerous and a potential source of life-threatening infection. Vegetation will obscure potentially dangerous objects and areas such as old shafts.

With time pit walls, waste pile slopes and underground workings become unstable increasing the risk of collapse and great care should be taken entering underground workings and being in proximity of pit walls.

The risk is greater still when entering underground workings and extreme caution should be taken and safety equipment should be worn at all times. It is not recommendable to enter underground workings alone and someone must remain outside of the mine to raise the alarm should an incident occur inside.

The presence of water can also obscure shafts and produce areas that are dangerous underfoot. Water is often becoming toxic and acidified on mines through manmade and natural processes and therefore care should be taken when coming in contact with aqueous liquids.

Wild animals frequently abode old mines, these include insects such as wasps, rats and vermin may also be common which spread disease and be aware of wild dogs and wild pigs that may attack if provoked or are injured.

8 CONCLUSION

Refusal of this Industry in "Our Own Backyard" will maintain poor practices in Countries of Lower GDP, promoting the Human Slavery, the use of Underage (children) workers in the Mining operations.
And the realization that High GDP Countries that are Mining Friendly (such as Finland, Norway, Canada, US, UK and Australia) have invested in solid laws and regulations that protect the Geological Resources and the Environment at the same level. These Countries have seen their economy to grow and be able to sustain World Wide Economic Crisis, and at the same time becoming less dependent on resources that come from high risk and conflict regions of the World. Other like France and Germany have decided to base all its production in Geological Resources from these low GPD Countries. Portugal, Spain and UK are in a transition stage and have to make that Political decision in a very short break time.
It is capital to change the way that Geological Resources Industry is seen by the Society and it is necessary to educate and inform people at different levels about the Industry and the Processes, so they can take informed decisions rather than supported in fundamentalists propaganda.

It must be clear that Geological Resources Industry is changing but it is nonsense to think that it can be done in one day, but that is good to have ambitious goals. Assume once and for all that Geological Resources are finite and that we all must work to find ways to reuse and recycle to be able to keep up with the growing and demanding population, without even think that it is possible to ban it.Informed Society make better judgments and supported decisions, lets promote the HOW instead of the NO!

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Chapter 7

Geoethics and water management

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CHAPTER 7. GEOETHICS AND WATER MANAGEMENT

SUMMARY

The two educational resources "*Water: A geoethical perspective on one of humanities most valuable resource*" and "*Geoethical aspects of hydropower plants*" were developed to be used in Higher education of geosciences and cover essential areas of water management. They follow the Case-Based-Learning methodology to teach students about ethical issues and dilemmas arising within selected fields of water management and provide a toolset to face these challenges. In this contribution we present specific knowledge as the bacis for further engagement with the theoretical framework of geoethics related to water management. As an example of numerous conflicts and dilemmas, the interlinkages between the specific targets of the United Nation's Sustainable Development Goals (SDGs) are discussed. Special issues related to water management discussed are: 1) the relationship between land-use, water management and climate and the interests of different sectors in water use; 2) effects of hydropower production on riverine ecosystems; and 3) the concept of water footprint to facilitate the discussion on personal consumption, global markets and the value of public awareness.

1 INTRODUCTION

This chapter introduces basics of the topic water management such as required for the GOAL Educational Resources "*Water: a geoethical perspective on one of humanities most valuable resource*" and "*Geoethical aspects of hydropower plants*", respectively.
Water is not in a static condition, there is no starting or ending point for the water cycle, occurring a continuous and dynamic exchange between the Earth spheres (UNESCO, 2011). The water cycle connects lithosphere, atmosphere, biosphere and hydrosphere which built the basis for all life on this planet and also represent the limited resources upon which humankind is developing. Due to this connecting nature and the limitation of natural resources, the field of water management is subject to a wide range of stresses. A lot of these stresses result in ethical challenges and dilemmas. The United Nation's Sustainable Development Goals (SDGs) represent humankinds plan to provide a good life for all people now and for future generations. As a basis for the understanding of potential geoethical conflicts and dilemmas related to water management, we discuss potential interactions based on the SDGs. Issues related to SDG 6 (Safe water and sanitation services) have numerous impacts on the other SDGs.
After creating this basic understanding, we discuss conflicts and dilemmas for three specific water management issues.

1. Competing interests of different stakeholders concerning water and land-use management are particularly big drivers of conflicts. Additionally, this part describes also the implications of their connections to the climate.
2. The production of renewable energy (including hydropower) is connected to many other SDGs and of importance for future development against the background of global warming due to greenhouse gas emissions. Hydropower plants and especially dams also have significant effects on the aquatic ecosystems of the rivers.
3. The personal daily behaviour of the individuals influences the water and energy consumption of the whole society. The concept of water footprint is presented as an analysis tool as well as an instrument to educate the public, for example by raising awareness for urgent issues connecting consumption and water management.

2 INTERLINKAGES AND INTERDEPENDENCIESS OF THE SUSTAINABLE DEVELOPMENT GOALS

The UN SDGs have set the 2030 agenda to transform our world by tackling multiple challenges humankind is facing to ensure well-being, economic prosperity, and environmental protection (UN, 2015a,b). Sustainable development is based on the indivisibility of economic prosperity, environmental sustainability, social progress, and effective democratic governance. In contrast to conventional development agendas focusing on a restricted set of dimensions, the SDGs provide a holistic and multidimensional view on development. Hence, interactions among the SDGs may cause diverging results.

Pradhan et al. (2017) analysed synergies and trade-offs within SDGs and between SDGs. According to their definition, obstacles are, if progress in one indicator has been connected in the past and the present with an obstacle in fulfilment of another and vice versa.

Within each SDG, synergies largely outweigh trade-offs. Particularly, SDGs 1 (No poverty), 3 (Good health and well-being), 4 (Quality education), 10 (Reduced inequalities), 12 (Responsible consumption and production), and 13 (Climate action) show large synergies. Highest number of negative correlations within the same goal are observed within SDGs 7 (Affordable and clean energy), 8 (Decent work and economic growth), 9 (Industry, innovation, and infrastructure), and 15 (Life on land). One example for this is that the sustainable development logic of SDG 8 calls for sustaining economic growth while improving resource use efficiency by reduction of material footprints.

For synergies between SDGs, a noticeable example is SDG 1 (No poverty) that is associated with synergies across most SDGs. Also for SDGs 3 (Good health and well-being), large fraction of synergies with various SDGs are also observed. Observed positive correlations between the SDGs have mainly two explanations. Firstly, indicators of the SDGs depicting higher synergies consist of development indicators that are part of the MDGs and components of several development indices. Secondly, the observed higher synergies among some SDGs are an effect of having the same indicator for multiple SDGs. The analysis of Pradhan et al. (2017) reveals the SDGs 8 (Decent work and economic growth), 9 (Industry, innovation, and infrastructure), 12 (Responsible consumption and production), and 15 (Life on land) to be associated with a high fraction of trade-offs across SDGs. These goals are thus currently in conflict with most other SDGs, antagonizing sustainable development. An example for this is that on average developed countries provide better human welfare but are locked-in to larger environmental and material footprints which need to be substantially reduced to achieve SDG 12.

For SDG 6 *(Ensure availability and sustainable management of water and sanitation for all)*, Pradhan et al. (2017) reported highest synergies with SDGs 1 (No poverty) and 3 (Good health and well-being). About 2.7 billion people (year 2015) live in countries in which SDG 3 has substantial synergies with SDG 6. Highest trade-offs were reported with SDG 12 (Responsible consumption and production).

Requejo-Castro et al. (2020) focussed on interactions of SDG 6 indicators and identified "First-order" (direct) linkages and "Second-order" (indirect) relationships between SDG 6 indicators and indicators from other SDGs (Fig. 1). Direct interlinkages are identified in relation to SDGs 3 (Good health and well-being), 5 (Gender equality), 7 (Affordable and clean energy), 8 (Decent work and economic growth), 10 (Reduced Inequalities), 11 (Sustainable cities and consumption), 12 (Responsible consumption and production), and 15 (Life on land). When considering "second-order" (indirect) links, identified interdependencies also includes SDG 1 (No poverty), 2 (2), 9 (Industry, innovation, and infrastructure), 14 (Life below water), and 16 (Peace, justice and strong institutions).

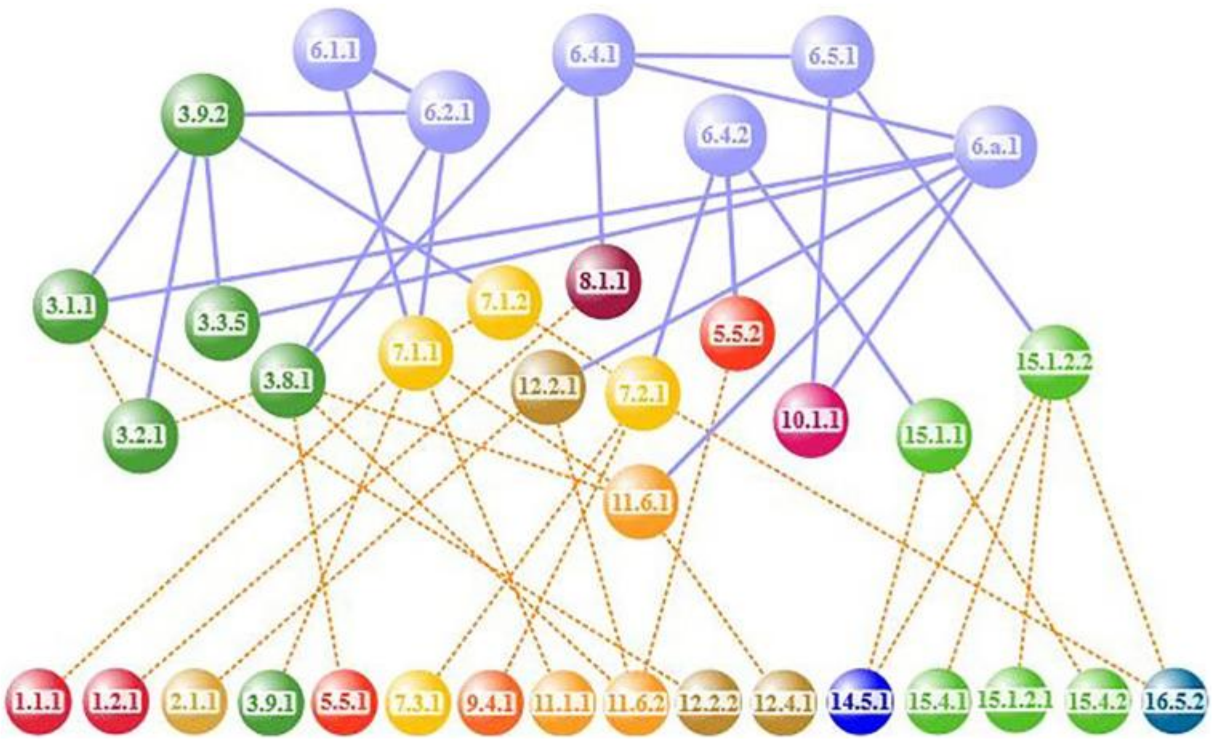

Figure 1. Identified SDG 6 related interlinkages. "First-order" (direct) linkages are represented by solid blue lines. "Second-order" (indirect) relationships are indicated by dotted orange lines (Retrieved from: Requejo-Castro et al., 2020)

Additionally, synergies and trade-offs for SDG 6 related to specific aspects are described in e.g. Kurian et al. (2019) and Faber et al. (2018) for the Water-Energy-Food Nexus, Jaramillo et al. (2019) with focus on wetlands, Vanham et al. (2018) with focus on water stress, Alcamo (2018) and Flörke et al. (2018) on water quality, Sørup et al. (2020) on urban water management, and Vörösmarty et al. (2020) on ecosystem-based water security.

3 RELATION OF WATER RESOURCES, LAND USE AND CLIMATE

Kaushal (et al. 2017, and all references there in) give a global overview on the state of knowledge on the interaction and close relationships between land use, the climate and water resources. The following largely represents an overview of this publication.

On a global scale, freshwater resources are decreasing in many arid and semi-arid areas, due to the overexploitation of groundwater. But, also water stored as ice has decreased due to changes in temperature and precipitation. The global trend of intensified irrigation also results in groundwater extraction or dam constructions on surface waters. The result of these and more observations has been referred to as the emerging Global Water Crisis (Manzoor, 2011).

Land use defines to a high degree how climate (and changes within it) interact with the quality and quantity of water on landmasses. The actions of human civilisation affect hydrological processes and therefore also influence the water cycle itself. These processes include the alteration of rainfall regimes via modification of urban areas, or the influences on evapotranspiration due to irrigation in agriculture. The compaction of soils results in sealing of soils and increases impermeable surfaces influence infiltration patterns and increase runoff as well as overland flow. The changes in precipitation distributions and the reduction of melting from snow covers also affect groundwater recharge. Groundwater storage on the other hand is further stressed due to abstraction.

These changes in hydrological processes further influence the structure and therefore also functions of aquatic ecosystems, which in return alter the associated services that are connected to the vulnerability to climate. In other words, the resiliency and resistance against climate change that ecosystems can provide for water management to a certain extent have been reduced significantly due to changes in land use. This has also contributed to the global water crisis.

Four stages along the alteration of aquatic ecosystems can be defined as shown in Fig. 2.

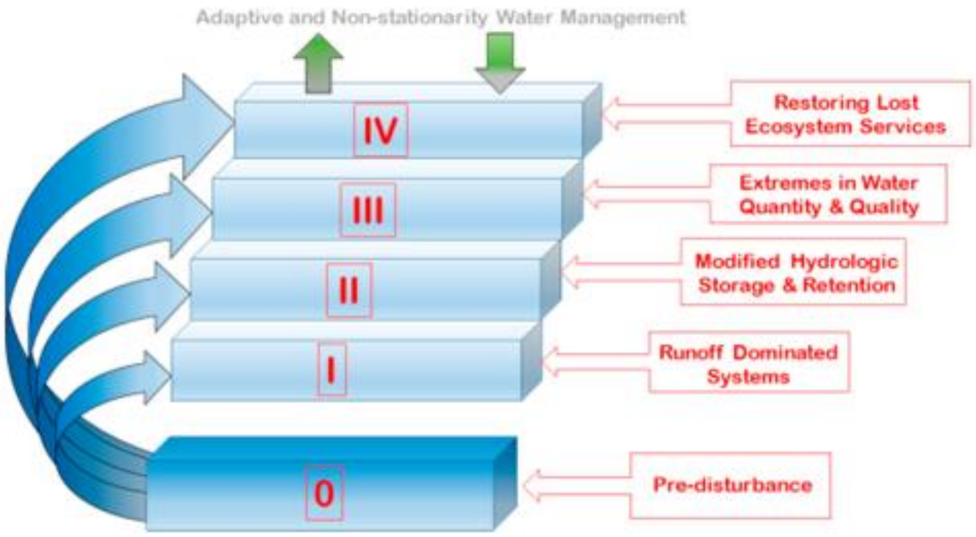

Figure 2. Conceptual model of interactive stages of land use and climate change on water resources (Retrieved from: Kaushal et al. 2017)

In stage 1 hydrological modifications and built environment establish a runoff dominance within the aquatic system and amplify water losses therein. The influences of vegetation on runoff might be complex and differ according to their species and regionally. In general, a decline in vegetation density results in increased runoff. Agriculture and the continuous processing of land for crop production often result in stronger erosion and compaction of soils and also decreases the infiltration capacity of water. This results in a lower groundwater recharge and simultaneously in higher runoff. Urbanisation in combination with the protection of this areas against floods (higher runoff) lead to channelization of headwaters and effect the structure and function of river networks which also affects water quality especially on the issues of nutrients (nitrogen and phosphorus) but also e.g. calcium, silicon of sulphate.

In stage 2 the losses in water storage and ecosystem retention reduce the capacity of ecosystems to buffer extremes in water quantity and quality. The loss of freshwater storage has many different reasons. Decrease in storage via ecosystem retention is connected to deforestation, compaction or sealing of soils. Storage in groundwater is also affected by these processes since infiltration is reduced. It is additionally stressed by increasing withdrawal which can be connected to increased urbanization or agricultural use. A lot of surface water is stored via dams since the beginning of the 20th century. This facilitated high agricultural production but also effected water flows and quality.

Stage 3 describes the situation, when extremes in water quantity and/or quality lead to local losses in ecosystem services and regional water security. For example, the amount as well as the variability of precipitation might decrease within a catchment area due to climate change and result in extremes in water quantity and also quality which further results in a reduced regional water security.

Stage 4 defines the stage, when water management and restoration strategies aim to regain losses in ecosystem structure, function and services. Conservation approaches and stormwater management are appropriate strategies to reduce the nutrient export, manage hydraulic residence times and connectivity. Due to the complexity of interactions, actions in watershed management and ecosystem restoration might hold trade-offs or result in unintended consequences. For example, the intended reduction in Nitrogen due to stormwater management might also result in the release of phosphorus from sediments.

The observation and investigation of the development of the global water crisis is a key element to tackle these problems. It can help to diagnose a global syndrome impairing water quantity and quality and to inform on the realistic management and ecosystem restoration by

- evaluating the severity of impairments across stages,
- anticipating and/or predicting water quantity and quality over time,
- improving and informing on the monitoring of water quality and quantity,
- identifying and detecting stability, resistance and resilience of water resources over time, and
- selecting appropriate infrastructure management and/or ecosystem restoration interventions.

Major challenges for future water management are on the one hand the two quantitative issues water scarcity as well as excess of water (e.g. storm water runoff). On the other hand, qualitative issues like the access to clean drinking water will become more urgent challenges. All of these are superimposed by the changes in distribution of weather and climate conditions as for example more frequent extremes in precipitation or temperature. Furthermore, the water ethics topic is being increasingly discussed in policies and practices of water resource management (UNESCO, 2011).

To provide realistic strategies to regain losses in structure, function and services of ecosystems and to mitigate the effects it is necessary to take the path of degradation of water systems into account. Water management will not be static in the future, but has to facilitate dynamic processes based on adaptive management. Research suggests that *conservation of natural lands is critical to slow down and/or reverse the interactive effects of land use and climate on water resources*.

4 EFFECTS OF HYDROPOWER PLANTS ON RIVER ECOSYSTEMS

In Europe, larger environmental changes of aquatic ecosystems occurred already in ancient and medieval times. European colonists spread practices and techniques of river uses to other areas of the industrialized world after they reached regions, which have previously only been influenced by indigenous people. Industrialization had large-scale effects on river uses and their impacts on morphology, hydrology, and aquatic biota. The use of fossil energy enabled intensification of uses with unprecedented ecological consequences. Well into the twentieth century, deteriorating water quality and hydro-morphological degradation were perceived as a necessary evil to foster economic development. Riverine impairment peaked in response to a combination of intensifying factors: increasing resource exploitation and use, a rising density of machinery in industry and private households, intensified agriculture driven by an ever-increasing number of machines, as well as fertilizers and pesticides. (Haidvogel, 2018)

Hydropower is a renewable source of energy that is considered widely as "green" energy. However, the infrastructure required to produce hydropower (e.g. dams) has numerous impacts on the river ecosystem and causes large differences in river ecological functioning. According to Schmutz and Sendzimir (2018), the influences on river ecology comprise the following main aspects:

- *Flow in rivers*

  River flow is understood the fundamental process determining the size, shape, structure, and dynamics of riverine ecosystems. Hydrological regimes are key characteristics of river flow which are strongly linked to habitats and biotic communities. Human activities such as water abstraction (irrigation and hydropower), dams, river channelization and land use result in changes of river flows significantly. An additional change agent for river flows is climate change. Nowadays, hydrological processes forming riverine ecosystems are well understood, and the importance of flow for maintaining the ecological integrity is well perceived. A large number of flow restoration projects have been carried out but research is still necessary to better understand the response of biota and riverine ecosystems. (Zeiringer et al., 2018)

- *General impacts of dams and reservoirs*

  There is no generally accepted descriptive nomenclature of dams. The term “dam” is often applied to both the physical structure retaining the water and the water so retained. We use dam solely to describe the physical structure (e.g., weir), and the term “reservoir” will be used to denote the artificially created water body. This leads to the following definition: “A dam is a barrier to obstruct the flow of water and to create a reservoir.” Reservoirs are built for specific community needs (according to Schmutz and Moog, 2018):

  - Drinking, industrial, and cooling water supply
  - Hydropower generation
  - Agricultural irrigation
  - River regulation and flood control
  - Navigation
  - Recreation and fisheries

  Most of the world’s existing dams have been built after the Second World War as a consequence or a basis of economic development. However, dam construction goes back in human history for more than 5000 years. Today, there are about 6000 existing or planned large hydropower dams (>15 m height) worldwide. The case of Austria is presented as an example: Austria is one of the countries with the highest density of hydropower dams (about 6 dams per 100 km^2). More than 5200 hydropower plants are in operation, whereby 6 % of the plants cover 88 % of total capacity (Table 1). The huge number of small hydropower plants effects a huge number of small rivers in Austria.

Table 1: Number and capacity of hydropower plants in Austria (adapted from Habersack et al., 2011)

Power [MW]	Number of plants [%]	Capacity [%]
≤ 1	84.1	4
> 1 to ≤ 10	9.9	8
> 10 to ≤ 50	4.1	26
> 50 to ≤ 100	0.8	13
> 100 to ≤ 300	0.8	36
> 300	0.3	13

  The main impacts associated with dams and reservoirs can be summarised as follows (Schmutz and Moog, 2018):

  - Interruption of river continuity (longitudinal and lateral, fish migration, sediment and nutrient transport)
  - Siltation of river bed and clogging of interstitial
  - Homogenization of habitats
  - Downstream river bed incision
  - Alteration of river/groundwater exchange
  - Downstream flow and water quality alteration

- *Sediment transport*

  Besides river flow, sediment transport is severely altered by dams. Depending on the morphological river type, sediments can be hydraulically habitat forming or just components of a morphological feature that determines the hydraulic patterns of a river. Aquatic biota (e.g., macroinvertebrates, fish) contain different sediment requirements (e.g., morphological adaption) concerning the sediment quantity and distribution in relation to different life stages. Moreover, different reactions in terms of an increased sediment surplus or sediment deficits by a disturbed sediment regime are given. Thus, studies on processes and consequently an improved process understanding of sediment dynamics on all river scales are among the most important issues for sustainable river management in the future. Based on this improved process understanding, restoration measures have to be adjusted to cope with, e.g., increased fine sediments, which are actually often trapped in reservoirs. Hence, a holistic view of the river systems and of the driving abiotic processes has to be targeted for future management—including responsible actors in the present sediment management like water management authorities as well as hydropower companies (Hauer et al., 2018a, 2018b).

- *Hydropeaking*

  Flow is a major driver of processes shaping physical habitat in streams and a major determinant of biotic composition. Flow fluctuations play an important role in the survival and reproductive potential of aquatic organisms as they have evolved life history strategies primarily in direct response to natural flow regimes. However, although the organisms are generally adapted to natural dynamics in discharge, naturally caused flow fluctuations may entail negative consequences (e.g., stranding, drift, low productivity), especially if the intensity is exceptionally high or the event timing is unusual. Aside from natural dynamics in discharge, artificial flow fluctuations with harmful impacts on aquatic ecology can be induced by human activities. Hydropeaking - the discontinuous release of turbined water due to peaks of energy demand - causes artificial flow fluctuations downstream of reservoirs. High-head storage power plants usually induce flow fluctuations with very high frequencies and intensities compared to other sources of artificial flow fluctuations. However, run-of-the-river power plants and other human activities may also create artificial hydrographs due to turbine regulation, gate manipulations, and pumping stations. Hydropeaking frequently occurs in river systems with high river slopes (e.g. alpine regions). Here, storage hydropower plants use the potential energy in water stored at higher elevations for electricity production on demand, which produces significant alterations of the flow regime downstream (e.g., decreased low flow, hydropeaking). (Greimel et al., 2018)

- *River connectivity*

  For a long time, connectivity conservation focused on interactions and exchanges between terrestrial and, in most cases, homogenous habitat patches. Thereby, rivers have all too often been considered as two-dimensional elements of terrestrial landscapes neglecting their own internal structure and heterogeneity. Although, knowledge and approaches from terrestrial assessments can also be transferred to aquatic ecosystems, rivers exhibit certain characteristics, which should grant them a special position in connectivity conservation (according to Seliger and Zeiringer, 2018):

  - Riverine systems are characterized by their inherent water-mediated connectivity wherein the river itself represents both habitat and migration corridor.
  - Connectivity acts on one temporal and three spatial dimensions: longitudinally from headwaters to confluences and the sea, laterally from the main channel to floodplains and vertically from the river towards the hyporheic interstitial and the groundwater
  - Hydrologic connectivity supports the passive downstream transport of matter and energy but enables a multidimensional dispersal of organisms.
  - While terrestrial connectivity often focuses on interactions of homogenous patches, the connection of different habitats is equally or, in aquatic ecology, maybe even more important, since certain species and life stages require diverse habitat patches to complete their life cycle.

  Fragmentation of rivers due to hydropower regulation is a main reason for the decline and reduced distribution of freshwater fishes. Sustainable hydropower production tries to mitigate these impacts. From a total environment perspective a research and knowledge-based approach could help to avoid or resolve any potential conflicts between hydropower and fish and between the different spheres of the total environment. Important issues as defined by Schleker and Fjeldstad (2019) are:

- Optimization of both hydropower production and fish sustainability requires a balanced approach and collaboration between industry, science, society and water management.
- A shift towards more sustainable river ecology beyond fish, and a changing use of hydropower production facilities requires a systemic research approach, for building up an efficient knowledge basis.
- Research on hydropower and fish is multidisciplinary, and the good solutions can only be achieved when a suite of scientific topics are included.
- Knowledge sharing and comparative analysis of different River Basin Systems is paramount.

Additional aspects related to hydropower for potential conflicts and dilemmas are:

- *Hydropower and People*

  If dams are built, people are directly affected if villages and even cities get flooded by new reservoirs. Kirchherr et al. (2019) report that up to 80 million people have been resettled due to the construction of large dams in the past century (about 1.3 million people have been resettled for the China Three Gorges Dam alone). In their study, they examined resettlement data for 29 large dam projects. Available data on resettlement programs have been found to be not accurate, thus they speak about the "resettlement lies". Accurate data, however, 1) would be needed for those deciding whether to pursue or not to pursue a project that includes resettlement; 2) are essential for project affected communities; and 3) for planning future large dam projects.

- *Socio-environmental conflicts related to dams and hydropower*

  Hess and Fenrich (2017) describe two realms of socio-environmental conflicts:

  - Underlying conflict causes: Unequal access to resources; land use patterns; socio-environmental impacts from interventions or activities; disputes over environmental knowledge.
  - Conflict treatment, handling or management: Governance schemes; participation processes; institutional and informal schemes for conflict management.

  According the Hess and Fenrich (2017), socio-environmental conflicts can be categorised in:

  - Control over the use of natural resources: Usually, conflicts on the use of land or water emerge when the use of one group excludes or downgrades the use of one or more other groups (e.g. large-scale dams threaten the water supply of downstream inhabitants and/or farmers).
  - Environmental and social impacts created by human and natural activity: this includes 1) Environmental contamination (Oil spills, intensive use of pesticides, air or water pollution, waste deposits; Exhaustion of natural resources, loss of biodiversity, exhaustion of groundwater resources, decline of fish population due to industrial fishing); and 2) Degradation of ecosystems, i.e. natural cycles are interrupted or natural phenomena are exacerbated (e.g. decline of fish population due to dams and exacerbation of flood damage due to land use).
  - Use of environmental knowledge: Conflicts on risk perception, on the use of environmental knowledge or on sacred or spiritual sites (e.g. dams affecting indigenous peoples).

5 PERSONAL CONSUMPTION AND PUBLIC AWARENES

The footprint concept: In 1996, the ecological footprint concept was presented (Wackernagel and Rees, 1996). Since then the footprint concept was adapted for carbon, water, land, energy and biodiversity as well as for single elements like nitrogen or phosphorus and many more. Even though the calculations between the different footprints differ, the general concept behind all of them is similar. It aims at presenting an indicator that summarises the pressure (influence) of human behaviours and activities on the environment or on single resources based on a quantitative analysis along the life cycle of a product and also considering the whole supply chain. Depending on the addressee the impact or pressure can be aggregated either for products, individuals or groups of people but also for geographical areas like streets, villages, countries or the whole planet. This flexibility facilitates communication with stakeholders at all scales (Vanham et al. 2019). The water footprint concept is closely linked to the virtual water concept, that is defined as the volume of water required to produce a commodity or service (Hoekstra and Chapagain, 2006).

The water footprint: Traditionally, water management and the assessments of sustainability within water consumption relied solely on the comparison of withdraw (demand) and supply of ground and surface water. To widen the perspective, Hoekstra and Mekonnen (2002) presented the first study on the water footprint (WF) as a multidimensional indicator for fresh water use. It considers the direct as well as the indirect water use. Direct water accounts for fresh water that is directly used at the considered process or product, whereas the indirect water use accounts for water that was used to produce products or materials used in current process or product. Three types of water are differentiated and connected to the source of water. The blue water refers to water that is taken from groundwater or surface water bodies. The green water refers to rainwater and soil moister that neither becomes runoff nor groundwater, since it would account for blue water then. Grey water on the other hand means the amount of water that is necessary to restore given water quality standards in the case of pollution caused by the production process. The aim of the water footprint is to provide a wider perspective on how a certain product, a consumer or groups of consumers are related to the use of freshwater in different places and at different times. It can therefore serve as a basis to further investigate and analyse the severity of this impact on these freshwater systems. This is also based on the vulnerability of this systems to stresses. Furtheron it can function as a reliable basis for the assessment of environmental, social and economic impacts. Another important aim is to provide a solid basis for the discussion on sustainable and equitable water use and allocation. (Hoekstra et al., 2011).

SABMiller and WWF (2009) give the following definition of the three water footprint types:

1. *Green water footprint* is water from precipitation that is stored in the root zone of the soil and evaporated, transpired or incorporated by plants. It is particularly relevant for agricultural, horticultural and forestry products.
2. *Blue water footprint* is water that has been sourced from surface or groundwater resources and is either evaporated, incorporated into a product or taken from one body of water and returned to another, or returned at a different time. Irrigated agriculture, industry and domestic water use can each have a blue water footprint.
3. *Grey water footprint* is the amount of fresh water required to assimilate pollutants to meet specific water quality standards. The grey water footprint considers point-source pollution discharged to a freshwater resource directly through a pipe or indirectly through runoff or leaching from the soil, impervious surfaces, or other diffuse sources.

Water footprint assessment represents the analytical tool consisting of four steps:

1. Setting goals and scope,
2. Water footprint accounting,
3. Water footprint sustainability assessment and
4. Water footprint response formulation.

The WF assessment relates activities and products to water scarcity, pollution and related impacts. It is not intended to tell people "what to do" but rather help them understand what can be done done and support a more conscious choice as consumer. A certain investigation of water footprint assessment can, but hasn't to execute all of the four proposed steps in each case. The first phase ("Setting goals and scope") is also concerned with the definition of the scope of the study (e.g. about a certain product, the consumption of a group of people or the use in a specific area) How many of the four assessment phases will be executed within the study? In the second step ("Water footprint accounting") the collection of data and allocation to different groups is done. Decisions from the previous step also give the level of detail that is applied in this phase. The third step ("Water footprint sustainability assessment") deals with the evaluation of environmental, social and economic perspectives within the investigated topic. The fourth and final step ("Water footprint response formulation") deals with the formulation of response options, strategies or policies (Hoekstra et al., 2011).

Hoekstra and Mekonnen (2012) presented a comprehensive analysis of the WF for the period 1996-2005 on a national level. They report that the global average annual WF of 9087 billion m^3 per year results form 74% of green, 11% of blue and the remaining 15% of grey WF. Concerning sectoral differences, agricultural production accounts for 92%, industrial production for 4.4% and domestic water supply for 3.6% of the total WF. They also report that, on average, about 25% of WF are international virtual water flows. About half of the blue WF is exported from 7 countries and each of them is at least partly under water stress. Consequently, the following questions are raising: Is water management sustainable in these countries? Are improvements of efficiency possible? Is water scarcity reflected by in the water prices? The USA, Brazil, Argentina, India, and Australia are the biggest net virtual water exporters, whereas the biggest net virtual water importers are in North Africa, the Middle East, Mexico, Europe, Japan and South Korea. The category of oil crops (e.g. cotton, soybean, oil palm, sunflower), and products derived from these plants account for the biggest share in virtual water flows (43%), whereof more than half of this is related to the trade of cotton products. Soybean accounts for about 20% of this share. The per capita water consumption of a nation depends on the amount and type of products that are consumed as well as the production conditions at the place of its origin. The authors report values between 550 – 3800 m^3 per year and capita for all countries with a population above 5 million. For developed countries the range spans from 1250 – 2850 m^3 per year and capita. The differences in these countries mainly result from different consumption patterns of water intensive products like for example bovine meat. On the other hand, high water footprints per capita result mainly from low water productivity in developing countries. The share of external WF of a nation is an indicator for that nation's external water dependency. It can vary from 4% up to 60-95%. Many countries in North Africa or the Middle East depend strongly on freshwater in other countries. But also, some countries like the Netherlands or the United Kingdom have strongly externalised their WF even though they don't suffer from water scarcity.

Vanham (2013) compared the WF of different diets. The first alternative represented the dietary recommendations issued by the German nutrition society (DGE) and the second was a vegetarian diet. The author reported a potential reduction of 25% (DGE recommended) or even 37% (vegetarian) of WF from consumption of agricultural products compared to the average diet in the years 1996-2005. Austria, which is proud of being rich of water, also is a net water importer. Similar results can be expected from other industrialised countries.

6 CONCLUSIONS

The UN SDGs are a global framework with aim to ensure well-being, economic prosperity, and environmental protection. The SDGs are indivisible in terms of economic prosperity, environmental sustainability, social progress, and effective democratic governance. Numerous SDG targets cause interactions to other SGD which can result in synergies and trade-offs. SDG 6 (Safe water and sanitation) targets result in a number of synergies but also trade-offs. Achieving SDG 6 targets creates highest synergies with SDGs 1 (No poverty) and 3 (Good health and well-being) and highest trade-offs with SDG 12 (Responsible consumption and production).

Conflicts and dilemmas related to water management are manifold. We discussed tree issues:

1. Different stakeholders have different interests according to water use. This creates a classical type of conflicts and dilemmas that happen mainly between different interest groups (e.g. water use for irrigation and industry via water supply for cities).
2. Hydropower is seen as green energy but the infrastructure required (i.e. dams) has numerous negative impacts on the environment and in particular the riverine ecosystem. However, dams potentially also have negative effects on humans and other socio-environmental impacts.
3. Last but not least, our personal daily behaviour influences the water and energy consumption of the whole society. We present the concept of water footprint (WF) to analyse and create awareness regarding the water issue.

By introducing to conflicts and dilemmas related to water management issues, presented in this chapter, the reader should be able to guide students through the two GOAL Educational Resources "*Water: a geoethical perspective on one of humanities most valuable resource*" and "*Geoethical aspects of hydropower plants*", respectively. These Educational Resources can be used in various courses and lectures. It would be beneficial if students have a basic understanding of the water cycle and the interactions of hydrosphere with lithosphere, atmosphere and biosphere. However, it is also possible to start with the suggested cases and provide further resources to the students to study these cases.

Persons who are highly educated in geosciences and water management are at the heart of humankind's attempts to deal with conflicts and dilemmas raising from technological solutions. They are not only supposed to solve technical problems, but also to understand and communicate their responsibilities. A modern education of professionals in geosciences therefore has to take into account these challenges. Geoethics provides the theoretical background therefore.

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Chapter 8

Geoethics and georisks

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SUMMARY

Georisks are a topic of great interest for geoethics due to their strong impact on society and enormous repercussions on the development of many countries all over the world. Costs of disasters have direct and indirect repercussions on local and global economic situation. Taking an ethical approach in the field of georisks, with particular attention not only to aspects of management, but also to aspects of risk communication and geo-education towards the public is necessary to assure societal safety. Geoscientists have to become more aware of being not only scientists or professionals but also social actors. Their role is to help society to understand the great importance to adopt preventive policies in the defense against georisks to assure people's safety.

1 INTRODUCTION: GEOSCIENTISTS AS SOCIAL ACTORS

Georisks (risks related to natural phenomena or induced by human activities) are of great interest for the geoethical reflection due to their strong impact on society and enormous repercussions on the development of many countries, where the costs of disasters constantly hang over the economic situation. Dealing with georisks from a geoethical perspective means to analyse ethical and social aspects in their management (Wyss & Peppoloni, 2015), in science and risk communication (Stewart, Ickert & Lacassin, 2017) towards different stakeholders (Peppoloni, Di Capua, Bobrowsky & Cronin, 2017), in geosciences education.

Over centuries, disasters have always scared populations, but the proper dissemination of scientific knowledge and an adequate preparedness can help to find strategies for mitigating their effects. Nowadays the scientific and technological progress can assure us a good level of safety. Obviously, the damage due to geo-hazards is not entirely avoidable, but can be greatly reduced through prevention and mitigation efforts, and an effective information and education of society (Di Capua & Peppoloni, 2014).

Geoscientists need to become more aware of being not only scientists or professionals acting in their fields of interest, but also social actors working for the common good (Peppoloni, Bilham & Di Capua, 2019). Geologists, engineers, and in general experts of the Earth system possess the scientific knowledge and preparation to bring science closer to society (Bobrowsky, Cronin, Di Capua, Kieffer & Peppoloni, 2017).

In the field of the disaster risk reduction, geoethics fosters the proper and correct dissemination of the results of scientific studies; develops and promotes geo-educational tools for the population; aims to improve the relationships between the scientific community and the other stakeholders of the society during all the different phases that characterize the disaster cycle (phases of prevention, emergency and recovery) (Di Capua & Peppoloni, 2014).

2 DEFINING RISK

Risk is defined as the symbolic product of hazard, vulnerability and exposure. It is quantified such as the loss produced on an element or group of elements at risk as a consequence of the occurrence of a given phenomenon of a given intensity. The hazard is the probability that a phenomenon of a given intensity occurs in a certain area in a given time interval. The vulnerability is the capability of an element to resist to a given phenomenon. The exposure is the value of the elements at risk (in terms of human lives, economic or historical-artistic values) in a certain area (Di Capua & Peppoloni, 2014).

These factors have been introduced to analyse the impact of natural phenomena on humankind and their effects are quantified using mathematical tools (included the probability calculus and the evaluation of errors and uncertainties).

A disaster can be defined as "*A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources*." (United Nations, 2009, p.9). In Kelman (2019) concepts about disasters are clarified and actions for preventing disasters listed.

Nowadays scientists are able to predict, with some degree of uncertainty, the onset and development over time of some natural phenomena. Moreover, the progress of science is giving new tools to defend people against natural and anthropogenic risks: new methods for the continuous monitoring of phenomena, early warning methods and technologies, efficient building techniques to ensure safety, adequate prevention programs, land management programmes, education campaigns for citizens. All these activities are grouped under the term "prevention" (Peppoloni & Di Capua, 2016; Peppoloni et al., 2019).

At the same time, science doesn't provide absolute certainties. In fact, especially in relation to geo-hazards, elements as uncertainty and probability affect the way in which scientists can manage the risk. For example, for the current level of scientific knowledge, it is impossible to establish at the same time when, where and how strong an earthquake will occur. Nevertheless, this doesn't mean solutions reducing risks and preventing disasters cannot be found.

3 GEOETHICAL VALUES FOR BUILDING A DISASTER RISK REDUCTION STRATEGY

Where a georisk is present, it is essential to assess costs and benefits of developing a risk mitigation strategy also considering a time perspective. In fact, a strategy which today may seem wasteful could be effective in a larger time interval, by evaluating its likely positive outcomes.

Prevention is the best way to protect population from georisks, but unfortunately, with few exceptions, modern societies don't perceive it as a value, and what is worst, politicians don't tend to support and promote prevention activities that will give fruits in the long term.

The duty of geoscientists, as experts of georisks, is to transfer the value of prevention to society, by emphasizing cases of good land management and consequent reduction of disaster potentiality. Prevention has to become the rational and responsible answer to the right of safety of each citizen (Peppoloni & Di Capua, 2016).

Ability, individual and joint responsibility, collaborative attitude, reliability, transparency, solidarity, non-discrimination, and impartiality are fundamental values that allow scientists to develop excellent science, that is the prerequisite in the strategy for an effective disaster risk reduction. But, in order to increase the resilience of a community (i.e. the societal ability to respond to a disaster, by restoring material and spiritual conditions existing before the natural event), scientists have to work so that values such as prevention (intended not only in terms of cost savings, but mainly as a social and cultural attitude that gives its fruits in a short, medium, and long term perspective), safety, sustainability, education take root into society and become a common societal background. Only if geoscientists inform and educate citizens, the defense against georisks can be possible and effective. The proper dissemination of scientific knowledge and an adequate preparedness of population can help to improve the resilience and so to reduce the risk. Geo-education is a tool to shorten the distances between scientists, population and decision-makers, avoiding the loss of confidence in science by citizens, avoiding the cultural and social marginalization of scientists and fostering the development of risk reduction strategies that are really effective and widespread. Not investing in prevention means to transfer irresponsibly the social and economic costs of a disaster on future generations (Di Capua & Peppoloni, 2014).

4 GEORISK REDUCTION AS A SOCIETAL CHALLENGE: ROLES AND RESPONSIBILITIES OF ACTORS INVOLVED

Risk reduction requires an all-of-society engagement and partnership, as clearly indicated in the guiding principles of the Sendai Framework for Disasters Risk Reduction (https://www.unisdr.org/we/coordinate/sendai-framework).

The defense against natural risks involves many actors: not only geoscientists, but also decision makers, local authorities, government agencies, mass media, citizens.

All these actors form a "defence system", that have to act with a common goal and in the same direction, each of them with a specific role, commitment and responsibility in relation to an impending risk. Only the good relationships among them can guarantee a coordinated effort and consequently the efficiency during all the phases related to the disaster cycle. A proper georisks management requires that each role is well-defined and governed by shared operational protocols, especially during the emergency phase, so that overlapping and misunderstanding among different actors don't jeopardize population safety and economic activities.

Geoscientists have the responsibility to conduct an updated and reliable scientific research, which provides a detailed analysis of the epistemic uncertainty for a more effective evaluation of the errors in the prediction models. Scientific models used for studying risk scenarios must be well-grounded on observational data, including clear indications of uncertainties, and discussed within the scientific community. Furthermore, geoscientists have the commitment to improve their ability in scientific communication, through the use of a simplified language but scientifically correct and suitable for different users. Their commitment should be also to maintain good relationships with decision makers and media, so that a multifaceted management of criticalities is possible.

Decision-makers are responsible for natural hazards prevention and mitigation policies. Unfortunately often they have completely different skills than those required by their role. So, they often ignore the limits of scientific studies regarding the prediction of the hazard and the level of seriousness with which a warning could be issued to the public. Sometimes they demand to geoscientists to provide deterministic scenarios, while only probabilistic ones are possible.

Mass media represent the link between scientists and society. During a crisis they should have the duty to give people correct information, necessary for the management of the emergency. They should make themselves responsible for sending public demands and expectations to politicians. Unfortunately, usually journalists have a poor qualification in geosciences. In addition, the language they use is quite different from the language of scientists. So, it happens they can misuse sentences and declarations by scientists out of the context in which they have been stated, and in the worst cases they transform the meaning of the scientists' words in a sensationalistic way. The time of the media communication is different from the time of science: scientists need time for their research and to disseminate scientific results, while often journalists need the scoop, so discussions about the limits of scientific researches and results are not adequately considered.

Citizens are usually considered as passive actors in a risk scenario, while they can play a key role. But among citizens there is a scarce preparedness on scientific matters and this implies their incapacity to defend themselves from georisks by investing on the own safety to increase individual and societal resilience. A scarce preparedness produces a low risk perception and consequently a lower resilience of the community as a whole. On the one hand citizens have the legitimate right to demand actions in defense of their safety, but on the other hand they have also the necessity and the duty to properly inform themselves about georisks.

A more prepared society in scientific terms, well-informed about the possible causes and effects of phenomena, would be able to discern the quality of the media information and force the media to become conscientious spokesperson of the social instances. Moreover, prepared citizens would be capable of evaluating choices of who manage the territory and to demand from them more efficacious actions. A virtuous circle would be triggered, in which all the actors involved would assume the ethical responsibility of their role (Bobrowsky et al., 2017; Di Capua & Peppoloni, 2014; Peppoloni et al., 2019).

5 CITIZEN SCIENCE

5.1 General concepts

Activities relative to the new concept of "citizen science" are developed with the objective to make citizens aware of the active role they can play in the defense against georisks, with the long term goal to improve the resilience of a community.

The Oxford Dictionary (https://en.oxforddictionaries.com/) defines "*Citizen science*" as "*a scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions.*" It is a scientific or para-scientific activity in which non-professional scientists voluntarily participate in the collection and analysis of data, in the development of technologies, in the evaluation of natural phenomena (Sanz, Holocher-Ertl, Kieslinger, Sanz García & Silva, 2014). Citizen science is based on the idea that knowledge is not a one-way road, and citizens can also give to scientists a support, providing them with precious insights that otherwise would have been overlooked (Ickert & Stewart, 2016).

Various scientific fields and disciplines are involved, and among them also the field of natural hazards. Regarding the seismic risk, some tools have been carried out for involving citizens and using them as a primary source of information. This is helpful for the scientists, to better develop actions for the risk management, and even to obtain valuable testimonies on the earthquakes in themselves, especially for those events that are, by nature, transitory: when they occur, usually no scientist is on the spot, ready to record them. But local people are there and so can have the ability to help by collecting data onsite to be scientifically analysed.

The involvement of citizens in scientific endeavour generates knowledge, understanding, awareness and responsibility. Citizens benefit from taking part in research, from contributing to scientific evidence and to address local, national and international issues, and through that, they can become potentially able to influence political choices (Peppoloni et al., 2019).

5.2 An example of citizen science: citizen seismology

5.2.1 A false sense of security as an effect of globalizing media information

The globalization of information disseminated through reports by mass media spreads knowledge about earthquakes all over the world. This process may induce the feeling that a strong earthquake is always confined to a faraway location ('the other side') respect to reader/listener.

Unfortunately, instead of disseminating the idea that a strong earthquake is a real possibility in seismic prone areas, those reports give a false sense of security to population and self-reassuring opinions may be generated such as: 'We are different from distant lands. They have earthquakes; we do not have earthquakes'.

Moreover, the earthquake is usually considered the cause of a disaster, and its effects are enhanced by a somewhat spectacular sense and dramatization. The general impression is a basic separation between non-seismic ("peace" periods) and seismic ("war" periods) time intervals: "seismic" negation occurs during non-seismic times, while dramatization, desperation and suffering occurs during seismic times. Spreading scientific knowledge amongst population and raising its scientific awareness is necessary to build new bridges between geosciences and society in order to fill that polarization and achieve a real and more responsible perception of the seismic problem.

5.2.2 Crowdsourcing to increase the social credibility of scientists

In this perspective, crowdsourcing (collecting information/data from numerous independent individuals) is a modern way of doing science: when a strong earthquake occurs usually a team of seismologists make surveys in the epicentral area in order to assess the level of building damages for deducing the seismic intensity of the shaking. For this activity the expertise is essential, because there is the necessity to discriminate between different engineering structures and building materials. But, looking at the macroseismic intensity field of a strong earthquake, it appears that the greatest part of the territory is interested by low macroseismic degrees and thus by transient effects. The investigation of large areas by teams of experts is a very expensive job. On the other side transient effects are felt or observed by people, and there isn't the need for particular competence to describe them. Moreover, strong earthquakes (with Magnitude ≥ 5.5) are not frequent, but smaller magnitude events, that most of times are felt by citizens, occur every week.

For this reason, in 1997, in Italy a small group of seismologists created a website for macroseismic data, one of the first in the world, where people could fill in a simple questionnaire, describing the effects, produced by a seismic shaking, occurred in their own village. Data were elaborated more or less by hand and macroseismic maps were published online after some days. People were immediately happy to contribute to collect observations.

In 2007, this team created a new website "Hai sentito il terremoto" (in English, "did you feel the earthquake") at http://www.haisentitoilterremoto.it/. Currently this website collects data through an online questionnaire that asks to describe the effects individually observed by each user. After the occurrence of an earthquake, citizens voluntarily fill in the questionnaire. Automatically, macroseismic maps and data are generated and published on the website, and updated as soon as new data are progressively available (Fig. 1) (De Rubeis et al., 2015).

The macroseismic team offers the possibility to users to become permanent members of a community of interested people who are alerted immediately after the occurrence of an earthquake within or close to the area where they live. Currently, more than twenty-six thousand citizens, located all over the Italian territory, are registered as macroseismic correspondents to the aforementioned website. Every correspondent and occasional user record the local observed effects of an earthquake and then a global map of the felt macroseismic intensities is generated by the online system in almost real-time. Those maps are greatly appreciated by the population that have the possibility to contribute collecting observations of scientific interest under the supervision of a public research institution.

Sometimes people have doubt about the independence of scientists from politics and see conspiracies to their own disadvantage. Just as example, it can happen that the population claims that the real value of the magnitude of an event is higher than that assigned by seismologists. This and other attitudes of distrust disappear when people know that data come directly from citizens. So, by "opening the doors of science" to citizens, scientists can get trust by them, increasing their social credibility.

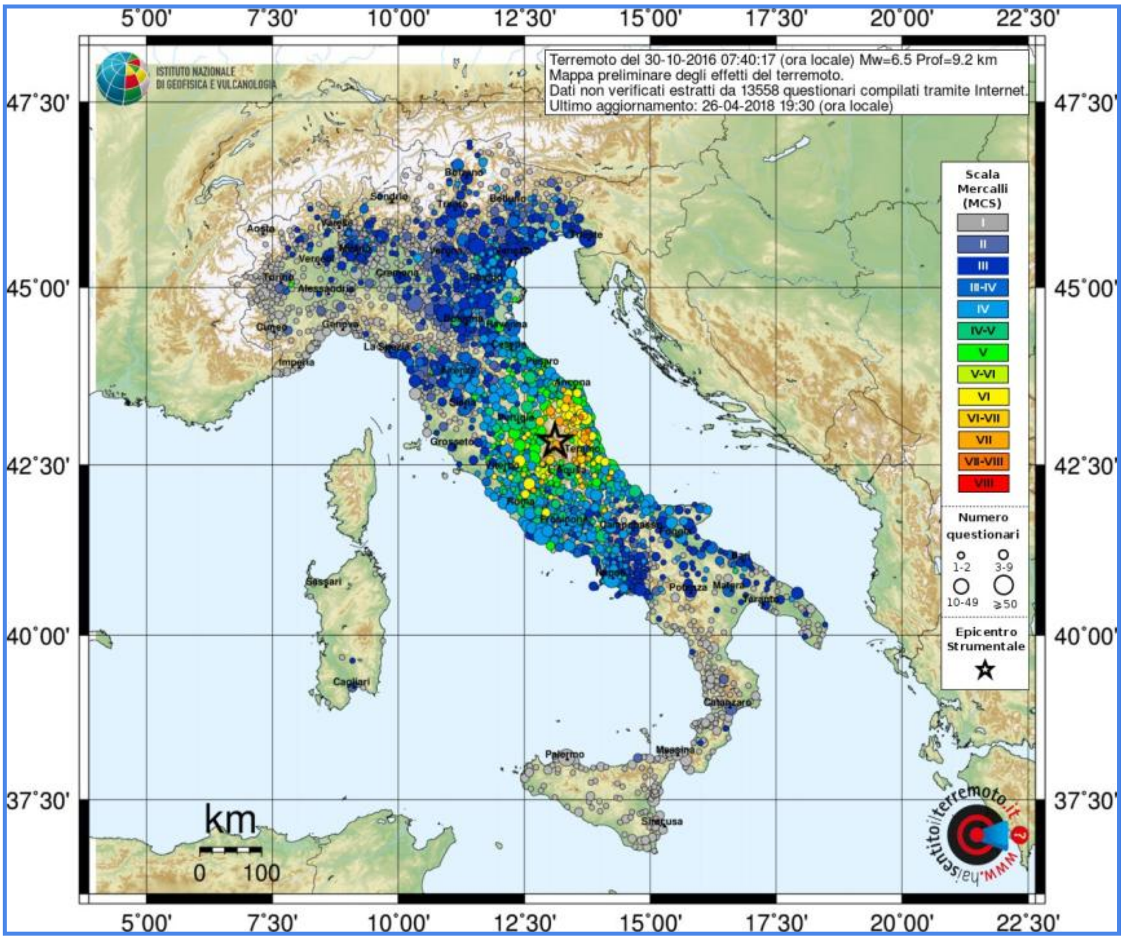

Figure 1. Intensity Map (MCS) of the October 30th 2016 earthquake in Central Italy generated through online questionnaires filled in on the “Hai sentito il terremoto” (in English, “did you feel the earthquake”) (Retrieved from the website http://www.haisentitoilterremoto.it/)

5.2.3 Key-points of the citizen seismology

a) Through citizen seismology, geoscientists have now information about even small events that previously were disregarded.

b) One of the peculiar aspects of gathering data from citizens is that a great quantity of information is collected in a very short time. Usually, at half an hour after a seismic event, the first macroseismic intensity map is generated by collecting six questionnaires. After one day of observations the map is basically generated through several hundred or even thousands of questionnaires.

c) Moreover, rapidity in generating and publishing results is fundamental, since after an earthquake people search for instant information.

d) Obviously, people's observations, unlike instruments, are not always correct and data can be flawed. For this reason, some rules to filter out low quality questionnaires have been created. In this way, questionnaires with too few answers or with answers that reveal contradictions in the description of effects are deleted. Initially, seismologists checked if the macroseismic intensity assessed by using the questionnaire was too high or too low in comparison with the expected macroseismic intensity for a certain village, because they were not sufficiently confident of data coming from people. Progressively seismologists became aware of the potential of having a lot of questionnaires and the possibility to discover unexpected phenomena to be investigated. For example, in 2014, an earthquake occurred in Greece. It was generated at a depth of eight kilometres and, theoretically, it shouldn’t have been felt in Italy. But questionnaires demonstrated the opposite.

e) People who are informed through emails about the events occurred in their area become more aware of the seismicity of their territory, since the 'alert service' is a sort of reminder that earthquakes are continuously present, even if high magnitude events rarely occur. In this way, the word "earthquake" is no longer synonymous with death and destruction.

f) After a strong earthquake or during seismic swarms, people can receive many emails that are sent by the online system of the website. It can happen that some errors can be made, but this not necessarily affects the appreciation of people towards the scientists' work. The need to be informed is stronger. For example, in 2015 the automatic localization systems of the Istituto Nazionale di Geofisica e Vulcanologia (Italian National Institute of Geophysics and Volcanology) failed to calculate the magnitude of an event occurred in Sicily. To an earthquake of magnitude 0.9, it was assigned magnitude 5.0 by mistake. Some minutes later the problem was solved, but, automatically, the software managing the website "hai sentito il terremoto" had already sent hundreds of emails to correspondents in Southern Italy. Some hours later the seismological team managing the website sent another email of excuses, being afraid of the reaction. But the comments received in reply showed that in any case people were happy to have been informed and to have the possibility of contributing. It was an occasion to show their appreciation of the seriousness, the precision, and the correctness of scientists in showing their errors and to review their data.

6 ETHICAL ISSUES IN RISK COMMUNICATION FROM A SOCIOLOGICAL POINT OF VIEW

6.1 A historic perspective

Providing a summary of the evolution of risk communication approaches through the lens of ethical issues is necessary to frame correctly problems, concepts and methods developed on the basis of practical experiences. The growth and the consolidation of risk communication as an independent, cross-cutting discipline appear to be strictly connected to the growing concern for both public's and individual recipients' needs and rights.

The shift from a source-centred approach toward public's engagement can be easily explained as a by-product of social conflicts arisen in the risk arena. Since late sixties the worries for an unfair distribution of power between risk manager and governmental agencies on one hand and citizens on the other hand has been resulting in an increasing tendency to recognize a few non-negotiable values and principles, such as the right to be informed, the right to be heard and the right to participate the decisional processes.

Meanwhile, psychology and social science triggered a great shift toward a new rationale of risk communication, as first evidence on risk perception and understanding made clear that people are everything but irrational and deserve consideration and respect on the part of scientists and experts.

Along seventies and eighties, a huge body of knowledge has been deployed in risk communication strategies, ensuring a not so painless transition from an arbitrary idea, about what risk communication was purported to be, to the world of good intuitions, and then towards a different approach to risk communication, grounded on principled practices and well-established principles arising from robust research evidence.

6.2 Key-points in risk communication

Risk has become a central issue in contemporary social science for some good reasons:

a) It is a key point to address modernization.
b) It emphasizes knowledge.
c) It stresses decision-making and democratic processes.
d) It shows rationality limitations in addressing side effects of decisions.
e) Highlights the multiplicity of values and forms of rationality.

Above all, risk is about future and it's nor neutral neither painless.

6.3 Fundamental characteristics of risk communication

- Risk communication is not a set of practices in search of a theory.
- It requires a highly-specialized knowledge and continuous training of communicators.
- Risk communication must not be improvised, as the stakes are very high.
- Implicit assumptions, established practices and unwritten rules should be carefully assessed.

6.4 Turning ethical principles in principled practices

- Everyone has the right to be aware and be alerted of an impending risk and possible disaster.
- If people feel or perceive that they are not being heard, they cannot be expected to listen.
- Messages and strategy must be shaped on empirical evidence rather than on mere supposition.
- Strategies and messages should be always tested. Risk communicators should evaluate and address unintended consequences of bad communication
- Reaching people, it's up to the source.
- Mutual trust is the first attribute of risk communication effectiveness.
- Being prepared to handle with uncertainty and unpredictability.
- Decisions should lie on well researched principles.
- Expertise from psychological and social sciences is at once necessary and indispensable.
- Basic training in risk communication is helpful and recommendable for who is involved in risk assessment, risk management and risk regulation.

7 DEFINING THE ACCEPTABLE LEVEL OF RISK FOR CIVIL PROTECTION PURPOSES

7.1 The acceptable level of risk: a political decision

How acceptable risk levels are determined in political decisions and related policies in the field of civil protection, i.e., regarding disaster risks and their reduction at the national and international level?

Establishing the acceptable level of risk for society and consequent actions to be taken to mitigate risks is a political and a scientific decision. Geoscientists have only the expertise necessary to provide accurate data and risk assessments based on deterministic or probabilistic models. Technical and operational decisions to be taken in a disaster cycle should regard the civil protection authorities and not scientists.

Some behavioural elements which can impede such a decision have to be recognized. Among these, heuristic and mental aspects in decision-making process play a primary role, because they interfere with preferences for selfish versus others' interests and with the evaluation of individual versus community gains and losses. Due to these processes, the political decision-maker, unless to be a statesperson, will easily prefer not to decide (Di Bucci & Savadori, 2017).

7.1.1 Changing the current paradigm of the political decision-making in disaster risk reduction

Political decision-making, however, could be induced by a change of mind in the voters' community. This reorientation of the society's values and interests can be stimulated taking advance from research on social norms, which underlines the role played by some people that drive innovation in a community, e.g., the trendsetters.

The scientific, technical and professional communities have the knowledge needed to address problems in the right way, are aware of the work to be done on the disaster risk reduction and can establish a direct relationship with single trendsetters and statespersons. In this way they can promote decision-making on disaster risk reduction, stimulating interest, providing advice, answering questions, deepening explanations, implementing further requests, building trust. Especially if they do not have any institutional position of responsibility, scientists and professionals can freely motivate and support trendsetters and statespersons with their expertise, being accountable only for their competence and intellectual honesty. No one expects a neutral position from scientists and professionals, but their expertise can be intended as a contribution of transparent and quantified, high-level, scientific information.

Some suggestions to promote political decision-making on the acceptable level of risk could be summarised as follows:

a) Identifying short-term gratifications for political decision-makers who have to be involved in long-term risk reduction policies.

b) Intervening and modifying the current state towards a more diffuse awareness of the need of risk reduction policies by activating trendsetters to promote a change in the public opinion and stimulating statespersons to implement policies which consider the disaster risk reduction a public good and therefore are willing to make decisions on the acceptable level of risk.

c) Acknowledging the primary role on the previous points played by the scientific, technical and professional communities.

8 HOW GEOSCIENTISTS CAN SUPPORT SOCIETY IN THE DEFENCE AGAINST GEORISKS

A society scientifically unprepared prevents the development of risk reduction actions really effective and widespread, and as consequence, the improvement of the resilience. To fill this gap, geoscientists are called to developing appropriate educational strategies, disseminating scientific knowledge, transferring correct and timely information on georisk scenarios and consequences of unpreparedness. The adequate preparedness can help to better face the fear of a disaster and to better react for minimizing damages.
Experts have the duty to make society aware that science cannot be the solution to all problems, but it can provide helpful tools to defend human lives, although accompanied by a certain level of uncertainty (Peppoloni et al., 2019).

8.1 Key-points in georisks from a geoethical perspective

1. In the risk decision chain, roles and responsibilities of each actor have to be clearly fixed.

2. Geoscientists needs to be more aware of their social role: they are not decision-makers, but they must provide reliable, unbiased and updated science-based information to decision and policy-makers so that decisions and policies adopted will be scientifically grounded.

3. Developing synergies between geosciences community, government agencies, and local administrations, through the development of operational protocols and the definition of an encoded stream of information from the scientific community to the authorities is necessary to assure a fruitful strategy to face georisks.

4. Informing population on natural risks is a priority and an ethical commitment for geoscientists: scientific data, results, and scenarios have to be explained to population and presented in appropriate ways to be understood.
5. Geoscientists need to learn to communicate geosciences knowledge on georisks without trivializing it, using a language intelligible for the population, while respecting scientific accuracy.
6. Geoscientists should organize a communication strategy before, during and after emergency phases, strengthening the use of new communication tools, like social networks and being available to hear and reply to doubts and personal beliefs of people on hazards.
7. Geosciences research outcomes must be public, but it is indispensable to provide explanatory information that are shaped on the basis of different final users, so that they can be easily and properly understood. Moreover, scientific observations should be clearly distinguished from working hypothesis.
8. Population should be informed also about the limits of the scientific methods used, so that it can better understand and share the decisions taken to deal with geohazards.
9. Society has to be helped to replace a culture based on facing the emergency with a culture centred on prevention to reduce georisks.
10. Developing educational campaigns on geohazards and georisks needs a societal involvement. Their aim should be not only to simply transfer scientific data, but also to increase awareness and responsibility.
11. Scientific knowledge is not a one-way road. In “Citizen Science” people are involved in the scientific endeavour, providing precious insights to scientists. This cooperation generates knowledge, understanding, awareness and consequently responsibility.
12. Geoscientists should contribute to develop a more correct risk perception in the population, avoiding prolonged alarmism that could have as extreme consequence a decrease of the attention and care by citizens. Similarly, excessive reassurance can diminish citizens’ trust in science.
13. Geoscientists have to act wisely, in the light of geoethical values, considering a reasonable balance between costs and benefits of prevention for suggesting realistic risk mitigation policies.
14. An acceptable limit of risk can be evaluated on scientific basis, but it remains a political decision. Geoscientists can help decision makers but cannot replace them in this role.

9 CONCLUSION: CONSEQUENCES OF A SOCIETY UNPREPARED

Among problems that can rise within a society unprepared in future crises and emergencies in georisks management, there are following aspects:

a) prolonged alarmism could have as an extreme consequence that a threat is not perceived as such all the time;

b) if the precautionary threshold becomes too high, the costs of prevention become excessive and therefore an attitude of resistance to risk mitigation policies arises in the population.

The extreme effect will be the development of a culture of emergency rather than a culture of prevention to face geo-hazards, with an increase of victims and economic repercussions of disasters on future generations. If society is not sufficiently involved in building a societal awareness on the importance of the scientific knowledge of natural and anthropogenic risks, there could be two negative consequences:

- the cultural and social marginalization of scientists, with a loss of sense of the role they can play in protecting society from natural hazards;

- the tendency of people to lose confidence in science, to embrace preconceived ideas in a non-critical way, ideas sometimes provided by the media, often incorrect, potentially resulting in loss of good sense or in irrational behaviour.

Without a society scientifically prepared, it is not possible to develop risk reduction strategies that are really effective and widespread.

10 RESOURCES

The development of a culture centred on preventive actions is a way to improve the resilience of societies to dangerous geological events. This needs firstly the development of the societal awareness on geological risks and their implications for human communities. Geoscientists are at the forefront of the defense against geological risks.

Developing preventive strategies requires accurate geosciences communication, diffused geo-education, and access to reliable scientific information, as well as effective governance. It also depends on improving communities' awareness on geological risks and the capacity to assess and establish reasonable and acceptable risk thresholds for society. This can help to facilitate the adoption of strategies to reduce the likelihood that potentially damaging geological events or processes occur, or the transformation of such events into disasters.

To this aim one video-pill containing fundamental concepts of geoethics in georisks is considered complementary resources to this eBook.

10.1 Video-pill: "geoethics and geological risks"

This video-pill is based on a video that provides an overview on the geoethical aspects and implications in georisk management, by introducing several key concepts: prevention, probability and uncertainty, risk scenario and its actors, geoscientists as social actors and their role, defence system, disaster cycle, operational protocols in emergency phase, science-society interface, and citizen science.

The video is formed by 5 blocks entitled:

1) Geological risks and prevention; 2) Prevention as a value; 3) The risk scenario; 4) Geoethics in georisk management; 5) How can geoscientists support society in the georisk defence?

The video is conceived as a tool to set up further reflections and discussions aimed at raising students' awareness about individual, professional, social roles and responsibilities of geoscientists, and building a shared framework of concepts and values used in georisks studies and management.

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Chapter 9

Geoethics in field-trips: a global geoethical perspective

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CHAPTER 9. GEOETHICS IN FIELD-TRIPS: A GLOBAL GEOETHICS PERSPECTIVE

SUMMARY

Geoethics is an emerging field in geosciences. Following the emerging need for geoethics to raise awareness in Higher education students, the main aim of the Geoethics Outcomes and Awareness Learning (GOAL) project is to elaborate a geoethics syllabus for academic Earth Sciences departments from Europe and beyond. Nevertheless, the GOAL project is only the first practical step of a long journey until the implementation of this syllabus, or even part of it, will take place in universities worldwide. It is important to note that the GOAL project is not just about producing a list of geoethics subjects and topics; it is also about how to teach it. Educationally, the project follows a contextualized approach supported by the case-based methodology and diverse strategies to develop the processes of teaching and learning. This educational aspect is quite a novel approach within the Higher education, in general, and among academy geoscientists, in particular. This chapter aims to present field-trips as a strategy to enhance the learning of geoethics in Higher education as well as highlighting that its affective domain has the potential to achieve GOAL project aims and an awareness geoethics learning.

1 INTRODUCTION

Geoethics widens the cultural horizon of geosciences knowledge and contributes to orient scientists and society in the choices for responsible behaviour towards the future of the humankind on planet Earth (Peppoloni & Di Capua, 2016, Vasconcelos et al., 2016). As a new field of study, it needs the development of projects to be widely recognized and the development of educational strategies that can assist teachers, researchers and students in acquiring its principles and values. The Higher education is much more rigid and conservative than the pregraduate education. As such, it is towards level of teaching that we must intervene. Moreover, reductionism is still the leading paradigm for academic science and although geosciences cross disciplines, many geoscientists and geosciences faculties still work within the reductionism paradigm. Therefore, incorporating the geoethics syllabus into the Higher education geosciences' curriculum will be a rather demanding challenge. It is suggested that the outdoor environment may be an easier and effective venue for integrating geoethics subjects within geosciences academic courses. This assumption is based on the following reality: (a) Field -trips are still a common teaching component in many geosciences academic courses. (b) Usually, lecturers have rigorous lectures plans for their courses, while the field-trips' program is more open. Therefore, it might be easier for the university lectures to raise geoethics topics during a field trip rather adding new topics to their prepared lectures. (c) Educationally, raising geoethics dilemmas through a concrete interaction with real world phenomena might be more effective than in a classroom lecture. Nevertheless, it is widely recognized that the affective domain - defined in geosciences as emotion, motivation, and connection to Earth – is an integral part of the field experience (Jolley et al., 2018).

A key factor for an effective use of the outdoor as a learning environment is the understanding that academy geoscientists have regarding the theoretical framework of the meaning of learning and the outdoor as learning environment. From the dawn of human existence, humans have been characterized by our learning ability regardless of the presence or absence of institutionalized learning frameworks (such as a school). Thus, learning is a natural process - it is an instinct. Although schools were established to provide education to people in order to serve them in daily life, it is amazing to see how many children all over the world are displaying a notable lack of interest towards learning in school and even a resistance towards school. This resistance is the result of the interaction of schooling with the instinct of learning. On the other hand, although out-of-class experiences provide important learning opportunities for students limited research has explored the value of field-trips in graduate students.
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1.1 The meaning of learning and the outdoor learning environment

1.1.1 The instinct of learning

The learning mechanism in human beings, as in other animals, is instinctive, and therefore occurs in response to stimulation. Possibly, the difference between humans and other species lies in the relationship between learning and the characteristics of natural and intrinsic motivation for learning. For the human species, learning has evolved far beyond the most basic existential survival, and serves humans' natural curiosity and the inborn human tendency to seek novelty and challenges. Thus, in humans, the main stimulus for learning is emotional, and the cognitive ability follows this emotional need. Unfortunately, the traditional approach to teaching adopted in schools and universities is mainly focused on the transmission of information from teachers to students, who usually have to memorize it and give it back through a one-time event called an 'examination'. Thus, the classic classroom or the traditional teaching approach stifles the natural learning instinct, consequently encouraging boredom, absenteeism, and rebellion among many students.

This gap between the natural instinct of learning and the traditional schooling approach is a central reason for the worldwide phenomenon of children's reluctance to attend and struggle to learn in schools.

It is generally thought that students' interest level and motivation in the Higher education is slightly different from those of the pre-academic education students. Mainly, since university students are not forced to be there. It is their choice. They choose to study a specific area of study and even have to pay for it (in many countries). However, this assumption is inaccurate, since even if university students choose their field of study, their ability to choose the courses they will study is very limited at least at the undergraduate level. Thus, even in the university, lecturers are exposed to many bored, unmotivated students. Therefore, the learning instinct of students should be relevant for university lecturers as much as it should be relevant to schoolteachers. As stated by Jolley (2919), work on the affective experience in Earth science suggests that students have largely positive feelings toward field education before the trip and these feelings become significantly more positive after the trip has finished. According to the same author, the importance of field education highlights the relevance of the affective domain in promoting deep approaches to learning, or learning for understanding, rather than the rote memorization conceptual content.

1.1.2 The outdoor learning environment

Earth science education has great potential to stimulate students' learning instinct by helping them see the relevance of what they learn in their own daily life. This statement is based on the Earth systems content and the existing "Earth science education research", which highlights the central role of the outdoor learning environment in creating personal relevance. This personal relevance should stimulate the learning instinct mechanism and, once this instinct is active, students will cooperate and engage in the learning process.

To be precise, it is important to emphasize that the outdoor learning environment has only the potential to stimulate the learning instinct mechanism. However, the fulfillment of this potential does not occur just by going out for a field-trip. The fulfillment of this potential is related to way it is integrated within the learning sequence and upon the teaching methods of the field-trip. The following is research-based description of an effective model for integrating outdoor activities as an integral part of a learning sequence (Orion, 1989; Orion, 1993; Orion & Hofstein, 1994; Orion, 2007; Orion & Ault, 2007; Yunker, Orion & Lernau, 2011; Orion, 2019).

The main potential of the outdoor learning environment is in dealing with phenomena and processes, which cannot be cultivated indoors. The outdoor is a very complicated learning environment, since it includes a lot of stimuli, which can easily distract students from learning. Thus, one of the first tasks of a teacher is to identify and classify phenomena, processes, skills and concepts which can be learned in a meaningful concrete way only in the outdoor environment and those that can be learned in a concrete way also indoors, as well as identify those abstract processes and concepts, where the outdoor contributes almost nothing for their understanding, and that can only be explained through more sophisticated indoor tools, such as pictures, films, slides and computer software.

Some few examples are the following:
The best way to understand the meaning of a fault line or plane is through a field direct interaction. However, the rock identification skills which are needed for this interaction should be learned best through a lab workshop.
The best way students can internalize a dune structure is through climbing its back moderate slope and gliding down the steep front slope. However, the investigation of the dune's sand grains should be done in the laboratory.
In some areas, one can find outcrops where students can identify an anticline and conclude a whole set of geological processes which were involved in the formation of this structure. However, many skills and concepts, which should lead to those conclusions, such as marine sedimentation, superposition and folding can be better explained through lab observations and simulations. Moreover, the understanding of the three-dimensional nature of a folding structure can be effectively achieved through a computer software, as well as the folding mechanism.
The above examples demonstrate the interrelationships between the outdoor and the indoor. Orion (1993) suggested a spiral model, which integrates both the indoor with the outdoors and learning environments with learning tools and learning methods (Fig. 1).

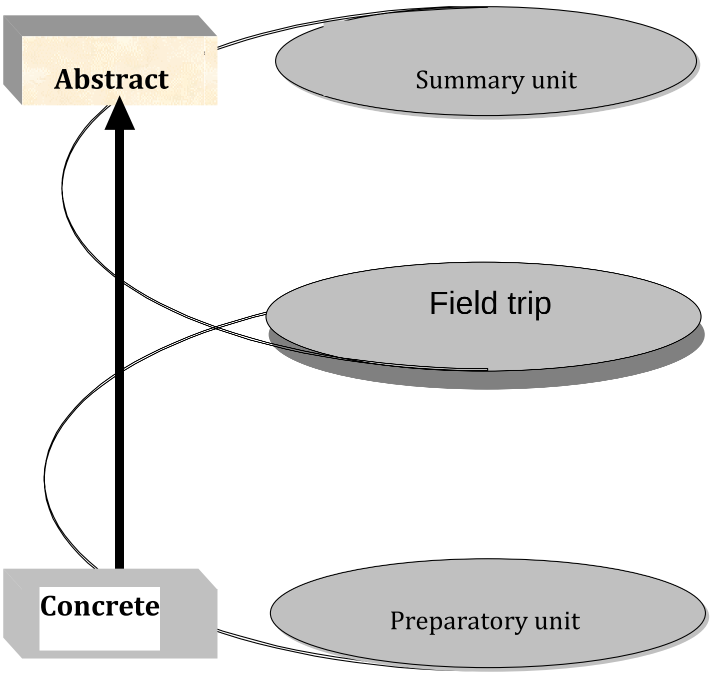

Figure 1. Spiral model of integrating learning environments in a teaching sequence
(Adapted from Orion, 1993, p. 329)

The sequence of teaching and learning as described in Fig. 1 develops from concrete to abstract. The only purpose of the preparatory unit is to prepare students for the outdoor learning experiences. This preparation for the outdoor learning experiences takes place in the efficient setting of the classroom. Certainly, many teachers have encountered difficulties in having learners focus on learning in the outdoor environment. Many studies have shown that the main reason for this difficulty is due to the novelty space of the outdoor setting. The novelty space consists of three main components: cognitive, psychological, and geographic novelty (Fig. 2). Cognitive novelty is the degree of familiarity of the students with the basic concepts and skills needed to perform tasks in the outdoor learning environment. Psychological novelty is the gap between students' expectations of the event and the actual event. For example, if students were expecting a hike, that is, a social event with refreshments, and, in practice, they are asked to perform a structured learning task, the psychological gap created in their emotional difficulties may be brought to the task. Geographical novelty is the degree of familiarity with the physical environment, the learning stations, and the way to get there. In unfamiliar surroundings,

learners will devote much of their energy in getting to know the new environment at the expense of their ability to concentrate on learning activities. Experience shows that the outdoor learning environment in which learning takes place near the school reduces the need to address the geographical novelty because learners know the environment very well.
The novelty space concept has a very clear implication on planning and conducting outdoor learning experiences. It defines the specific preparation required for an educational field-trip. Preparation which deals with the three novelty factors can reduce the novelty space to a minimum; thus, facilitating meaningful learning during the field-trip.
The cognitive novelty can be directly reduced through concrete learning activities (classroom or laboratory) to gain the knowledge and skills that are needed for the exploration of the field phenomena. For example, exploring rock specimens that the students will encounter in the field, as well as simulation of phenomena and processes through laboratory experiments.

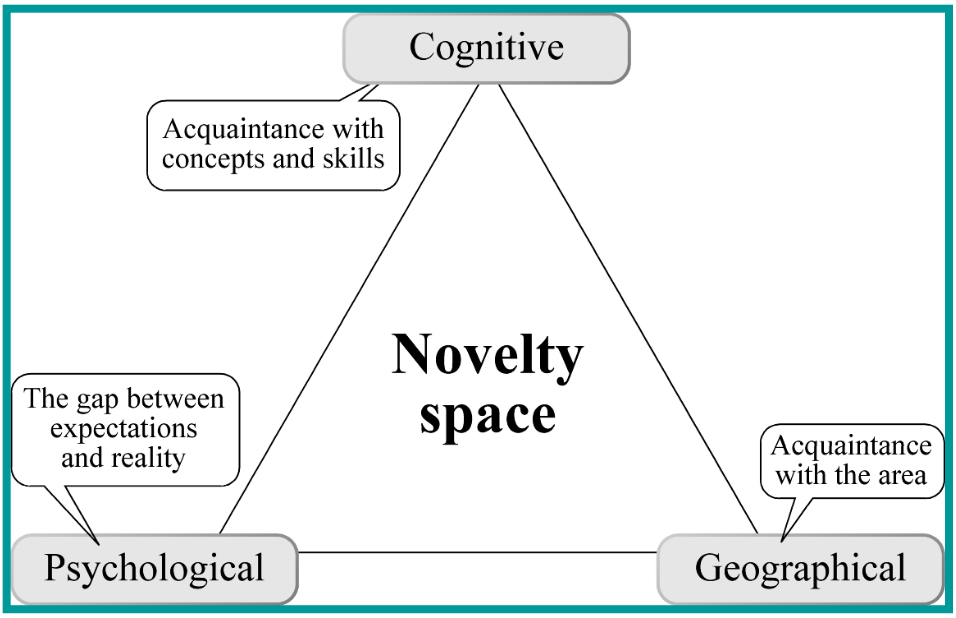

Figure 2. Components of the novelty space of the outdoor learning environment.
(Adapted from Orion, 1993, p. 326)

The psychological novelty can be reduced relatively easily in-class preparation through detailed information about the event: purpose, learning method, schedule, number of learning stations, length of time, expected weather conditions, expected difficulties along the route, etc.
It is important to emphasize that experience shows that after the first field trip away from the classroom, there is no need to deal with the psychological novelty of the outdoor learning environment, as students already know what to expect. The geographic novelty can also be reduced indirectly in the classroom by slides, films and working with maps.

The justification for taking students outdoors is to experience a direct concrete interaction with the learning phenomena. Therefore, the outdoor learning activity should be placed in the concrete part of the learning process. The field-trip, along with the preparatory unit, serve as a concrete bridge towards more abstracts learning levels. Thus, a field-trip should be planned as an integral part of the curriculum rather than as an isolated activity. The outdoor learning experience should be based on worksheets, which lead the students to interact with the phenomenon and not with the teacher. To interact with the teacher, they can stay in the classroom.
The concrete interaction should lead the students to achieve two main educational objectives: a) construction of understanding and b) elevation of open questions and puzzles in relation to the studied phenomenon. The teacher should act as a moderator between the students and the concrete phenomena. Some of the students' questions might be answered on the spot, but only those questions that might be solved according to the evidences that exist in the specific outdoor site. Otherwise, why use the precious time and the limited span of concentration which

characterizes the outdoor learning environment. Lectures, long discussions, and the long summaries should be kept for the next phase that should be conducted in the more convenient indoor environment.

2 FIELD-TRIPS AND THE GOAL EDUCATIONAL APPROACH

2.1 The Higher education common teaching approach

The educational approach of the outdoor learning environment presented above is an integral part of the GOAL educational approach and promotes a holist approach to Earth system (Vasconcelos et al., 2020). Unfortunately, GOAL educational approach, in general, and the outdoor learning environment theory, in particular, are quite different from the common traditional way of teaching geosciences in universities worldwide.
Geosciences courses are taught in university by scientists, who usually have no educational background. They were selected to teach a specific course because of their scientific knowledge and their educational abilities is only a subsidiary factor. Many courses, especially for the bachelor level are based on frontal lectures and information transmission, which is the opposite method to the constructivist approach. Even the academic geosciences field-trips are based on lectures in field, with only minor interaction with the field phenomena and mostly interaction with the lecturer.
Moreover, since university lecturers perceive themselves as researchers and as teachers, many of them do not have time, the willingness, or both, to invest in improving their teaching abilities.
One of the cornerstones of Higher education is academic freedom. This freedom is reflected in both research and teaching and, in contrast to schoolteachers, university lecturers have the freedom to decide what they teach (the syllabus) and how they teach it (methods).
Therefore, the implementation of the GOAL syllabus through the GOAL educational approach as an integral part of the geosciences Higher education curriculum is totally depended on the individual willingness of geoscientists to take part of this process. It is suggested that field trips might serve as an easier venue for geoscientists to adopt and integrate geoethics topics and dilemmas within their courses.

2.2 The unique role of field-trips within the geosciences Higher education

Historically, many areas of the geosciences are field-based sciences, especially areas like geology, geomorphology, hydrology, palaeontology, mining, etc. Over the years, the balance between lab-based studies and field-based studies has been shifted towards the lab and computerized studies, however, many university level geosciences course worldwide still use field trips as an integral part of their curriculum. Courses like introduction to geology, mapping, stratigraphy structural geology, palaeontology, Earth resources, historical geology, sedimentology, volcanism, metamorphism, igneous rocks, geomorphology and hydrology are only part of a short list of academic courses worldwide that integrate field-trips.

There is a very high probability that any field-trip, in any of the above subjects (and many others), in any place in the world, will include a phenomenon that presents a geoethics issue.

However, as already mentioned, the common method of conducting field-trips is almost the opposite to the outdoor learning environment model presented above in the theoretical framework section. The academic geosciences field-trip is usually conducted at the end of the courses and not at the beginning as a bridge from the concrete to the abstract. The common academic teaching method during field-trips is mainly based on lectures and only little (if at al) on a concrete interaction with the field phenomena.

Thus, we cannot expect geoscientists to integrate geoethics aspects into their courses' field-trips without some guidance and concrete examples.

2.3 Global examples of integrating geoethics aspects into field-trips

Although the ability of most of geoscientists to integrate and adopt both GOAL's syllabus and new teaching approach within their courses is quite likely because they are motivated geoscientists, who would like to do it in some extent. However, even that motivated group will need some kind of practical assistance.

The following are random examples of field phenomena from different countries that are included into geosciences academic field-trips. These examples demonstrate the relative ease with which geoethics elements can be incorporated into almost any geoscience field trip in any country.

It is suggested that such examples might serve as an assistance tool for those geoethically motivated geoscientists.

Example 1: geoheritage

Figure 3 is a photo of a section of Pleistocene continental sediments in Lavadores beach of Portugal (near Porto) that represents sea level changes. It is located at a short driving distance from the geosciences faculty of Porto University. Therefore, it is a popular destination for geological field trips as part of many courses such as Introduction to Geology, Sedimentology, Geomorphology, Climate Change and Historical Geology. However, because of the urbanization along the coast, this outcrop is almost the last one that survive the dense building in this area.

Figure 3: Pleistocene continental sediments in Lavadores (Portugal)

Table 1. An example of a scientific study of the geological outcrop of Figure 3

Geoethics and the exposure by the road

1. To which group are these layers classified (circle):

Igneous / Sedimentary / Metamorphic

2. What is the field observation that led you to your above conclusion:

____

3. Are all the layers of the same age? *Yes / No*

4. What is the geological principle that your above conclusion is based on?

____

5. Look at the different layers. What is the main difference between the reddish and the grayish layers?

____

6. Look at the pebbles layer and fill the table below:

	Field observation	Conclusions
Grain size	Clay / Silt / Sand / Pebble	Medium of transportation: wind / water
Classification grade	Barely sorted / Medium / Well	Energy of transportation:
Lithospheric content	Homogeneous / Heterogeneous	Source:
Roundness	Angular / Rounded / Very rounded	Distance of transportation:
Shape	Sphere / Flat	Environment of deposition:

7. What is the geological principle that your above conclusions are based on?

____

8. What kind of scenario might explain the periodical appearance of layers of pebbles and layers of sand?

____

9. Which processes of the rock cycle are expressed by this stop (Circle)?

Melting; Slow Cooling; Eruption; Fast Cooling; Slow cooling followed by Faster cooling; Uplifting; weathering (chemical erosion); Mechanical erosion; Transportation; Sedimentation; Lithification; Burial; Metamorphism.

10. This section of rocks that you just studied is almost the outcrop that survived the heavy urbanization of this area. As you know, this area is very popular and the land here is very expensive. There is a rumor that the property owner of this land intends to build a hotel on this last open area.

- What is your opinion about building on this last outcrop?

____

- To your opinion, is it possible to prevent the property owner to destroy this outcrop?

____

- How would you try to convince the property owner to protect this outcrop while building the hotel?

Table 1 demonstrates an example of a learning inquiry sequence that can be conducted in this site. At the end of the inquiry the lecturer only has to add a few questions that will raise a local geoethics dilemma. For example:

Example 2 (quarries):

Figure 4 is a photo of an abandon gneiss quarry in Bangalore India. This exposure consists of metamorphic phenomena and igneous structures. The richness of the geological phenomena and location of this site have made it a popular destination for geological field trips as part of courses such as Introduction to geology, metamorphism, igneous rocks, Petrology, mapping, mining, Earth resources and historical geology. Figure 5 shows a water pool that formed at the bottom of the still active part of the quarry. While standing above the abandoned quarry, at the point where the photo of Figure 5 was taken, one can notice that the active quarry and pool at its bottom are located in the centre of a residential neighbourhood. Around the pool, there are noticeable sources of pollution and in addition, there are evidences that the local residents use this water for domestic purposes.

Figure 4: The metamorphic and igneous rocks

Figure 5: The water pool in the bottom of the quarry

Table 2. An example of a scientific study of the abandon quarry (see Figure 5)

Questions regarding the quarry
1. How many types of rocks you identify here? ______________________________
2. Which are the types? ______________________________
3. Draw a geological cross section along the quarry that demonstrates the field relationships between the rocks types that you identified here:
4. Write down the geological events and processes that formed this exposure, from oldest to youngest:

Table 2 demonstrates an example of a learning inquiry sequence that can be conducted in this site at the end of the geological inquiry, the teacher can easily add a geoethics aspect by taking the students a few meters up the abandon quarry, and raise local geoethics dilemmas through a short activity as presented in Table 3

Table 3. An example of a geoethics activity making aware of dilemmas.

Geoethics and dilemmas – The other side of the quarry
1. Look around you. Do you identify any geoethics issue concerning the location of this quarry in the middle of a neighborhood? ______________________________
2. Look down to the water pool that formed at the bottom of quarry. What is the source of the water here? Explain:______________________________
3. Do you identify pollution sources around the pool? Explain:______________________________
4. The local residents use the water pool for domestic purposes (including drinking). Do you think that they are aware of their environmental situation?

____

5. Do you think that the local residents have the basic scientific knowledge to deal with this local environmental issue?

Explain: ____

6. Do you think that the children who live in this neighborhood should study about the properties of water and the earth systems in their school?

____

7. What in your opinion is the responsibly of the geoscience community to inform the public and to provide the public with basic Earth systems knowledge?

Example 3 (fossils):

Figure 6 presents a fossil (ammonite) rich layer from Israel (Makhtesh Ramon). However, the fossils phenomenon can be found in many countries all over the world. Geosciences students might approach this phenomenon through geological field trips of courses such as Introduction to geology, Palaeontology, Sedimentology, Geomorphology, Petrology, mapping, mining, Earth resources and historical geology.

Figure 6: A limestone layer with Ammonite (Israel)

Figure 7: The ammonites (close look)

Table 4 demonstrates an example of a learning inquiry sequence that can be conducted in a fossil geological site. The following activity is part of the worksheets of the field booklet of an educational geological field-trip that was developed for the course "Makhtesh Ramon – A window to the geological history of southern Israel".

Table 4. An example of a scientific study of the fossils site (Figure 6.)

Questions regarding the Ammonite wall

A. A distant observation

1) Look at the rocks around you. To what group of rocks, do they belong?

Explain: ____

2) What is the geological principle that your above conclusion is based on?

____

B. A closer look

1) Approach the exposure and identify the rock that appears here.

Properties	Observations (circle)	Conclusions

Layers	*Exist/not exist If exist: Horizontal/tilted*	
Color		
Crumbling	*Crumble / non crumble*	
***Hardness** (Only for a non-crumble rock!)*	*Can be scratched by: fingernail/ only by iron /not even by iron*	
***Crushing by teeth** (Only for a crumble rock!)*	*Ground / non ground*	
Mouldability (while wet)	can be moulded**/**cannot be moulded	
Reaction to HCl (6%)	Very bubbly /slightly bubbly/ no reaction	
Additional observations		

Rock's name: ____

2) Are the rock's layers' horizontal or tilted?

____

3) What can you conclude from the above observation concerning the layers?

____

4) What is the geological principle that your above conclusion is based on?

____

5) Do you identify evidence of ancient life in the rock? If so, try to draw the structure that appears the rock:

6) What is the formation environment of this rock (circle)?

continental / deep sea / open sea / shallow sea

7) What is the geological principle that your above conclusion is based on?

___

8) Which stages of the rock cycle might be identified through the observations you made here (circle)?

Melting / fast crystallization of a magma / slow crystallization of a magma / uplifting / exposure / erosion / weathering / transportation by wind / transportation by the sea / transportation by river / river sedimentation / dune sedimentation / marine sedimentation / lake sedimentation / cementation / burial /

At the end of the geological inquiry, the teacher raises local geoethics dilemmas through a short activity as presented in Table 5.

Table 5. Fossils as an example of a geoethic activity

Geoethics and fossils

1. There are geologists who encourage their students to collect fossils.

- What is your attitude about fossils' collection?

___

2. This layer was much impressive about 40 years ago, but then it became a popular stop for tour guides and visitors took many fossils.

There is an ammonites' untouched exposure in about 1 km distance along this path. The geoparks planners intend to place a sign here. This sign shall guide hikers to the ammonite outcrop that is up the trail. What do you think about this intention?

Example 4 (water pollution):

The quality of water is a global concern and one of the most important geoethics issues that should be tackled through field trips and fieldwork as part of courses such as hydrology, water management, water engineering, earth resources, environmental geosciences and Earth systems. The city Bahir-Dar in Ethiopia is located by the famous Lake Tana (Figure.8). However, the main drinking source of Bahir Dar are springs that are located more than 10 km out of the town and not the lake water (Figure 9).

Figure 8: Lake Tana

Figure 9. The spring – drinking source of Bahir-Dar

Table 6. An example of a hydrological study of a spring (see Figure 9)

Questions regarding the spring

1. What is your estimate of the distance traveled by water until they arrive here? Circle:

short distance (few km) / medium distance (tens km) / long distance (more than 100 km)

2. Explain your estimation:

____

3. Take water from depth and measure its temperature:

____

4. Measure the temperature of the air:

____

5. What is your conclusion following your above measurements?

____

6. A discharge of a flow is the amount of water flowing in a river at a given time. It is common to measure the flow rate in cubic meters per second. What should be measured here to calculate the flow of the stream here?

a) ____________________ b) _____________________ c)____________________

7. Use the measure tools that brought by the teacher and measure the following parameters:

- The width of the flow: ____
- The average depth of the flow:

____

- The speed of the flow: ____

8. Following your measurement what is the discharge of the flow?

9. Does the current discharge, which you measured here, reflect the annual discharge?

Explain:

10. Following your temperature and discharge findings (together with the topography), what can you conclude about the source of the water here.
- Is the water here is only surface water or the source is an underground water?

Explain:____

11. The chemical identity of the water. Use the sticks and measure the following parameters of the water:

pH (acidity): ________ Chlorides (salinity):_________ Carbonates: ________ Nitrite: _______

Nitrate:________

12. Do the above results supports your conclusions concerning the source of the water?

Explain:____

13. What is your conclusion concerning the quality of the water?

At the end of the hydrological inquiry, the teacher can raise local geoethics dilemmas through a short activity as presented in Table 7.

Table 7. An example of a geoethics activity making aware of dilemmas.

Geoethics and drinking water

1. Although Bahir Dar is located on coastline of Lake Tana, the drinking water of the city are coming from here, more than 10 km of the city.

- Why comes the drinking water of Bahir Dar from distant springs and not from the nearby lake?

____

2. The local residents use the water pool for domestic purposes (washing, laundry and in some areas sewage flows to the lake).
- Do you think that the local citizens are aware of their environmental situation?

____

3.Do you think that the local residents have the basic scientific knowledge to deal with this local environmental issue? Explain:

4. Do you think that the hydrosphere and the Earth systems should be included within the city's school curricula?

___

5. What in your opinion is the responsibly of the geosciences community in relation to Earth science education in schools and in about providing the public with basic Earth systems understanding?

Example 5 (communication with the public):

Geosciences, in general, and geology, in particular, are not considered particularly attractive to a large part of the public, young population and adults alike. The main reason for these negative attitudes is the limited communication skills with the public of many geoscientists along the history. The main reason for these negative attitudes is the ongoing failure (for centuries) of the geosciences community to communicate with the lay public in a clear and relevant language for non-professionals.

Geologists tend to talk with the public with their professional jargon. It is very common that while interacting with the lay public a geologist will use sentences like "These layers in front of you are Senonian chalk and chert of Manuha formation". Or "this Cenomanian layers are the evidence of regression…" Or presenting diagrams of 3-dimension geological structures".

Figure. 10 presents a Kaolin quarry in the heart of the Makhtesh Ramon national park (Israel). Makhtesh Ramon is a unique geological phenomenon and it would not be exaggerated to say that every geology student in Israel visits this place at least once during his academic studies. Students might visit Makhtesh Ramon on field-trips of courses such as Introduction to geology, Palaeontology, Sedimentology, Geomorphology, Petrology, mapping, igneous rocks, mining, Earth resources and historical geology.

The Israeli Nature Authority, which is responsible for the Ramon National Park, has restored the quarry. The colorful sand piles that were placed as a children's playground in one side of the restored quarry and the water pool that was created in its other side (Figure 10) turned this place into an attractive site for many visitors.

The site planners have incorporated only one reference to the geological aspect of the site: a cross section that has nothing to do with this kaolin quarry, but rather presents a very complicated geological cross section of Makhtesh Ramon (Figure. 11).

Figure 10. The restored quarry in the heart of the Makhtesh Ramon national park

Figure 11. The cross section of Makhtesh Ramon

One of the main components of Geoethics is the ability to communicate with the public. Table 8 presents a short activity that might be conducted during or at the end of an academic geological field trip

Table 8. An example of a geoethics activity – public communication.

Geoethics – questions in public communication
Take about 10 minutes, walk around and then summarize your impression of the geosciences information communicated here. Possible questions are: • Do you understand the geoscience messages of the signs? • Are they clearly understandable for the public? • Are they related to this specific site? • Would you decide to present different or additional messages? • Would you do it differently?

3 CONCLUSION

Educational field-trips can enhance students' interest and awareness in various geoethics topics. They can be prepared accordingly to the geoethics dilemmas existing in the schools' area and aligned with a specific curriculum. It also links the instinct to learn with the need to teach and to learn the conceptual contents without the need to memorize them without understanding. By integrating the development of knowledge and competencies, and by increasing the motivation to learn, field-trips can be a powerful educational strategy to teach geoethics in Higher education. More relevantly, the effective domain of field-trips has the potential to achieve GOAL project aims and an awareness geoethics learning.

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Chapter 10

Conclusion and final outlook

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CHAPTER 10. CONCLUSION AND OUTLOOK

SUMMARY

This final chapter summaries the outcomes of the project GOAL (Geoethics Outcomes and Awareness Learning) and gives an outlook on potential future developments in the field. For promoting geoethics, within the project a geoethics' syllabus for Higher Education as well as educational resources have been developed. These educational resources cover various topics ranging from ethical aspects in the use of technology, theoretical aspects of geoethics, including geoethical values and principles like responsibility and intellectual freedom, geoethical aspects related to georisks management and their mitigation, geoethical implications in geoheritage and palaeontological issues, and geoethics in environment and water protection as well as geoethics in both class and outdoor including field-trips. All the materials produced are available online for free at the GOAL project website (https://goal-erasmus.eu/). To further promote geoethics, transferring the knowledge from schools to society is key. We describe that the activities of the International Association for Promoting Geoethics (IAPG) are in the cornerstone to reach this goal. Additionally, we describe ideas for future projects to support this goal.

1 CONCLUSION

The Erasmus+ project GOAL (Geoethics Outcomes and Awareness Learning – logo in Figure 1) arises from the urgent necessity to promote a new, emerging research area – geoethics – in Higher Education (HE).

Figure 1. GOAL Logo

According to the International Association for Promoting Geoethics (IAPG) – Geoethics is the discipline that studies and reflects upon the values that underpin appropriate human behaviours and practices, whenever human activities interact with the Earth System (http://www.geoethics.org/definition). Several authors argue that Western culture and modern science look at nature as an offering to human beings; accordingly, throughout the ages, human beings made use of natural resources and developed methods to protect themselves from dangers of nature, without worrying about the impacts of their actions on Earth system (Sterling, 2010). Conversely, the classic Eastern and many indigenous cultures asserts that people are one with nature; although human beings rely on Earth systems to sustain themselves, people are perceived as an integral part of nature, harmoniously interacting with it and respecting bio and geodiversity. In both cases, though for different reasons, the emergence of geoethics proves to be imperative to manage modern Human-Earth system interaction. Considering Earth System Science as a field of study devoted to the understanding of the Earth as a system (including understanding individual sub-systems, such as geosphere, hydrosphere, atmosphere and how these sub-systems interact and influence one another), it focuses towards a more holistic view of Earth and its processes. The foundations of geoethics are traced back to three main elements: the importance of geological culture as an essential part of the geoscientist's background, the concept of responsibility (individual and social), and the definition of an ethical criterion on which to guide behaviours and practices in geosciences. These pillars are rooted in a set of values that, for simplicity, can be divided into three groups that partially overlap: ethical, cultural, and social values (Peppoloni, Bilham & Di Capua, 2019).

GOAL's main objective was to develop a geoethics' syllabus for HE and offer suggestions on educational resources in order to promote awareness-raising on ethical and social implications (that is, to act responsibly) of geosciences knowledge, education, research, practice and communication, hereby enhancing the quality and relevance of students' knowledge, skills and competencies. To do so, the project focused on various topics:

- The ethical aspects in the use of technology in Science Education.
- The promotion of geoethical values and responsibility including definitions of geoethics, geoethical values, and geoethical issues and dilemmas.
- The discussion of geoethical aspects related to:
    - georisks management and their mitigation,
    - geoheritage and palaeontological issues (including aspects about geoparks, massive tourism and georesources), and
    - geoethics in environment and water protection.
- The consideration of geoethics in both class and outdoor including field-trips.

All these innovative and creative materials were elaborated by members of different countries under a social constructivism approach and in the scope of a case-based learning as considered one of the most appropriated methodology to develop students 21st century social and emotional skills, such as problem-solving and collaboration and emphasizing creativity, initiative and adaptability. System thinking skills were also aimed as being needed to the effectiveness of the understanding of the geoethics' values and concerns, and to be aware of the extent of human activities' impact on Earth system.

The unique set of material shall engage students in the idea that geosciences develop and promote cultural, educational and scientific values that must be considered a social capital of human communities. It is available free of charge from project website (https://goal-erasmus.eu/) and is aimed to be used in various courses and curricula as a whole or as single pieces. Main target groups for this educational material are HE students, professors and researchers in geosciences.

2 OUTLOOK

As future steps, opportunities for science learning should be expanded by promoting the transference of knowledge from school to society thorough the potentiation of ways to interact between geoscientists and citizen in a new research area – geoethics, by actively involved people in problem raising and solving. In order to disseminate geoethics awareness into the society, the existing geoethical syllabus and the different educational resources elaborated in GOAL need to be adapted. Such tools that needs to be developed include (but are not limited to) short video pills and role-playing games. With these resources it will be possible to actively engage students and families at schools, citizens in science centers, public in social and digital media channels (for example, special radio programs and podcast promotion), old citizens in senior universities, children at paediatric wings of hospitals and in childcare institutions (scouts, church-groups of different religions, youth-centres), nature lovers from societies for adults (like, for example, Alpinist Club) and visitors in geoparks, museums and exhibitions. Also, in Children's Universities a non-formal university-based science engagement activity for children and young people can be created. Professionals with a Higher education in geosciences are at the heart of humankind's attempts to deal with a lot of issues during which conflicts and dilemmas occur. They are not supposed to solve these with technical expertise only, but also to understand their professional and social responsibilities. As nowadays, there is a growing evidence that citizens begin to consider the importance of science and need to be more informed in order to be proactive in solving global problems (Vasconcelos et al., 2018), modern education of professionals in geosciences therefore has to account for these challenges. Other professions, like medical doctors, have training programmes in professional ethics inherited in their educational curricula. However, for geoscientists a professional ethics training is usually not included in their curricula although it would be extremely valuable. Geoethics is capable of providing the theoretical background to these challenges and to encompass both professional ethics and social responsibilities towards society and Earth system.

The International Association for Promoting Geoethics (IAPG) is a key player in achieving the transfer from HE to society. For the IAPG, a final goal is to have a School on Geoethics (http://www.geoethics.org/geoethics-school) in each continent. The schools are the physical location that can be used as "umbrella" for implementing activities. Within the IAPG, geoethics could be promoted by a task group of teachers of geosciences educators.

Within this general aim to transfer the knowledge to society, specific activities for disseminating geoethical values in society should focus on:

- establishing protocols with civil institutions such as schools, science centres, media, children and senior universities, paediatric wings of hospitals, geoparks, museums, naval schools and others culture-social organizations to promote the development of activities focused on geoethical issues in order to raise a critical attitude to the knowledge of Earth;
- adapting and applying resources elaborated in GOAL project in non-formal dissemination public activities in order to raise awareness on geoethics;
- co-designing and applying educational resources, with diverse societal stakeholders and within a geoethical approach, focused on anthropogenic impacts associated with the rampant consumption of the Earth's georesources;
- elaborating and applying new educational resources to promote citizens' awareness related to human's responsibility to care for Earth; and
- creating new partnerships in local communities to foster the integration of geoethical values and views in the daily-life of citizens.

To achieve these future aims, partners of the GOAL project are committed to widening their networks by involving other working groups capable to include geoethics into their activities, coming from other universities especially also from outside the geosciences community, and by actively looking into funding possibilities that are necessary for reaching these goals. Under the working title "*Geoethics' Underpinning Earth System Science: from school to society (GUESS)*" (logo in Figure 2) we aim to foster science education within the inherent sustainable development goals for all the society.

Figure 2. GUESS Logo

According to Orion (2019) the future directions and emphases of the research in the geosciences education will deep on the existing research of the Earth system approach in areas like the development of environmental insight, but it will also include new avenues of research focused on changing the attitudes of geoscientists towards their role in society and the adoption of geoethical values. GUESS aims to create new partnerships in local communities to foster improved science education for citizens in the scope of geoethics underpinning Earth System Science and inherently sustainable development goals. Humans must recognize their role as participative beings on Earth's sub-systems, and that life on Earth depends also on the responsible management of the Earth system. Yet the world is far from achieving sustainable development goals. GUESS aims to be a robust and evolving open-schooling project that will create and exploit an innovative learning set of tools and activities to provide science education for citizens. Designed by a team of experts and pioneers in science education, geoethics and geosciences education, to rich GUESS aims the following assumptions are made:

i. Science Education is an essential component of a learning continuum for all, from pre-school to active engage citizenship.

ii. Open schooling to society enhances community involvement.

iii. Co-design awareness activities between formal and non-formal educational providers, enterprise and civil society ensures natural engagement of all societal actors.

iv. Social mobilization and raise public awareness is a demand to enable the voice of citizens in the scope of geoethics and Earth system protection.

Recognizing this breadth of challenges, citizens have to be more informed and actively involved in projects directed to disseminate science or even to contribute to create scientific knowledge-based society in order to better face anthropogenic global and local changes. This requires the urgent development of non-formal awareness activities directed to promote a citizenship that should be capable to understand the importance to include geoethics within its fund of social knowledge.

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CHAPTER 9
GEOETHICS IN FIELD-TRIPS: A GLOBAL GEOETHICS PERSPECTIVE

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CONCLUSION AND OUTLOOK

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APPENDIX 1: GOAL GEOETHICS SYLLABUS

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TITLE OF THE CURRICULAR UNIT	**Geoethics**
RATIONALE	To respect the Earth system is an ethical responsibility, as much as a necessity, in order to assure a sustainable life. Geoethics can greatly contribute to building a more knowledgeable and responsible society. Geoethics is an emerging field of knowledge, considering that less than a decade has passed since its formal definition and publication of a significant number of books, chapters and articles (Wyss and Peppoloni, 2014; Gundersen, 2017; Peppoloni et al., 2017; Bohle et al., 2019). Nevertheless, the development of an ethical thinking towards the Earth system has been growing for a very long time, also as a philosophical reflection in different cultures and historical moments (Peppoloni et al., 2017; Bohle, 2019), particularly in “environmental ethics” and “sustainability ethics” (Du Pisani, 2006; Theodossiou, Manimanis & Dimitrijević, 2011; Chemhuru, 2017; Bohle et al., 2019). The urgent need to create a Geoethics syllabus for the formal Higher education curriculum emerges when considering the lack of students’ awareness about this new disciplinary field. The integration of Geoethics values, methods and applications as an integral part of the educational training will allow geoscientists to become more aware of their social role and capability to intervene in the Earth system in a more responsible way, to respect life on the planet in all its forms, and to better serve society, looking at its safety and health (Bobrowsky et al., 2017). Moreover, knowing and applying Geoethics values will imply practicing geoscience as an effort to accomplish the universal goals of the Education for Sustainable Development and to fully understand that careless actions by humans, impacting the Earth system, can lead to irreversible consequences and threaten the survival of human life on the planet. An in-depth preparation and training in Geoethics will help young and early career geoscientists to find acceptable and responsible solutions in their geoscience activity and to understand the importance of accurately informing society about negative and positive repercussions of any possible intervention in the environment (Bobrowsky et al.,2017). Communicating geoscience using appropriate language and methods is an important geoethical value, useful to make citizens capable of actively contributing to improve the quality and sustainability of human life on the Earth.
IMPLEMENTATION	Students need to have a standard knowledge in Earth Sciences so as to be able to highlight, analyse and discuss geoethical issues (including dilemmas). Nevertheless, the syllabus can be applied in all courses in the wide area of Earth System Sciences or whenever the knowledge about Geoethics values is required. The syllabus (and complementary educational resources added) was developed to be used in any country and mainly in a curricular unit of Geoethics

	within a Higher education course. However, each module can be partially added and explored within other curricular units where the geoethical approach may be relevant. The time required for its implementation has to take into consideration the prior knowledge of the students, the familiarity with the educational methodology adopted and the in-depth approach of the subject contents required.
AIM	Narrowly contribute to improving the capacity of all geoscientists to think and act (geo)ethically so that future generations can be proactive citizens, by promoting a geoethical understanding and thinking of our planet and playing an important role in creating conditions for a sustainable human life on Earth.
OBJECTIVES	• To understand the meaning of Geoethics. • To be capable of applying (geo)ethical values in Earth system sciences activities. • To critically analyse geoethical issues and dilemmas. • To know tools for facing and, if possible, solving geoethical issues and dilemmas. • To apply geoethical values in the evaluation and protection of the geoheritage. • To address geoethical values in the mitigation of geological risks. • To consider ethical aspects in the water management. • To geoethically evaluate environmental issues. • To responsible manage natural resources chain. • To support geoeducation in promoting Geoethics and its values. • To fully understand the importance of Geoethics for a sustainable development of planet Earth and act consequently.
SKILLS	- Critical thinking - Case and Problem Solving. - Cooperative attitude. - Social and Cultural awareness. - Scientific and Professional responsibility. - Earth System-thinking.
METHODOLOGY AND STRATEGY	CBL methodology originated in 1870 in Law and Business Harvard Schools in the United States of America and was developed by Christopher Langdell (1826-1906). He started to refer to real cases in his classes, breaking away from decades of transmissive teaching. In this approach, cooperative learning is emphasized, but it can also be individual. The CBL methodology starts from cases (a dilemma is taken from real life and laid in the form of a case) and students are generally asked to work in groups, so they are exposed to several viewpoints and ideas (fig. 1). Students are also asked to evaluate each other's opinions. The exploration of a case usually finishes with a plenum discussion. This approach develops students' collaborative competences and their communication competencies (Vasconcelos & Faria, 2017).

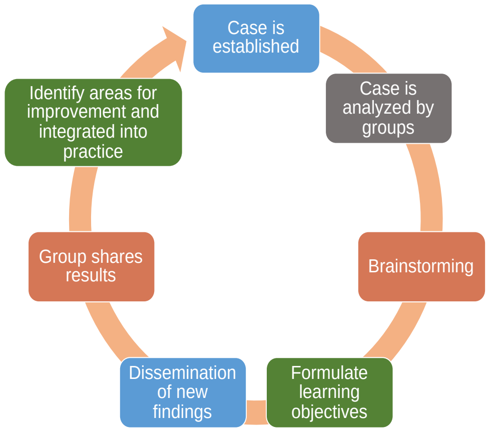

Figure 1 – The cyclic process of CBL
(Adapted from Williams, 2005, p. 578).

CBL requires students to recall previous knowledge to solve the cases. In contrast, in PBL methodology the problem drives the learning process. Since CBL requires a prior knowledge, it provides to students the opportunity to effectively relate their previous knowledge with the new.

There are commonly used strategies in CBL like, for example, follow-up discussions, modelling activities, computer work, field trips, laboratory work, pencil and paper work, debates and role-plays, simulation games teamwork projects, video pills watching and articles critical analysis. On the other hand, specific teaching and learning strategies can be designed to lead students through a case, involving suitable questions, time allocation to group discussion and appropriate assessments of both group and individual outcomes so as to help students to find suitable solutions for the dilemmas.

CONTENT

- **Geoethics: foundations, definition, meaning and values**
  √ Three fundaments to start:
  - √ The origins of the geoethical thinking.
  - √ From ethics to geoethics.
  - √ The meaning of geoethics.

  √ The concept of responsibility: meaning and individual duties.
  √ The four geoethical domains: individual, inter-personal/professional, society, Earth system.
  √ The ethical reference system of geoscientists.
  √ Intellectual freedom: a pre-requisite for practicing geoethics.
  √ Geoethical values: ethical values, cultural values, social values.
  √ Codes of ethics and training in geoethics.
  √ Geoethics applied to geosciences: knowledge and skills of geoscientists, and themes of geoethics.
  √ The four main features of geoethics: actor-centric, virtue ethics, geoscience knowledge based, context-dependent in space and time
  √ Key geoethics concepts: sustainability, prevention, adaptation, education.
  √ The Cape Town Statement on Geoethics.
  √ The Geoethical Promise.

- **Geoethics and Georisks**
  √ Definition of risk.
  √ Risk perception.

√ The acceptable limit of risk.
√ Fundamental elements in risk studies.
√ Risk management cycle (preparedness, response, recovery, mitigation) and the concept of resilience.
√ Building a risk reduction strategy: key-points and values.
√ Culture-based on facing the emergency and culture centred on prevention.
√ Roles and responsibility of actors involved in the risk decision chain.
√ Citizen science in georisks' management.

- **Geoethics and Geoheritage**

√ Definition of geoheritage and its different types of values.

√ Natural and human-made threats to geoheritage.

√ Fundamental elements in geoheritage management.

√ Relation between geoheritage, public policies, and society.

√ Importance of transnational regulations to guarantee the conservation of geoheritage.

√ Influence of cultural and social setting on the restrictions related with collecting natural specimens.

√ Best practices to avoid the over-artificialization of natural environments related with geoconservation actions.
√ Compatibility between geoconservation and other types of land-use management.

- **Geoethics and Mining**

√ Complexity in global (and local) markets of mineral resources.

√ Environmental justice related to mining.

√ Involvement of all stakeholders in mining projects.

√ Public awareness of the importance of mineral resources for society.

√ The relevance of well-informed citizens in the responsibility of the decision-making process.

√ Responsible science communication to promote clarity and transparency in dissemination.

√ Regulation and standards operation procedures internationally recognized in mining.

√ White Paper on Responsible Mining.

- **Geoethics and Water Management**

√ Human right to water and the United Nations Sustainable Development Goals (UN SDGs).

√ Environmental justice related to water.

√ Implications of climate change on water management.

√ Competing interests of different stakeholders concerning water and land-use management.

√ Coherent environmental policies as essential baseline to achieve societal goals related with water.

√ Transnational implications of large water-infrastructure projects.

√ Specificities related with ground water management.

√ Personal daily behaviours and the influence on water consumption.

- **Geoethics in Educatio**n

√ Educating students to become geoethically responsible citizens.

√ Outdoor experiences as an important source to develop geoethical awareness.

√ Responsibility to include geoethics concepts, values and principles in Higher educational courses.

√ Geoethics as an integral part of the professional training of geoscientists.

EVALUATION

In a Social Constructivism-base educational approach, evaluation must be regarded as a way to assess students learning achievements so as to scaffold their learning process and allow them to overcome their biggest difficulties in engaging with the teaching methodologies and subject contents. It also gives professors a feedback of the strategies they are using to guide students in their problem-based or case-based learning.

As such, the presentation of a geoethics case and its exploration in terms of values and principles that can be discussed and highlighted is the addressed proposal to evaluate students.

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APPENDIX 2 :INTRODUCTION TO GEOETHICS: DEFINITION, CONCEPTS, AND APPLICATION

Co-funded by the Erasmus+ Programme of the European Union

GOAL Educational Resource

AUTHORS	Silvia Peppoloni (INGV, Italy) & Giuseppe Di Capua (INGV, Italy)
TITLE OF THE CASE	Introduction to geoethics: definition, concepts, and application
SHORT CASE DESCRIPTION	This is the introductive resource of a course or module on geoethics, providing the definition, a theoretical framework, key-concepts, and themes.
KEYWORDS	Earth system; Geoethical domains; Geoethics; Responsibility; Social role of geoscientists; Values.
PRIOR KNOWLEDGE	Basic knowledge on one or more disciplines included in geosciences.
AIM	Introducing the audience to the basic theoretical framework of geoethics, by illustrating its main characteristics.
OBJECTIVES	• To know the definition of geoethics. • To understand essential information about elements of the theoretical framework of geoethics. • To raise questions, reflect and discuss about the meaning of concepts proposed by geoethics. • To put in evidence the centrality and significance of the principle of responsibility. • To become more aware on the social role of geoscientists and commitments towards the Earth system. • To know some keywords used in the geoethical analyses.
CASE	Every course on geoethics needs for a basic introduction to the main concepts. This educational resource is based on a video that provides a short overview on the theoretical framework of geoethics: its definition, the principle of responsibility, the four geoethical domains of the geoscientist's experience (individual, inter-personal, societal, environmental domains) and the main characteristics of geoethics (actor-centric, geoscience knowledge based, virtue-ethics, context-dependent in space and time). The video is formed by 8 blocks entitled: 1) An ethical reflection for geoscientists; 2) What is geoethics?; 3) What is the geoscientist's responsibility?; 4) Individual and inter-personal domains; 5) Societal and environmental domains; 6) What are the main characteristics of geoethics?; 7) What are the main areas of application of

geoethics?; 8) Towards a new way of thinking our interaction with the Earth system.

Video contents are built on several key-concepts currently used in ecological and geoethical thinking: Socio-Ecological Systems, Earth System, Conservation, Economic Development, Sustainable Development, Geodiversity, Biodiversity, Humans as a "geological force", Future Generations.

The video is conceived as a tool to set up further reflections and discussions aimed at raising students' awareness about individual, professional, social, and environmental roles and responsibilities of geoscientists, and at building a shared framework of values to be adopted for helping society to become more sustainable and respectful towards abiotic and biotic elements on the planet.

QUESTIONS

1. On what can we base our main life decisions?
2. What does it mean the word "responsibility" and which can be its implications in our daily life experience?
3. Which is the definition of geoethics, and what meanings can you discover in it?
4. What is the social role of geoscientists, as researchers and/or professionals? Which can be their ethical and social obligations? How they can help society to face global changes?
5. Do you think it is realistic to find a sustainable balance between conservation of the planet and the economic development to ensure people safety and healthy life?
6. Which can be the values that could guide humans' responsible behaviors toward the Earth system?

PROCEDURE

Preparation:

1. Watch the video "Introduction to geoethics: definition, concepts, and application" (https://www.youtube.com/watch?v=j3qBw0kSWs0&t=2s) without any preliminary introduction or comment.
2. Elaborate questions (1 through 6).
3. Watch the video again and stop it at the end of each block to start a more in-depth discussion and reflection about contents of the specific block.

4. Read the introduction on geoethics by Peppoloni et al., 2019 (http://docs.wixstatic.com/ugd/5195a5_23670a25b64a46249a971718c2fa6c9f.pdf).

Working Group (4-5 students):

1. Open a discussion on possible meaning and implications of key-concepts listed in the section "Case". Each group should report briefly results of the discussion to all other groups.
2. Each student should write down his/her list of values on which he/she takes the most important decisions affecting his/her life.

Discuss about a possible list of shared values in the group. Summarize the results at the end of the group work. This group work aims at showing the importance of dialogue to establish a reasonable alignment of values in a group of people (or society), regarding a common issue.

3. Each group should list 10 global problems affecting humanity and Earth system. Each group should report briefly results of the discussion to all other groups.
4. Set a current scenario: each working group should plot a graph [x axis: societal capacity to solve the problems (low, medium, high); y axis: importance of the issue for society (low, medium, high)]. Each point in the graph will be related to the following geoethical issues: a) mining; b) groundwater depletion; c) soil degradation; d) anthropogenic risks; e) natural risks; f) air pollution; g) plastic pollution; water pollution; h) fossil energy; i) renewable energy; l) nuclear energy; m) sea-level rise; n) climate change; o) reduction of biodiversity; p) population increase. Each working group aims at discussing own perception about the importance of the above issues for society, and own idea about the capacity of society to solve or make them sustainable in the future.
5. Build future scenarios: each working group should plot a graph [x axis: time interval (10- 50-100 years); y axis: priority for society (low-medium-high)]. Each point in the graph will be related to the following geoethical issues: a) mining; b) groundwater depletion; c) soil degradation; d) anthropogenic risks; e) natural risks; f) air pollution; g) plastic pollution; water pollution; h) fossil energy; i) renewable energy; l) nuclear energy; m) sea-level rise; n) climate change; o) reduction of biodiversity; p) population increase. Each working group aims at giving own idea on the time evolution of the societal priorities for each issue, based on own idea of future development of human societies.
6. Answer the questions raised.

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Website:

- http://www.geoethics.org/ (IAPG – International Association for Promoting Geoethics)

APPENDIX 3: GEOETHICS AND GEOLOGICAL RISKS

Co-funded by the Erasmus+ Programme of the European Union

GOAL Educational Resource

AUTHORS	Silvia Peppoloni (INGV, Italy) & Giuseppe Di Capua (INGV, Italy)
TITLE OF THE CASE	Geoethics and geological risks
SHORT CASE DESCRIPTION	The development of a culture centered on preventive actions is a way to improve the resilience of societies to dangerous geological events. This needs firstly the development of the societal awareness on geological risks and their implications for human communities. Geoscientists are at the forefront of the defense against geological risks.
KEYWORDS	Disaster cycle; Geoethics; Geological risks; Hazard; Prevention; Resilience; Risk communication; Risk education; Risk perception; Risk scenarios; Social actors.
PRIOR KNOWLEDGE	Basic knowledge on earthquakes, floods, volcanoes, tsunamis, landslides, and other geological hazards.
AIM	Giving an overview on geoethical aspects and implications in georisk management.
OBJECTIVES	• To know the role of geoscientists in the defense against georisks. • To become aware on social actors involved in a risk scenario and their responsibilities. • To understand that prevention strategies require the engagement and partnership of all parts of society. • To understand the importance of concepts like "probability" and "uncertainty" in risk analyses. • To know some keywords used in georisks management.
CASE	Developing preventive strategies requires accurate geoscience communication, diffused geo-education, and access to reliable scientific information, as well as effective governance. It also depends on improving communities' awareness on geological risks and the capacity to assess and establish reasonable and acceptable risk thresholds for society. This can help to facilitate the adoption of strategies to reduce the likelihood of potentially damaging geological events or processes occurring, or the transformation of such events into disasters. This educational resource is based on a video that provides an overview on the geoethical aspects and implications in georisk management, by introducing several key concepts: prevention, probably and uncertainty,

risk scenario and its actors, geoscientists as social actors and their role, defense system, disaster cycle, operational protocols in emergency phase, science-society interface, citizen science.
The video is formed by 5 blocks entitled:
1) Geological risks and prevention; 2) Prevention as a value; 3) The risk scenario; 4) Geoethics in georisk management; 5) How can geoscientists support society in the georisk defense?
The video is conceived as a tool to set up further reflections and discussions aimed at raising students' awareness about individual, professional, social roles and responsibilities of geoscientists, and building a shared framework of concepts and values used in georisks studies and management.

QUESTIONS

1. Which is the difference between hazard, vulnerability, exposure, and risk?
2. What are "probability" and "uncertainty"?
3. Which are social actors involved in a risk scenario?
4. What is the social role of geoscientists, as researchers and/or professionals, in the defense against georisks? Which are their ethical and social obligations? How they can help society to face georisks?
5. Who should communicate hazards to society? Who should take decisions during an emergency phase?
6. Which are the best strategies to educate people to defense against georisks?
7. How people can have an active role in the defense against georisks?

PROCEDURE

Preparation:

1. Watch the video "Geoethics and geological risks" (https://youtu.be/rZSjzOxiGUk), without any preliminary introduction or comment.
2. Elaborate questions (1 through 7).
3. Watch the video again and stop it at the end of each block to start a more in-depth discussion and reflection about contents of the specific block.
4. Read articles listed in the references.

Working Group (4-5 students):

1. Open a discussion on possible meaning and implications of key-concepts listed in the section "Case". Each group should report briefly results of the discussion to all other groups.
2. Each group should collect information through Internet, by visiting websites of scientific organizations, institutions, research institutes, universities, governmental agencies, about hazards and risks affecting the town in which the group is located. Results should be summarized and discussed the working groups, to define possible interventions and their priorities.
3. Set a risk scenario (role-playing game): each working group assume

the roles of different actors involved in a fictional risk scenario (related to an impending risk due to an earthquake, a flood, a tsunami, a possible volcanic eruption). Each working group takes responsibility for acting out these roles within a narrative (leaded by the teacher), in order to explore demands, expectations, responsibilities, possible decisions of each actor. Dialogue among actors should lead to take shared decisions on how to face one or more phases in a disaster cycle (Disaster mitigation: directly preventing future emergencies and/or minimizing their negative effects. Disaster preparedness: plans or preparations made in advance of an emergency that help individuals and communities get ready. Disaster response: any actions taken during or immediately following an emergency, including efforts to save lives and to prevent further property damage. Disaster recovery: happens after damages have been assessed and involves actions to return the affected community to its pre-disaster state or better – and ideally, to make it less vulnerable to future risk).

4. Answer the questions raised.

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APPENDIX 4: EARTH SYSTEM NEXUS HUMAN INTERACTION: A GEOETHICAL PERSPECTIVE

Co-funded by the Erasmus+ Programme of the European Union

GOAL EDUCATIONAL RESOURCE

AUTHORS	Cristina Calheiros (University of Porto, Portugal), Nir Orion (Weizmann Institute of Science, Israel) & Clara Vasconcelos (University of Porto, Portugal)
TITLE OF THE CASE	Earth system nexus human interaction: a geoethical perspective
SHORT CASE DESCRIPTION	Paço de Calheiros is a manor house and farm involved in many activities. It is a special place where the water (hydrosphere), the soil (geosphere) and the local climate (the atmosphere and its close interactions with the geosphere) are very important. Geoethical dilemmas arise as the sustainability of this heritage may be in jeopardy.
KEYWORDS	Geoheritage; Georesources; Sustainability; Water cycle.
PRIOR KNOWLEDGE	Earth sub-systems; Geoheritage; Georesources; Holistic view of the Earth system.
AIM	Promotion of geoethical values (ethical, cultural and social) related to human interaction with the Earth system through reflection on georesources, geoheritage and the need for geoscientists to raise public awareness of their work.
OBJECTIVES	• To defend geoethical values to preserve the Earth system (social value). • To enhance the geological landscape by raising human aesthetic values like, for example, respect for the land that sustains our lives (cultural value). • To understand the need to strictly respect the natural systems and dynamics when designing interventions on the environment (ethical value). • To discover ways of protecting and enhancing geodiversity for the sustainable development of communities (ethical value). • To develop sustainable activities in order to ensure energy supply and natural resources for future generations (social value). • To explain the work of geoscientists to better preserve the Earth system (ethical value). • To bolster citizens' awareness of the work of geoscientists (social value). • To boost geoethical education in schools and in higher education (social value). • To raise citizens' awareness of geoethics (social value).

CASE

Paço de Calheiros is a 17th century manor house with a 13 ha farm located on a rural hilltop in the Lima Valley, in northern Portugal (fig.1). The house was built with local resources, essentially made from granite, and is classified as a Monument of National Interest. Its surroundings are classified as Historic Gardens by the Association of Historic Gardens of Portugal. It is now owned by the third Count of Calheiros. The family is historically connected to the foundation of Portugal, in 1143. The farm's main activities involve the management of: tourism, vineyards, wine production, small corn production, vegetable garden and a chestnut forest (fig.2).

Fig. 1 – Paço de Calheiros.

Fig. 2 – Example of activities at Paço de Calheiros: a) chestnut forest, b) vegetable garden, c) vineyards and corn production, d) tourism.

In a rural context, the management of water cycles is of the upmost importance, essential to the community's freshwater supply (for farming and other agricultural activities), as well as to ensure the water quality after its use. In this case, the wastewater from the main house is treated in a constructed wetland and reused for irrigation in the gardens. The amount of water required to meet the demand for food, energy, human uses and the ecosystem is associated to uncertainties regarding the impact of climate change. The heart of Paço de Calheiros farm is its freshwater spring. This phenomenon of the hydrosphere is a result of interactions between the geosphere and the atmosphere. The topographic height of this area, an outcome of the geosphere, influences the temperature of the atmosphere and, therefore, the amount of precipitation (rainfall) in this granitic area. The geological forces have formed granite joints through which rainfall enters the unconfined aquifer and crosses its unsaturated area. As the water table is at a higher level than the unconfined aquifer, together with the slope inclination, the underground water appears at the surface of the farm as a spring (Fig.3).

Fig. 3 – Water spring.

A stream flows down the hill, a part of which passes through the farm (Fig.4). This is part of a decades-old agreement, establishing the farm's right to a certain amount of water. Accordingly, the records show that the farm would always be entitled to enough water to push an orange downhill (Fig.5).

Fig. 4 – (a) stream passing near the farm, (b) waterway flowing through the farm.

The type and the quality of this farm's wine - vinho verde (the name literally means "green wine" but is translated as "young wine" because it is bottled 3-6 months after the grapes are harvested) is also directly related to the interactions between Earth systems (Fig.6). The water (hydrosphere), the soil (geosphere) and the climate in this area (the atmosphere and its close interactions with the geosphere) are favorable to vines that produce a light, fresh wine, as in the case of this farm. Many of the small farmers usually train their vines high off the ground (up trees, fences, and even telephone poles) in order to cultivate vegetable crops below them, regarded as a supplementary food source for their families (Fig.7). Thus, the farm is part of the socio-cultural heritage of this region and preserves its geological heritage (landscape).

Fig. 5 – Water pushing an orange in the farm's canals.

Fig. 6 – Vineyards at Paço de Calheiros.

Fig. 7 – Food production under the vines.

The Count of Calheiros was walking through the farm with his grandson and questions arose when reflecting on the surroundings and geologic site. The grandson started thinking about the future of the farm and asked some questions.

QUESTIONS

1. What would happen if the spring that provides the house with water should run dry?
2. If there were a decision to divert the part of the stream the farm has a right to (for example, to support building a factory that would bring jobs to the village inhabitants), what would be the impact on wine production and organic farming?

3. If a road were to be built across the farm (for example, to improve access to the main village), to what extent would we be able to preserve the geological heritage?
4. What are the consequences of not informing the owners of these houses and the village inhabitants about the area's geology?
5. How can we avoid the risk of not preserving this geoheritage site?

PROCEDURE

1. Watch the video (https://youtu.be/TMM2XgHBc3w) and the video (https://youtu.be/QzINvZ4HN4A) and think about possible answers to the questions.
2. Read the following articles, "Peppoloni, & Di Capua (2017)" (https://goal-erasmus.eu/wp-content/uploads/2019/02/GEOETHICS-ETHICAL-SOCIAL-AND-CULTURAL-VALUES-IN-GEOSCIENCES-RESEARCH-AND-PRACTICE.pdf) and "Bobrowsky et al (2017)" (https://goal-erasmus.eu/wp-content/uploads/2018/10/Emerging_Field_Geoethics.pdf), and write down some Geoethical values that may be at risk in this site and which ones citizens should fight for in order to preserve this geoheritage. Think especially about the Geoethical values involved in preserving the water supply as well as the wine and agricultural production.
3. Read the Agenda 2030 for Sustainable Development (https://www.un.org/sustainabledevelopment/development-agenda/) and try to relate the targets of the Agenda and the Geoethical values that can contribute to bolstering their fulfilment.

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APPENDIX 5: CAN WE DARE SAY MODERN SOCIETY DOES NOT NEED MINERAL RAW MATERIALS?

Co-funded by the Erasmus+ Programme of the European Union

GOAL EDUCATIONAL RESOURCE

AUTHORS	Clara Vasconcelos (University of Porto, Portugal), Tiago Ribeiro (University of Porto, Portugal) & Alexandre Lima (University of Porto, Portugal)
TITLE OF THE CASE	Can we dare say modern society does not need mineral raw materials?
SHORT CASE DESCRIPTION	Mining is an activity that has been done for ages all over the world. Nevertheless, it is undeniable that it causes environmental impacts in sites that have a profound ecological and cultural importance to the people who have lived there for many years. Mining damages are not only about the land and environment, they are also about people. But can we dare say we can live without it? In this case we explore the possible lithium mining in Portugal where huge controversies are being established between inhabitants, mass media, geology experts and mining companies.
KEYWORDS	Geoethical values; Lithium; Mining; Transparent communication.
PRIOR KNOWLEDGE	Exploitation; Exploration; Mineral resources; Mining.
AIM	Promote a reflection about the increasing demand for minerals from developing countries and upon transparent dissemination of information by all actors directly involved in mining.
OBJECTIVES	• To defend social and cultural values to preserve the land where mining is made. • To appraise the need for mineral resources in the smooth running of modern society life in the 21st century. • To explain geoscientist work to better preserve the land and environment in mining sites. • To value the sense of respect for those who live in a land for thousands of years. • To defend a concrete commitment to managing the economic, social and environmental challenges related to mining and ensure responsible extraction of minerals. • To select open communication strategies engaging all actors involved in mining process. • To plan trusting and transparent dissemination by all actors directly involved in mining in order to promote a sustainable benefit for all parties.

- To judge activities that do not protect the environment and do not minimize nor mitigate negative impacts on land and communities.

CASE

FIRST SCENARIO:

Lithium (Li) is the third element of Mendeleev's periodic table (fig.1). Currently, given the lithium's properties and its main compounds, such as carbonates, chlorides, and lithium hydroxide. This element has high potential recognized applied to technology, especially green technologies, presenting a great economic and environmental importance.

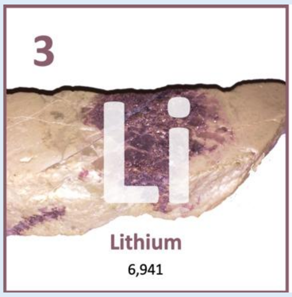
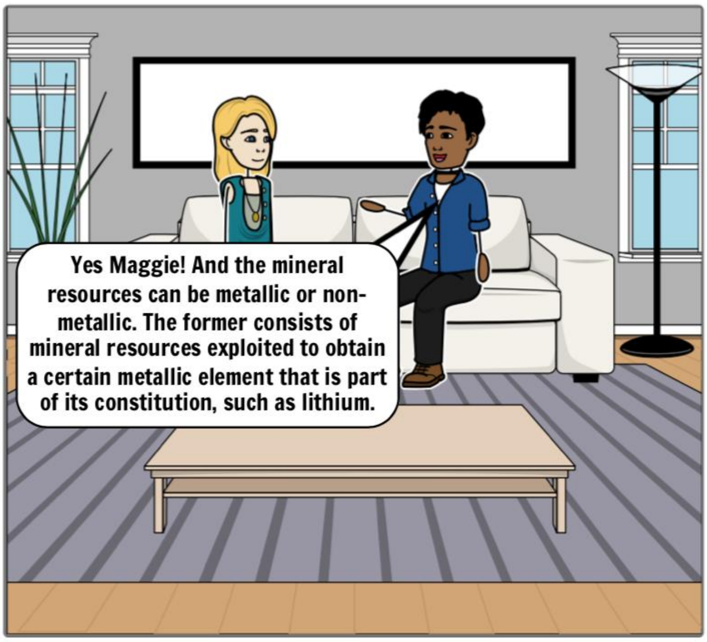
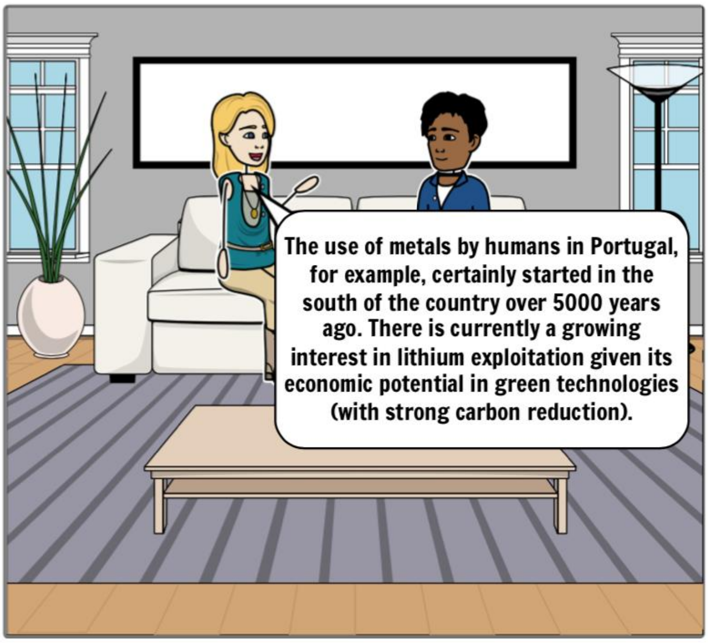


Fig. 1 – Lithium: present on lepidolite mineral (Li phyllosilicate). Credits: Tiago Ribeiro (2019).

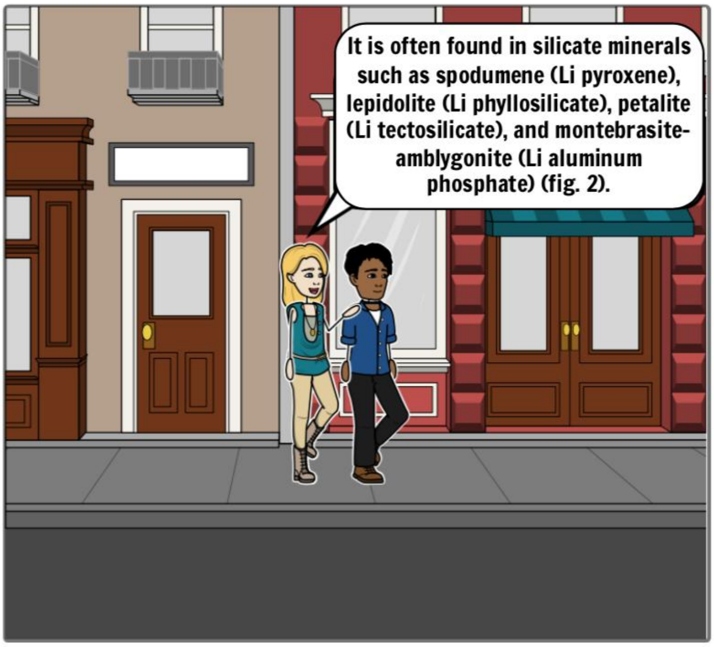
In Portugal, there are several regions with high potential for lithium exploration, located mainly in the north and center of the country. The possible exploitation of lithium in Portugal has caused great controversy, mainly in the populations near the potential exploration and exploitation zones.

1. Read the dialogue about the lithium, also known as Portuguese white petroleum.


Yes Maggie! And the mineral resources can be metallic or non-metallic. The former consists of mineral resources exploited to obtain a certain metallic element that is part of its constitution, such as lithium.


The use of metals by humans in Portugal, for example, certainly started in the south of the country over 5000 years ago. There is currently a growing interest in lithium exploitation given its economic potential in green technologies (with strong carbon reduction).


And in what minerals do we find lithium?


It is often found in silicate minerals such as spodumene (Li pyroxene), lepidolite (Li phyllosilicate), petalite (Li tectosilicate), and montebrasite-amblygonite (Li aluminum phosphate) (fig. 2).

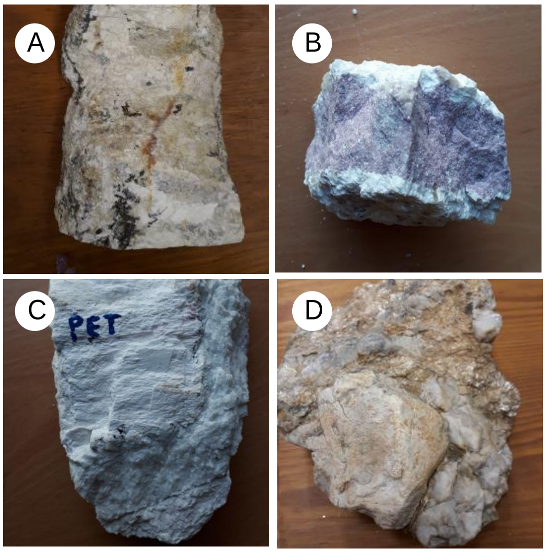
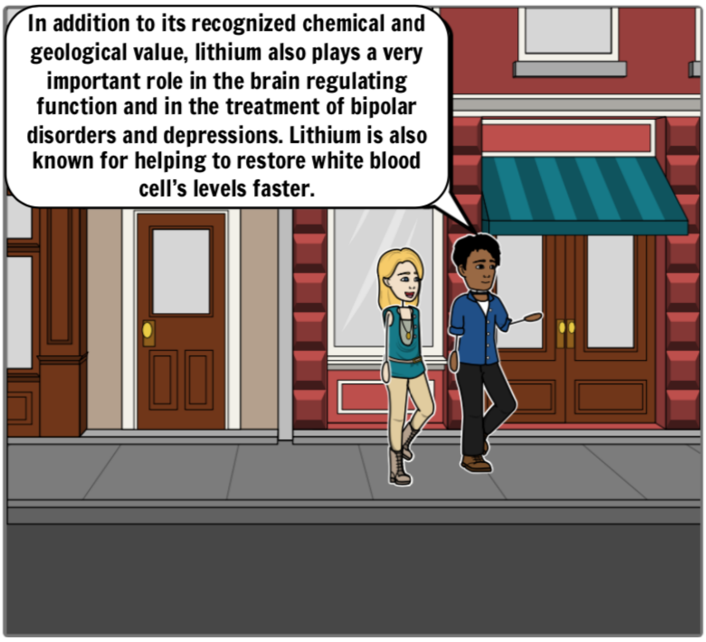
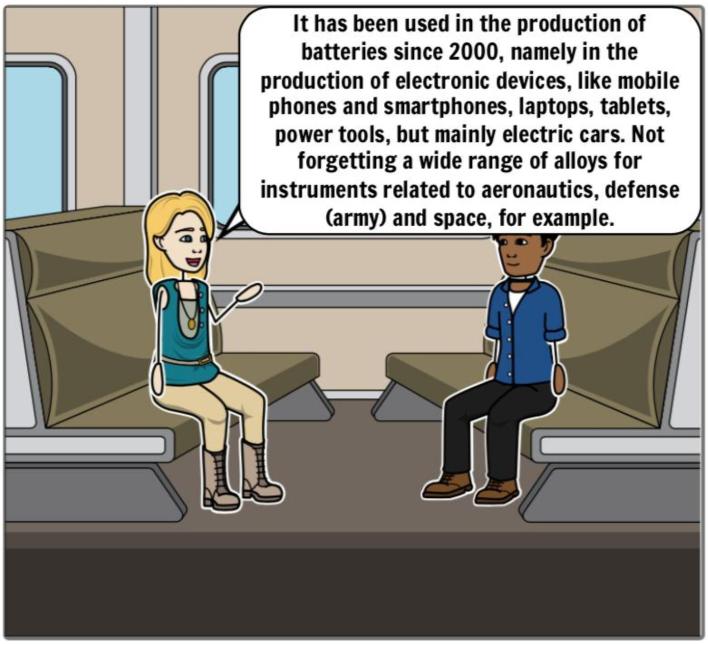
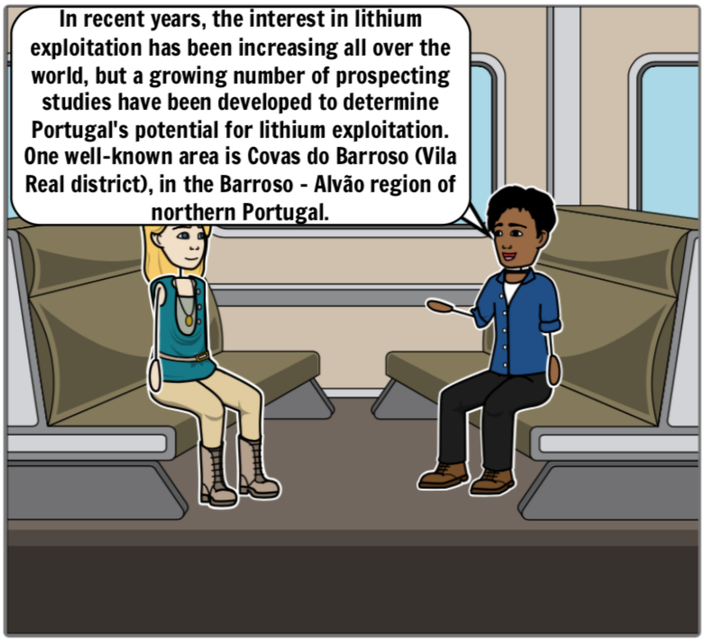


Fig.2 – Lithium minerals' hand specimens: A. Spodumene (Li pyroxene); B. Lepidolite (Li phyllosilicate); C. Petalite (Li tectosilicate); D. montebrasite-amblygonite (Li aluminum phosphate). Credits: Alexandre Lima (2019).




It has been used in the production of batteries since 2000, namely in the production of electronic devices, like mobile phones and smartphones, laptops, tablets, power tools, but mainly electric cars. Not forgetting a wide range of alloys for instruments related to aeronautics, defense (army) and space, for example.


In recent years, the interest in lithium exploitation has been increasing all over the world, but a growing number of prospecting studies have been developed to determine Portugal's potential for lithium exploitation. One well-known area is Covas do Barroso (Vila Real district), in the Barroso - Alvão region of northern Portugal.

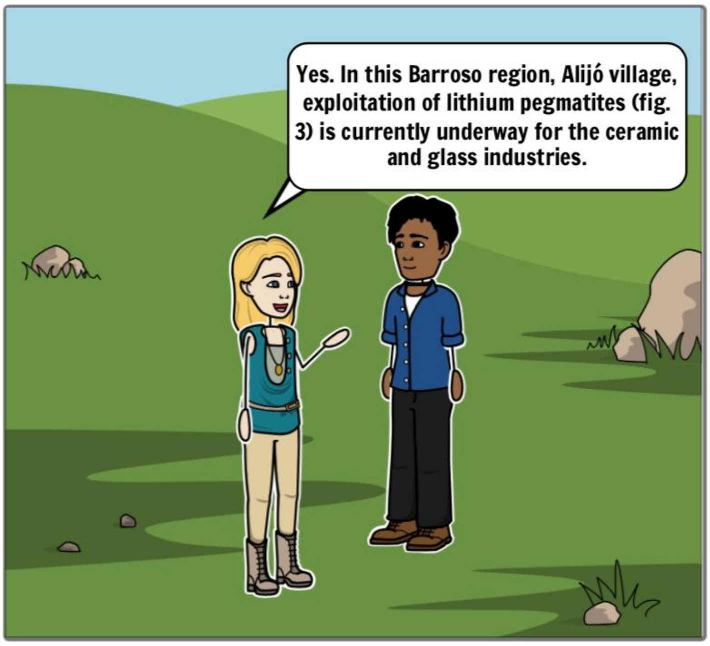
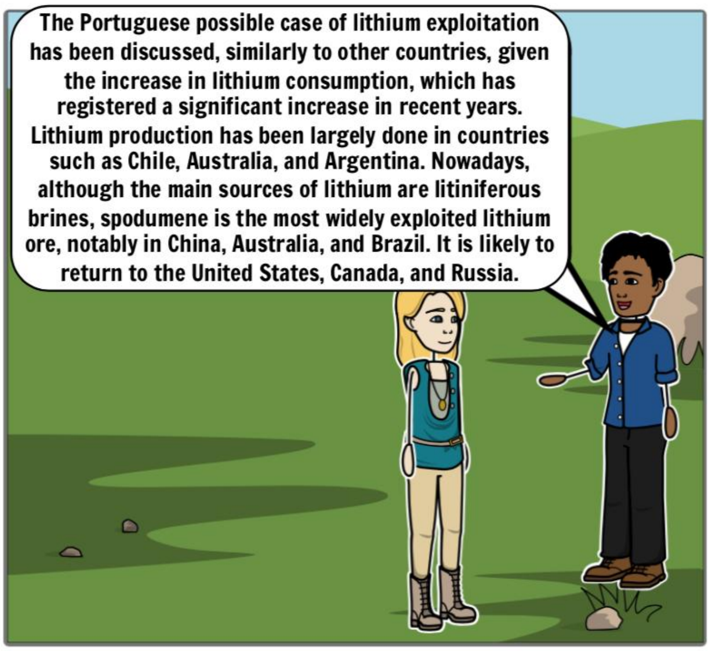
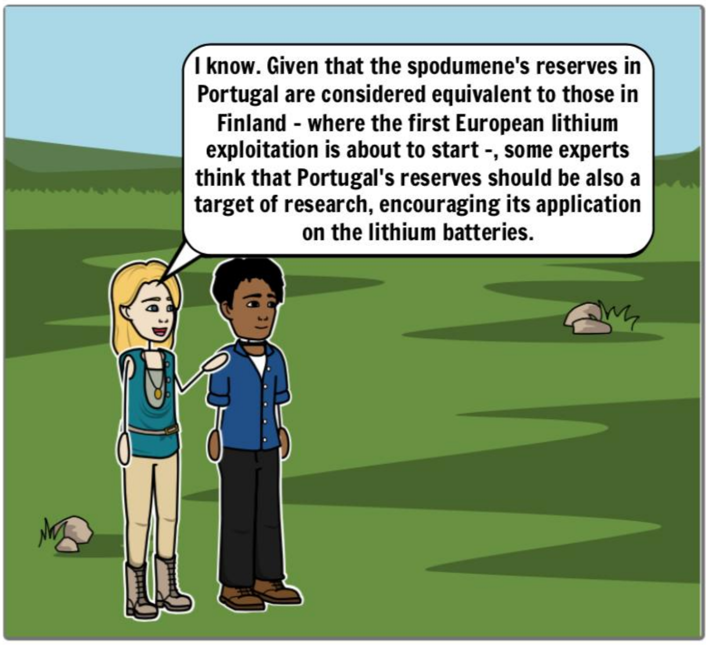
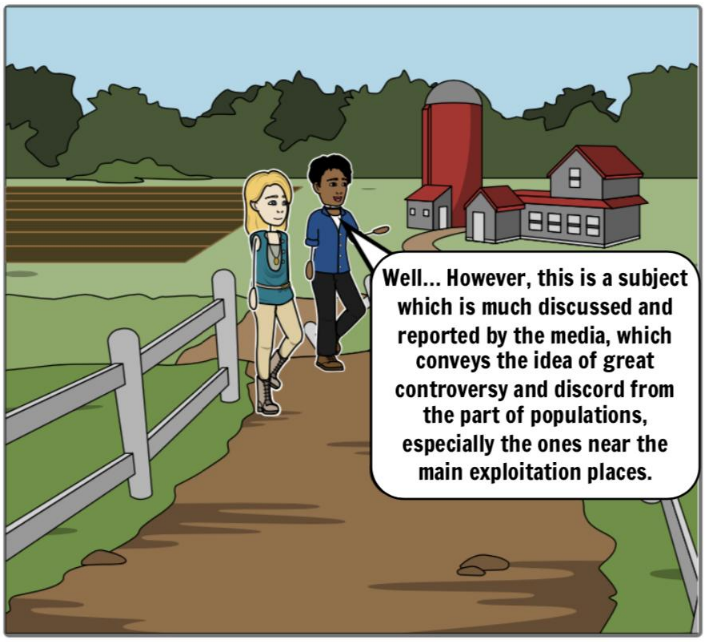
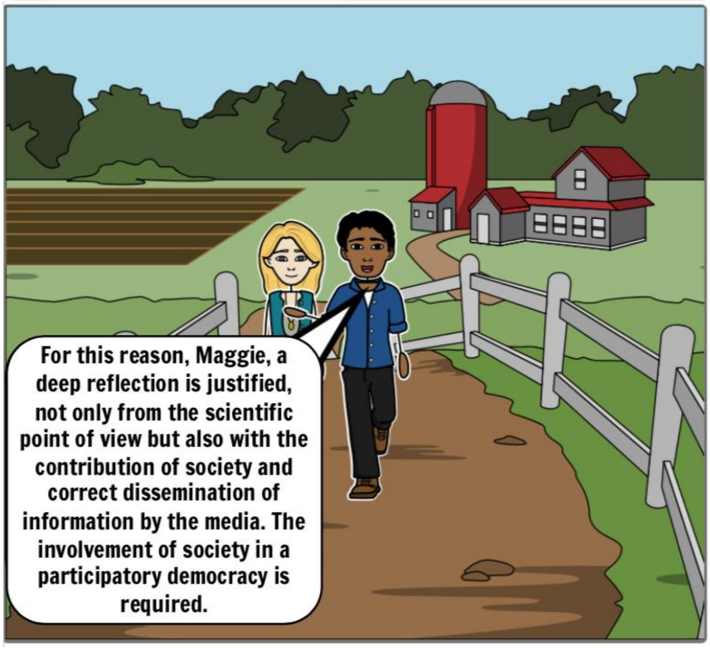


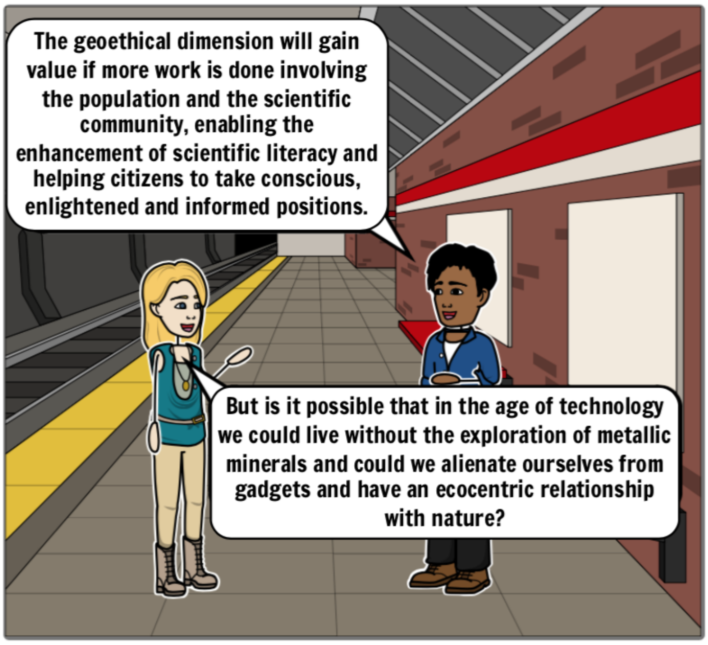
Fig.3 – Lithium pegmatite exploitation in the village of Alijó (Barroso's region). Credits: Alexandre Lima (2019).


The Portuguese possible case of lithium exploitation has been discussed, similarly to other countries, given the increase in lithium consumption, which has registered a significant increase in recent years. Lithium production has been largely done in countries such as Chile, Australia, and Argentina. Nowadays, although the main sources of lithium are litiniferous brines, spodumene is the most widely exploited lithium ore, notably in China, Australia, and Brazil. It is likely to return to the United States, Canada, and Russia.


I know. Given that the spodumene's reserves in Portugal are considered equivalent to those in Finland - where the first European lithium exploitation is about to start -, some experts think that Portugal's reserves should be also a target of research, encouraging its application on the lithium batteries.


Well... However, this is a subject which is much discussed and reported by the media, which conveys the idea of great controversy and discord from the part of populations, especially the ones near the main exploitation places.


For this reason, Maggie, a deep reflection is justified, not only from the scientific point of view but also with the contribution of society and correct dissemination of information by the media. The involvement of society in a participatory democracy is required.



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SECOND SCENARIO:

The possibility of spodumene-based lithium deposits' exploitation in Covas do Barroso (Portugal) is being discussed. This public controversy has created a vast deal of information from the media, leading to the existence of radical opinions in society, particularly in the inhabitants of this region. Although there is talk about the existence of lithium mining activities in Barroso, these activities are still under analysis. Before advancing the lithium exploitation, a favorable environmental impact evaluation study is compulsory. Without it, the companies are simply authorized to perform prospecting operations.

1. Watch the video https://youtu.be/SVfUk32LmgQ.

QUESTIONS

1. What are the consequences of a not correct dissemination of mining procedures by all actors involving in the mining process?
2. How important is the mining process dissemination given by the mass media to inform inhabitants?
3. Suggest ways of how the negative impacts in environment and local communities can be minimized and mitigated?
4. List a plan of rehabilitation based on environmentally and socially sustainable standard elements and management systems in a mining site.
5. Can we dare say modern society does not need mineral raw resources? - compile a list of resources you use everyday that depend on raw materials to be built (you can start with your *smartphone*…).

PROCEDURE

1. Watch the video *Geoethics and responsible use of geo-resources* (https://www.youtube.com/watch?v=G1eRIoV_6uw).
2. Read the *White paper on responsible Mining* written by IAPG Task Group on Responsible Mining (https://goal-erasmus.eu/wp-content/uploads/2018/10/White_Paper_on_Responsible_Mining_IAPG_2017.pdf) and think in possible answers for the questions.

Important links:

- https://www.publico.pt/2019/05/13/economia/opiniao/litio-metal-futuro-portugal-1872284?fbclid=IwAR1GdfDswTzhYnOQ6gKzG_uIj54gtc7wzuE3SL%20tyfgkV7qbL6tw1hK1ghdU
- https://www.youtube.com/watch?v=IXawf9OBOyw

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APPENDIX 6: GOOD PRACTICES IN THE PROMOTION OF GEOETHICAL VALUES IN A UNESCO GLOBAL GEOPARK

Co-funded by the Erasmus+ Programme of the European Union

GOAL EDUCATIONAL RESOURCE

AUTHOR	José Brilha (University of Minho, Portugal)
TITLE OF THE CASE	Good practices in the promotion of geoethical values in a UNESCO Global Geopark
SHORT CASE DESCRIPTION	In the Arouca's UNESCO Global Geopark (Northern Portugal) mining activities and geoconservation co-exist and together promote sustainable use of geoheritage with benefits either to local communities and to the international scientific community.
KEYWORDS	Fossils; Geoheritage; Geotourism; Sustainability.
PRIOR KNOWLEDGE	Fossil; Geodiversity; Geoheritage; Geotourism; Global geopark.
AIM	Develop awareness of geoparks as key territories with innovative strategies fully engaged with geoethical principles.
OBJECTIVES	• To recognize the three main pillars of a geopark strategy - geoconservation, education, and geotourism. • To explain that the value of geoheritage is based on sound scientific knowledge produced by the geoscientific community. • To defend the need for a good balance between the exploitation of geological resources and preservation of geoheritage. • To list natural and anthropic threats that can jeopardize geoheritage. • To recognize that mining may affect negatively geoheritage and, at the same time, could be a way to reveal new important geological features. • To explain the importance to communicate geological knowledge in a way to be understood in general terms by laypeople. • To defend the need for effective management of fossils avoiding illegal selling and smuggling. • To illustrate the role of local communities in the conservation of geoheritage raising the sense of land belonging in the inhabitants due to their natural heritage. • To relate the geopark concept with specific UN Sustainable Development Goals.

CASE

A "Global Geopark" is an official label given by UNESCO since 2015 to territories that have successfully proved to comply with the geopark principles, integrating a Global Network that has already 147 members in 40 countries (data as of 2019). The Arouca Geopark in Northern Portugal, presently a UNESCO Global Geopark, was established in 2009 (Fig.1).

Fig. 1 – Location of Arouca UNESCO Global Geopark in Portugal.

The inventory of geoheritage revealed the existence of about 40 geosites in an area of 330 square kilometers. Some of these geosites have international scientific value, one of the necessary requisites for UNESCO recognition.

The Valerio's quarry is one of these geosites with high scientific relevance. It is a slate quarry operating accordingly with the Portuguese legislation and where layers of Ordovician slate offer magnificent exemplars of giant trilobites. Trilobites are fossils of extinct marine animals, usually with a few centimeters long. However, in this quarry and due to conditions not yet fully understood by paleontologists, these trilobites may reach 50 cm long (Fig.2).

Fig. 2 – Trilobites in the center's exhibition.

	These are the longest trilobite fossils in the world, which makes these fossils a geoheritage with international scientific value. Usually, quarrying is considered a major threat to geoheritage. However, Valerio's quarry geosite is a good example to show that mining and geoconservation are not impossible to co-exist. The owner of the quarry has developed a deep knowledge and fascination about trilobites, and he collects all fossils that appear during the normal quarrying operation. These fossils are properly collected and stored, studied by paleontologists and the main exemplars are available to be appreciated by the general public and students in the interpretative center that was built specifically for this aim by the quarry company. This interpretative center is, quite obviously, a certified partner of the Arouca UNESCO Global Geopark. Valerio's quarry geosite constitutes a best- practice case showing that with proper management it is possible to have quarrying and geoconservation in the same place. This is particularly relevant because not only the exploitation of a mineral resource is important for the local economy but also because the scientific, educative and touristic use of geoheritage is assured, also bringing benefits for the local community.
QUESTIONS	**1.** What is a geopark? **2.** How many geoparks exist in the world? **3.** Why geoparks are innovative land-use planning tools? **4.** Why mining is usually considered a threat to geoheritage? **5.** How can geoconservation be assured if society needs to exploit tons of geological resources every day? **6.** How is it possible to have mining inside a geopark? **7.** How can mining contribute positively to geoconservation? **8.** What is the consequence for the local community to have a mining and geoconservation in the same place? **9.** Describe the impacts of illegal selling and smuggling of fossils and minerals. **10.** Relate the best-practices identified in the Arouca UNESCO Global Geopark with specific UN Sustainable Development Goals. **11.** Explain how geoparks can be considered a showcase of geoethical values in practice.
PROCEDURE	**1.** Setup work groups of students and hand out one paper mentioned in the references to each group. After some minutes, each group has to present the main ideas of the paper to the classmates. **2.** Presentation of the PowerPoint' slides by the teacher: https://goalerasmus.eu/wp-content/uploads/2019/12/PP_Arouca.pdf **3.** The teacher should promote questioning and write in the board the main questions raised. **4.** The same work groups have to search for relevant information in order to be able to present possible answers to the questions. **5.** Final discussion promoted by the teacher in order to clarify the main topics presented as aims.

	Important links: - Arouca UNESCO Global Geopark: http://www.aroucageopark.pt/en/ - UNESCO Global Geoparks: http://www.unesco.org/new/en/natural-sciences/environment/earth-sciences/unesco-global-geoparks/ - UNESCO Global Geoparks: celebrating earth heritage, sustaining local communities: https://unesdoc.unesco.org/ark:/48223/pf0000243650 - UN Sustainable Development Goals: https://www.un.org/sustainabledevelopment
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APPENDIX 7: A GEOETHICAL CONFLICT IN “LO HUECO” FOSSIL SITE

Co-funded by the Erasmus+ Programme of the European Union

GOAL EDUCATIONAL RESOURCE

AUTHORS	Daniel DeMiguel (ARAID & Universidad de Zaragoza, Spain), Beatriz Azanza (Universidad de Zaragoza & IUCA, Spain) & Guillermo Meléndez (Universidad de Zaragoza & IUCA, Spain)
TITLE OF THE CASE	A geoethical conflict in "*Lo Hueco*" fossil site
SHORT CASE DESCRIPTION	The exceptional Late Cretaceous site of *Lo Hueco* in Central-East Spain has yield an enormous, new and unusual unexpected concentration of dinosaurs in 2007 as a result of works in infrastructure development, and constitutes one of the best world- case examples of how to solve a conflict between infrastructure construction and the preservation of the fossil heritage, with benefits either for the administration and to the scientific community.
KEYWORDS	Agreement; Fossils; Geoethical conflict; Geoheritage; Paleontology.
PRIOR KNOWLEDGE	Dinosaurs; Fossils; Geodiversity; Geoheritage.
AIM	Develop knowledge and awareness about geoethical conflicts between works of infrastructures and the geoconservation of paleontological sites, and the discovery of new fossils.
OBJECTIVES	• To understand that the value of fossils is based on sound scientific knowledge produced by the geoscientific community. • To examine the solutions found in this real-case study for the conservation of the paleontological heritage from a geoethical perspective. • To discuss the cultural value of the paleontological heritage and the impact of its conservation on society, in environmental, cultural and economic terms. • To debate the need for a proper balance between development of infrastructures and development of works, with preservation of heritage. • To relate the conservation of the paleontological heritage with the sustainability of the Earth. • To raise citizens’ awareness of geoethics.

CASE

In May 2007, a small hill named "*Lo Hueco*", near the village of Fuentes (Cuenca, Central-East Spain), was excavated in the frame of the works under the construction of the Madrid-Levante high-speed railway by the company ADIF (*Administrador de Infraestructuras Ferroviarias*) (http://www.adif.es/en_US/index.shtml) (Fig.1). The archaeologists discovered an unexpected and extraordinary amount of large bone remains assigned to Upper Cretaceous (70-80 million years) sauropod titanosaurs (Barroso-Barcenilla et al., 2009; Ortega et al., 2008;). Preliminary fieldworks revealed a rich and varied fossil assemblage in the outcrop, works on the railway stopped, and an urgent and systematic paleontological excavation started. Given that there was no preliminary evidence on the surface that indicated the presence of a deposit of these characteristics, it was necessary to rethink the strategy of action in the section. The railway works were paralyzed in the area to facilitate the location, documentation and protection of the fossils. The excavation forced to introduce a modification in the construction works of the Madrid-Levante high-speed line, already in service, at the location of the site, where a tunnel was planned, and in order to preserve it, the section in trench was built. All this gradually involved more than 60 paleontologists and 100 manual workers from diverse public institutions and private companies and continued until December 2007.

Fig. 1 – Aerial view of the palaeontological site of *Lo Hueco* (right) and detailed picture of the works. (Adapted from from Barroso-Barcenilla et al., 2009, p. 1269).

Lo Hueco is located at a short distance from two other very important paleontological sites: *Las Hoyas*, with fauna and flora remains from the Lower Cretaceous (about 130 million years ago), and *Portilla*, with a same age as *Lo Hueco*, which constitutes an area enriched in remains of dinosaur eggs attributable to titanosaur dinosaurs.

Lo Hueco is considered to be a Fossil-Lagerstätten (as exhibits extraordinary fossils with exceptional preservation—sometimes including preserved soft tissues) sedimentary deposit (Fig.2), and the fossil collection excavated (with more of 14.000 remains) constitutes one of the largest and most relevant collections (mainly of fishes, turtles, lizards, crocodiles, dinosaurs and vegetal remains) not only in the Iberian record but also in the European one of the upper-most stages of the Upper Cretaceous (see Ortega et al., 2008; Barroso-Barcenilla et al., 2009; Cambra-Moo et al., 2012). Apart from this scientific value, the paleontological record of *Lo Hueco*, specially that concerning the dinosaurs, contains all the necessary elements to be a reference for the social culture as well.

Fig. 2 – Zone of excavation (left) near the railway works and example of square (right) showing the unusual concentration of fossil (specially sauropod titanosaur) remains including articulated bones. Retrieved from: http://www.adifaltavelocidad.es/.

The Science Museum of Cuenca was not being able to accommodate all the tons of fossils and sediments excavated that resulted from *Lo Hueco*. As such, ADIF financed the rental of a warehouse where the deposit and laboratory of the collection were installed. Thanks to this discovery, the current museum was expanded, a new center was created (Fig.3) and man and researchers were hired.

Fig. 3 – Sauropod titanosaur vertebrae remains exposed in the Interpretation Center in Fuentes. Retrieved from: https://www.dinosauriosdecuenca.es/storage/contents/fichas/vertebrados_2-.jpg.

Thanks to the works carried out in *Lo Hueco*, in where there were no signs of any fossil site of such characteristics, new heritage has recently come to light. Without any other information, this can pose a very important geoethical conflict between the need of a new infrastructure construction and the preservation of a newly found fossil heritage of unique characteristics. However, the protection of the geoheritage (including the paleontological heritage) and geoconservation along the route of high-speed works is one of the essential principles of ADIF within its policy of Corporate Social Responsibility. This not only evidences that infrastructure works of a very high value for the economic and social progress of a

	country and other companies can help to the discovery of new paleontological heritage, but also that they can invest money to help to recover and promote this heritage.
QUESTIONS	**1.** What must prevail: the economic and social benefit of a new (necessary) infrastructure or the conservation of the nature (which is indeed a social benefit as well)? **2.** How can be predicted the location of new fossil sites? **3.** Why are the works on infrastructure usually considered a threat to paleontological heritage? **4.** What is the effect of having temporary works on infrastructure construction in parallel with excavations? **5.** How can the works of infrastructures contribute positively to the paleontological heritage? **6.** What are the possible consequences of human activities, carried out in "*Lo Hueco*", in the geosphere and, consequently, in the Earth system? **7.** What is the consequence for the local community to have an excavation and a railway work in the same place? **8.** To what extent can geoethics values and principles help to solve this conflict?
PROCEDURE	**1.** The preparation for this activity should use the information available in scientific publications and media (newspapers, photos, TV videos, and others) most of them provided in the section references and links. **2.** Watch the video pill: "*GOAL: Geoethics issues and geoethical dilemmas*" – https://youtu.be/1KBFAqMMnpo. **3.** Virtual fieldtrip: a) Use of the website (https://www.dinosauriosdecuenca.es/centro-expositivo-fuentes/vertebrados) of the interpretation center in Fuentes for a virtual fieldtrip. b) Start a plenary debate with students facilitated by the teachers about the Late Cretaceous fossil site of "*Lo Hueco*". The plenary debate will start with the participation of all students and teachers and, if possible, with paleontologists and personnel from the Administration (these latter related with this real case as much as possible). c) The debate should finalize with only the presence of the students and the teacher to discuss ideas in an environment with no external pressure. **Important links:** ☐ https://www.diariosur.es/20071106/sociedad/descubierto-cuenca-mayor-yacimiento-20071106.html ☐ https://www.20minutos.es/noticia/300060/0/cementerio/dinosaurios/fuente/

	☐ https://www.europapress.es/castilla-lamancha/noticia-yacimiento-hueco-fuentes-cuenca-mas-importante-dinosaurios-peninsula-iberica-20071031160450.html ☐ https://elpais.com/diario/2007/11/16/sociedad/1195167605_850215.html
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APPENDIX 8: GEOETHICAL ASPECTS OF HYDROPOWER PLANTS

Co-funded by the Erasmus+ Programme of the European Union

GOAL EDUCATIONAL RESOURCE

AUTHORS	Günter Langergraber (BOKU, Austria), Sebastian Handl (BOKU, Austria), Susanne Schneider- Voß (BOKU, Austria) & Markus Fiebig (BOKU, Austria)
TITLE OF THE CASE	Geoethical aspects of hydropower plants
SHORT CASE DESCRIPTION	Hydropower is a renewable source of energy that is considered widely as "green" energy. However, the infrastructure required to produce hydropower (e.g. dams) has numerous impacts on the river ecosystem. Geoethical conflicts and dilemmas shall be discussed based on the case of a small hydropower plant along the Salza river.
KEYWORDS	Geoethical aspects; Hydropower; Riverine ecosystems; Water management.
PRIOR KNOWLEDGE	Basic ethics; Riverine ecosystems; Water management.
AIM	Critically reflect and discuss the impact of using perceived "green energy" sources in an ecosystem context-based on the geoethical conflicts and dilemmas that arise when using hydropower.
OBJECTIVES	• To analyze the effects of hydropower plants on riverine ecosystems and the environment. • To understand the effects of hydropower on ecosystems conservation. • To know about the involved stakeholders in the decision-making process. • To become aware of geoethical conflicts and dilemmas related to hydropower. • To evaluate the importance of water as a non-renewable natural resource. • To predict how geosciences can help society in facing water demands in less favored countries.
CASE	Hydropower is a renewable source of energy that is considered widely as a source for "green" energy. However, the infrastructure (dams) required to produce hydropower has a big impact on the river system.

Fig. 1 – The Salza river is known for the beautiful landscape and water sports.

The Salza river (also Mariazeller Salza) is an eastern tributary of the Enns river. It originates in Lower Austria and flows South of Mariazell through the Styrian nature preserve of Wildalpener Salzatal and meets the Enns after 90 Km. The Salza is known as a pristine river and a popular spot for water sports (rafting, kayaking, etc.; Fig.1). Most water sport activities start downstream of the Prescenyklause. The Prescenyklause (Fig.2) was constructed with a weir (a small dam) for a saw mill in 1848. Today the water of the reservoir is used to power a small electric power plant.

Fig. 2 – The Prescenyklause 1931 (left) and today (right).

However, already for centuries, the Salza valley and neibouring valleys have been used as source for the enormous demand for wood of the metal industry on the Enns river. The wood has been transported on the rivers, firstly documented for the Salza river in 1373. The use of "Klausen" (lock for log floating) for rafting of wood has been a common practice in rivers with strong current. The Prescenyklause is the only structure remaining of the once large-scale water transport facilities in Enns, Salza and Mürzgebiet. As a monument of forestry services from the first half of the 19th century, it has been a listed as building of cultural heritage since 1974. Today, the Prescenyklause is in its original form resulting from careful repair.

Extensive renovations had been carried out in the years 1926 to 1928, and in 1951. In 1954, the rafting at the Prescenyklause stopped. Due to the massive construction of the Klause, it was possible to use it as a forest engineering building for more than 100 years. From 1985 to 1987 the Klause has been re-adapted to a power plant. Therefore, the existing dam has been renovated and reinforced and a tunnel has been struck into the rock next to the Klause. Now, the water flows through this tunnel and drives two turbines that produce electricity. The entire power plant is underground and therefore it is not visible. The cavern power plant is controlled by the headquarters in Mariazell. By this construction, it was possible to preserve the original Klause, and to secure its continued use at the same time (all the other old forestry hydraulic structures in Austria are expired and largely disappeared). The power plant has a power of about 1.5 MW.

A group of students from Vienna travelled to the Salza river for rafting and kayaking for a weekend. They enjoyed the nice scenery of the Salza river. However, when they had been transported to the starting point of their first kayak tour downstream from the Prescenyklause (Fig.3), they could see the massive contruction and questions of the impact of the Klause on the Salza river raised.

Fig. 3 – The starting point of kayaking tours downstream the Prescenyklause.

After a day of kayaking there was a lively discussion about hydropower during dinner. The following questions were raised:

QUESTIONS

1. Which are general impacts of dams on riverine ecosystems?
2. What are the stakeholders to be involved in the planning of a hydropower plant?
3. What geoethical conflicts and dilemmas are linked to hydropower plants, e.g. in terms of sustainability, "green" thinking and environmental impact?
4. Can all conflicts be solved to satisfy all stakeholders? How?
5. Which technical measures can be implemented at sites with hydropower plants in general and at the Prescenyklause in particular to improve the riverine ecosystem?
6. How to deal with the resulting dilemmas?
7. How to sustainably preserve water so future generations can benefit from this natural resource?

PROCEDURE

Preparation:

1. Read the introduction on geoethics (Peppoloni et al., 2019; http://docs.wixstatic.com/ugd/5195a5_23670a25b64a46249a971718c2fa6c9f.pdf)
2. Watch the video pill "*GOAL: Geoethics issues and geoethical dilemmas*" - https://www.youtube.com/watch?v=1KBFAqMMnpo
3. As introduction to the topic of hydropower, read the following chapters in the book "*Riverine Ecosystem Management - Science for Governing Towards a Sustainable Future*" (Schmutz &

Sendzimir, 2018 - https://link.springer.com/book/10.1007/978-3-319-73250-3)

a) Chapter 4 (River Hydrology, Flow Alteration, and Environmental Flow)
b) Chapter 5 (Hydropeaking Impacts and Mitigation)
c) Chapter 6 (Dams: Ecological Impacts and Management)
d) Chapter 9 (River Connectivity, Habitat Fragmentation and related Restoration Measures).

[For more detailed information, you can also read chapters 2, 8, and 24]

Group work (4-5 students):

1. As a warm-up, each student should write down his/her spontaneous mental connections with the "rivers" and "dams" (in keywords). Discuss in the group what kind of new ideas and concepts on the relation between humans and rivers evolved from these keywords. Summarize the results at the end of the group work.
2. Elaborate questions 1 through 6: Firstly, discuss the question in the groups. After each question the results from the groups are presented, discussed and summarized. This guarantees that each group has the same basis for discussing the next question.

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Further reading on specific aspects of hydropower:

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APPENDIX 9: WATER: A GEOETHICAL PERSPECTIVE ON ONE OF HUMANITIES MOST VALUABLE RESOURCE

Co-funded by the Erasmus+ Programme of the European Union

GOAL EDUCATIONAL RESOURCE

AUTHORS	Sebastian Handl (BOKU, Austria), Günter Langergraber (BOKU, Austria), Susanne Schneider- Voß (BOKU, Austria) & Markus Fiebig (BOKU, Austria)
TITLE OF THE CASE	Water: a geoethical perspective on one of humanities most valuable resource
SHORT CASE DESCRIPTION	The water supply for the Austrian capital Vienna is used as case-study and starting point to discuss geoethical implications on several aspects involved with the use of the renewable resource water. Geoethical conflicts and dilemmas are addressed that arise from the utilization pressure on the resources water and land use.
KEYWORDS	Geoethical aspects; Holistic thinking; Natural resources; Water management; Water supply.
PRIOR KNOWLEDGE	Basics of sanitary engineering; Water management; Water supply.
AIM	Promotion of geoethics values and principles related to the human interaction with the water cycle through the reflection about water as a mayor resource of life.
OBJECTIVES	• To analyze geoethical issues and dilemmas connected with water supply on two different spatial scales (local and global). • To understand the need to preserve natural systems and its dynamics when designing interventions on the environment. • To defend the involvement of all stakeholders in the decision-making process. • To contrast the objectives of different sectors with interest in water use. • To support Geoethical values to preserve a functional environment as the fundamental basis for renewable resources as drinking water. • To value public awareness of geoscientific work.

CASE

A group of students goes on a field trip along the two water mains of the Vienna Water Works in Austria.

At their first stop at the museum in Kaiserbrunn the students learn about the history of the Vienna water mains:

The provision of spring water for Austria's capital dates back to imperial times. Vienna's First Spring Water Main was established in 1873 initialized by the emperor of Austria Franz Joseph I., who gave the first spring "Kaiserbrunn" as a present to the city of Vienna to bring a long lasting solution to the cities ongoing problems with drinking water quality that resulted in disease and epidemics. The Second Spring Water Main was opened in 1910. Since that time the whole population of Vienna (about 1.8 Mio) is supplied with spring water of excellent quality. The Water runs into the city only by the force of gravity and by implementation of drinking water hydropower plants it additionally produces green electronic energy in a quantity equivalent to supply a city of about 50.000 inhabitants.

Fig. 1 – The "Kaiserbrunn"-Spring given to the people of Vienna by the emperor Kaiser Franz Joseph I.

The guide in the museum, who is also an employee of Vienna Water Works, explains some challenges that he and his colleges are facing at their daily work.

1) For the biggest share, Vienna Water Works is in possession of the land in the catchment area of the springs. Three typical land uses are conducted in in this area. Forestry is the historic economic backbone of the region. Therefore, the employees of Vienna Water Works nowadays are also concerned with forestry to establish and maintain the land cover as a filter and important barrier against contamination. The forestry strategy follows the target of maximizing the protective nature of the land cover for the water.
2) The catchment area is also subject to tourism since it's a popular hiking area. Consequently, the Vienna Water Works established a

comprehensive strategy to deal with wastewater of mountain huts in the catchment area to minimize the risk of pollution from this source.

3) Mountain pasture is an old tradition in the region and the rights to conduct it are culturally important. Since the underground residence time of water in the karstic limestone vary strongly between the scales of days up to years, the excrements from the livestock of mountain pasture as well as from the wild animals in the forests pose a risk of pollution to the drinking water in the springs under certain meteorological and hydrological conditions. This risk is addressed on two levels. First, particularly vulnerable areas like dolinas are protected via low earth walls that keep surface runoff from entering and by fences that keep out wild animals. Secondly water quality is monitored constantly at each spring separately, so in case of a contamination they can be redirected to the river.

The second site visited by the students is the “Kläfferquelle”. The biggest spring in the eastern alps and also a geopark site where visitors can learn about the history of the capturing of the spring and also see the impressive tunnel and the surface openings of the spring where about 1.000 l/s of water exit the Hochschab-Massif.

Fig. 2 – The “Kläfferquelle”at Wildalpen. View of the spring in the mountain (left). Sign for geopark at the entrance (right).

On the way back to Vienna, one of the students shares a link to an online video that gives an overview on the global water consumption and the concept of water food print with his/her colleges.

In the evening a lively discussion about the management of the catchment area by the Vienna Water Works in comparison to water supply facilities in other places started during dinner: Within the group the relevant questions arised.

QUESTIONS	**1.** Which geoethical issues and dilemmas arise from different interests in land use in this (and other) catchment area(s) of springs? **2.** What would happen if the land would not be in possession of the Vienna Water Works and the landowner would decide to change the forestry strategy? (for example, towards maximization for wood production or implementing agriculture) **3.** How geoethical values can be met by the operation and management of the catchment area of the springs? **4.** Which geoethical values are met by the Water Footprint Network? **5.** Which SDGs (Sustainable Development Goals) have a strong impact on water supply management and may also pose a (partly) conflict of interests to SDG-6 (Ensure availability and sustainable management of water and sanitation for all)? **6.** Which geoethical issues and dilemmas are related with the achievement of the different SDGs and their linkage? **7.** How can Earth Scientists be involved in the process of achieving the SDGs related to water management? **8.** Explain how geoethical values support geoscientists in their role in the process of achieving the SDGs.
PROCEDURE	**Split students in random small groups of 4 or 5 and ask them to follow the bellow procedures:** **1.** As an introduction to the water supply of Vienna, watch the video "Viennas Water short" (https://www.wien.gv.at/video/403/Viennas-Water-short) and the Interview with Lukas Plan (Geologist at Dep. of Geology and Paleontology, Natural History Museum Vienna, Austria) "GOAL: KLÄFFERQUELLE - SOME FACTS ABOUT THE BIG KARSTIC SPRING" (https://youtu.be/qFwfniq5J78). **2.** Answer questions 1 and 2 after watching the video pill "GOAL: Geoethics issues and geoethical dilemmas" at https://www.youtube.com/watch?v=1KBFAqMMnpo. [Further reading for more detail: "Marone & Peppoloni, (2017)" at https://www.annalsofgeophysics.eu/index.php/annals/article/view/7445] **Plenary session were the answers of all groups are collected and discussed.** **3.** Answer individually question 3) after reading the article "Peppoloni & Di Capua (2016)" at https://goal-erasmus.eu/wp-content/uploads/2019/02/GEOETHICS-ETHICAL-SOCIAL-AND-CULTURAL-VALUES-IN-GEOSCIENCES-RESEARCH-AND-PRACTICE.pdf. [Further reading for more detail: "Bobrowsky et al., (2017)" https://goal-erasmus.eu/wp-content/uploads/2018/10/Emerging_Field_Geoethics.pdf] **4.** Watch the video "Where is water?" (https://www.youtube.com/watch?v=b1f-G6v3voA) and check

the homepage of the Water Foodprint Network (https://waterfootprint.org/en/):

a) Each student estimates her/his actual and virtual water consumption of the day separately (starting from breakfast, showering, consumption of goods, etc.) by writing down her/his consumption and water uses.
b) Answer question 4 in the groups already established.

Collect and discuss the answers to questions 4 in a plenary session.

5. Read the Agenda 2030 for Sustainable Development (https://www.un.org/sustainabledevelopment/development-agenda/).

a) Each group should deal with at least 3 Goals. Each of the 17 Goals should be covered by at least one group. The groups work on answering questions 5 and 6.

[Further reading could be UN-Water-Development-Reports (https://www.unwater.org/publication_categories/world-water-development-report/)]

Plenary session where the answers of all groups are collected and discussed.

6. Go back into the groups and answer questions 7 and 8.

Plenary session where the answers of all groups are collected and discussed potentiating the appropriation of new geoethical values and principles towards a Sustainable Development.

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APPENDIX 10: GEOETHICS IN EDUCATION: FROM THEORY TO PRACTICE

Co-funded by the Erasmus+ Programme of the European Union

GOAL EDUCATIONAL RESOURCE

AUTHORS	Nir Orion (Weizmann Institute of Science, Israel) & Ron Ben-Shalom (Weizmann Institute of Science, Israel)
TITLE OF THE CASE	Integration of geoethical aspects of georesources within field trips of Earth sciences academic courses
SHORT CASE DESCRIPTION	One of the geoethical subjects of the GOAL project is Earth resources. Aspects of this subject could be included in several academic geoscience courses. For example, introduction to geoscience, geological mapping, mining, Earth resources, natural resources, etc. Many geoscience courses include field trips as an integral part of the course. This educational resource presents examples of using geoscience field trips to raise geoethical dilemmas that appear while the mining of earth resources interacts with geoheritage and/or with the economical resource of geotourism.
KEYWORDS	Educational resource; Field trip; Geoheritage; Georesources; Geotourism; Natural resources; Outdoor learning environment.
PRIOR KNOWLEDGE	Geoethics; Geoheritage; Georesources; Geotourism; Outdoor learning environment.
AIM	Promotion of the integration of geoethical values (ethical, cultural and social) within geoscience academic courses.
OBJECTIVES	• To present concrete examples of field trip activities related to Earth science phenomena that appear worldwide. • To present concrete examples of field activities that can be easily modified for teaching in various academic courses in any country. • To defend geoethical values to preserve the Earth system (social value). • To present concrete examples of field trip activities that raise ethical, social and cultural dilemmas that appear everywhere. • To boost geoethical education in schools and in higher education (social values).

CASE

Field trips are still a common teaching environment for many geoscience academic courses. Moreover, the outdoor environment enables exposing students to concrete geoethical dilemmas that arise directly from their field observations.

However, to fulfil the educational strengths of the outdoor environment, lecturers have to change their teaching method in the field. In the outdoor, they should focus on active learning instead of their lecturing habit. They should use worksheets with instructions and questions that would direct the students to a concrete interaction with the phenomena and not with the lecturer (GOAL's eBook).

The following are two examples of the suggested method of raising geoethical dilemmas concerning the exploitation of Earth resources:

Case 1: Makhtesh Hatira – The interaction of mining with social and cultural values.

The Israeli Makhteshes are a unique geological phenomenon (Fig.1).

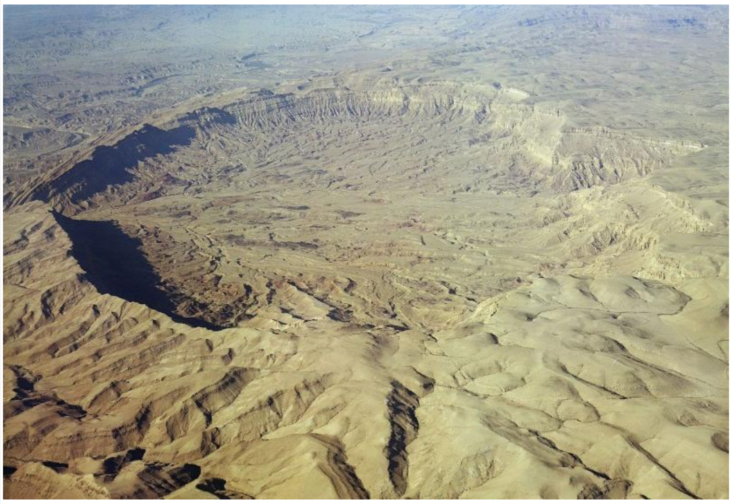

Fig. 1 – Areal view of Makhtesh Hazera, Northern Negev, Israel.

Makhtesh is an erosional crater formed by the unique stratigraphy, structure, and geological history of Israel's Negev Desert. Erodible sandstones that were overlain by brittle limestone and dolomites were folded to anticlines that emerged as islands above the Thetis sea. Abrasion and truncation of those island anticlines started the erosion processes that led to the formation of the Makhteshes (Fig. 2).

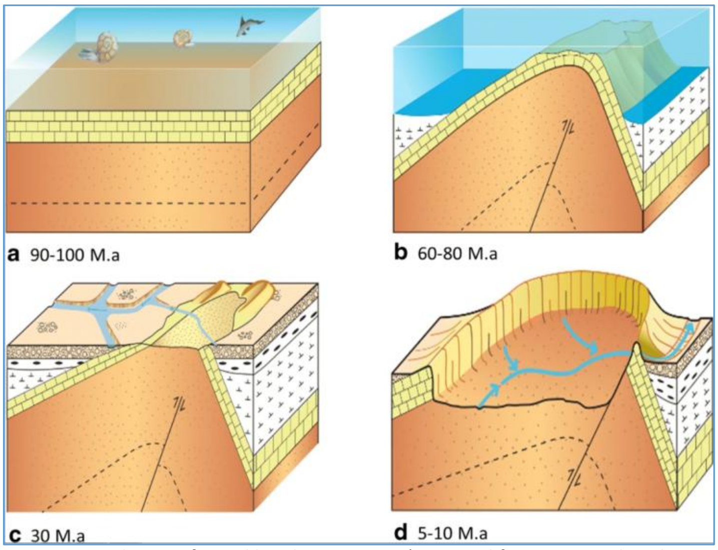

Fig. 2 – Evolution of a Makhtesh in 4 stages (retrieved from Finzi and Ryvkin, 2016).

Makhtesh Hatira is a popular site for tourism as well as for a variety of geoscience academic courses and each geoscience student visit this site at least once during his/her academic studies.

Makhtesh Hatira was designated as a National Reserve. However, in the hurt of this unique geological/geomorphological phenomenon, a big sandstone quarry that mines the colorful Nubian sandstone, which is one of the main attractions of Makhtesh Hatira (Fig.3, Fig. 4).

Fig. 3 – Sandstone quarry in the heart of Makhtesh Hatira.

Fig. 4 – Colorful sandstone in Makhtesh Hatira.

This conflict between mining and geotourism is a well-known and very common all over the world. Therefore, the "quarry" activity in the procedure section (appendix 1), is applicable worldwide.

Case 2: The Dead Sea – The interaction of the Dead Sea industry with the tourism industry

The Dead Sea is a unique Earth systems phenomenon (Fig.5).

Fig. 5 – The Dead Sea North basin.

The Dead Sea has two basins. The deep northern basin of about 400 m depth and southern very shallow basin. The Potassium industry took over of the southern basin and converted it to evaporation ponds. Many hotels were built along the coastline of the biggest pond for the hundreds thousands of tourist who come to experience the leisure and medical attractions of the Dead Sea. However, following the sedimentation of halite crystals on the bottom of the evaporation pond, the Dead Sea

	industry raises the pool walls every year. Consequently, the water level of the pool continuously rises and already reached level of the ground floors of the hotels. To prevent the flooding of their lobbies, the hotels have to pump the water. The hotels asked the Dead Sea industry to deepen the ponds instead of raising the ponds' walls. The Dead Sea industry refused and this case went up to the court. This conflict between earth resources industry and geotourism is common all over the world. Therefore, the activity "The story of two industries" in the procedure section (appendix 2), is applicable, with the needed modification worldwide.
QUESTIONS	**1.** In what conditions, if at all, is it right to mine earth resources at a unique geoheritage site? **2.** What will be the social and economic implications, if the mining was stopped at the Makhtesh or at the Dead Sea? **3.** What are the consequences of not informing the public about the unique geology of the Makhtesh? **4.** How can we avoid the risk of not preserving these geoheritage sites?
PROCEDURE	Procedures concerning georesources - https://goal-erasmus.eu/wp-content/uploads/2020/02/IO4E-The_Rock_Cycle_of_Machtesh_hatira.pdf
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GOAL EDUCATIONAL RESOURCE

AUTHORS	Nir Orion (Weizmann Institute of Science, Israel) & Ron Ben-Shalom (Weizmann Institute of Science, Israel)
TITLE OF THE CASE	Integration of geoethical aspects of georisks within field trips of Earth sciences academic courses
SHORT CASE DESCRIPTION	One of the geoethical subjects of the GOAL project is risks. Aspects of this subject are included in many various academic geoscience courses. For example, introduction to geoscience, tectonics, structural geology, mapping, geomorphology, etc. Many geoscience courses include field trips as an integral part of the course. This educational resource presents examples of using geoscience field trips to in order to raise geoethical dilemmas of georisks and public knowledge and understanding.
KEYWORDS	Earthquakes; Educational resource; Georisks; Outdoor learning environment; Sinkholes.
PRIOR KNOWLEDGE	Geoethics; Georisks; Outdoor learning environment; Public knowledge.
AIM	Promotion of the integration of geoethical values (ethical, cultural and social) within geoscience academic courses.
OBJECTIVES	• To present concrete examples of field trip activities related to Earth science phenomena that appear worldwide. • To present concrete examples of field activities that can be easily modified for teaching in various academic courses in any country. • To defend geoethical values to preserve the Earth system (social value). • To present concrete examples of field trip activities that raise ethical, social and cultural dilemmas that appear everywhere. • To boost geoethical education in schools and in higher education (social values).

CASE

Field trips are still a common teaching environment for many geoscience academic courses. Moreover, the outdoor environment enables exposing students to concrete geoethical dilemmas that arise directly from their field observations.
However, to fulfil the educational strengths of the outdoor environment, lecturers have to change their teaching method in the field. In the outdoor, they should focus on active learning instead of their lecturing habit. They should use worksheets with instructions and questions that would direct the students to a concrete interaction with the phenomena and not with the lecturer (GOAL's eBook).
The following are two examples of the suggested method of raising geoethical dilemmas concerning the exploitation of georisks:

Case 1: The Dead Sea hotels and earthquake risk along plates boundaries – The interaction between earthquakes risks, geoscientists' knowledge and society awareness

Part 1: The Potassium industry took over the southern shallow basin of the Dead Sea and converted it to evaporation ponds (Fig.1).

Fig. 1 – Dead Sea Plants Evaporation Ponds at the Southern Dead Sea basin.

Many hotels were built along the shoreline of the biggest pond for the hundreds of thousands of tourists who come for the recreational and medicinal attractions of the Dead Sea (Fig. 2).

Fig. 2 – Ein Bokek hotel area, along the shore of the Dead Sea plants *evaporation* Pond.

However, following the sedimentation of Halite on the bottom of the evaporation pond, the pond water level keeps rising, resulting in the Dead Sea Plants having to raise the pond's dams every year. The rising water level already reached the foundations and the ground floors of the hotels. To prevent the flooding of their lobbies, the hotels have to pump the water (Fig.3). Although the ground floors of the hotels are dry, their foundations are soaked in corrosive Dead Sea water.

Fig. 3 – Pump pipes (left) and a Pump disguised as a sculpture (right), Dead Sea hotel beach.

Part 2: The Dead Sea is located in a rift valley formed by the Dad Sea transform – an active tectonic plate boundary between the Arabian and African plates. The Lisan formation which is exposed in many marginal terraces in the rift valley, is a sequence of lake sediments that were deposited in Lake Lisan ("tongue" in Arabic) that existed in the last glacial (70–14 ka).

The formation is largely composed of seasonal laminae of aragonite and clay/marl. The Lisan Formation contains "dancing varves", which are seismites - seismically disturbed sequences, that are a few centimeters to a few dozen centimeter thick (Fig.4).

Fig. 4 – Lisan Formation exposure containing a seismite (red circle) - seismically folded sequence.

The occurrence of these seismites in such recent sediments indicates the possibility of near future seismic activity. The High and rising water level of the industrial ponds and the fact that hotel foundations are already under water poses a serious risk to the public.

Case 2: The sinkholes geomorphological risk – The geoethical earth systems ignorance of the society

The Dead Sea has been shrinking rapidly for the past few decades, due to the diversion of water from the Jordan River (which feeds the Dead Sea) and mineral mining from its waters in the south, as water from the deep Northern basin is pumped into evaporation ponds in the south. As a result, the water's surface is currently receding by more than 1 meter per year. As the salty water recedes, fresh groundwater wells up and dissolves layers of sub-surface rock salt, creating large underground cavities, above which sinkholes form (Fig.5 and Fig.6).

Fig. 5 – A section of the Jerusalem-Eilat road near Ein-Gedi (Dead Sea shoreline), that was recently abandoned due to opening of sinkholes.

Fig. 6 – Collapsed road section in one of the sinkholes, Ein-Gedi.

QUESTIONS	1. What is the role of geoscientists in updating the society about potential risks? 2. What would be the impact of informing the public about the potential earthquakes risks on the corrosive foundations of the hotels on the tourism industry in the Dead Sea? 3. What are the consequences of not informing the Dead Sea hotels visitors about the risk of staying there? 4. How should geoscientists inform the public? 5. What could be the implications of not informing the public about the potential extent of sinkholes formation along the Dead Sea shoreline? 6. What would be the implications of informing the public about the potential extent of sinkholes formation?
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GOAL EDUCATIONAL RESOURCE

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TITLE OF THE CASE	Integration of geoethical aspects of geoheritage within field trips of Earth sciences academic courses
SHORT CASE DESCRIPTION	One of Geoethical subjects of the GOAL project is geoheritage. Aspects of this subject are included in many various academic geoscience courses. For example, introduction to geoscience, tectonics, structural geology, mapping, geomorphology, geological history, paleontology and more. Many geoscience courses include field trips as an integral part of the course. This educational resource presents examples of using geoscience field trips to raise geoethical dilemmas of geoheritage and public knowledge and understanding.
KEYWORDS	Educational resource; Geoheritage; Outdoor learning environment.
PRIOR KNOWLEDGE	Geoethics; Geoheritage; Outdoor learning environment; Public knowledge.
AIM	Promotion of the integration of geoethical values (ethical, cultural and social) within geoscience academic courses.
OBJECTIVES	• To present concrete examples of field trip activities related to Earth science phenomena that appear worldwide. • To present concrete examples of field activities that can be easily modified for teaching in various academic courses in any country. • To defend geoethical values to preserve the Earth system (social value). • To present concrete examples of field trip activities that raise ethical, social and cultural dilemmas that appear everywhere. • To boost geoethical education in schools and in higher education (social values).

CASE

Field trips are still a common teaching environment for many geoscience academic courses. Moreover, the outdoor environment enables exposing students to concrete geoethical dilemmas that arise directly from their field observations.
However, to fulfil the educational strengths of the outdoor environment, lecturers have to change their teaching method in the field. In the outdoor, they should focus on active learning instead of their lecturing habit. They should use worksheets with instructions and questions that would direct the students to a concrete interaction with the phenomena and not with the lecturer (GOAL's eBook).
Following are two examples of the suggested method of raising geoethical dilemmas concerning the preservation of our geoheritage:

Case 1: Makhtesh Hatira as a geoheritage phenomenon

The Israeli Makhteshes are a unique geological phenomenon (Fig.1).

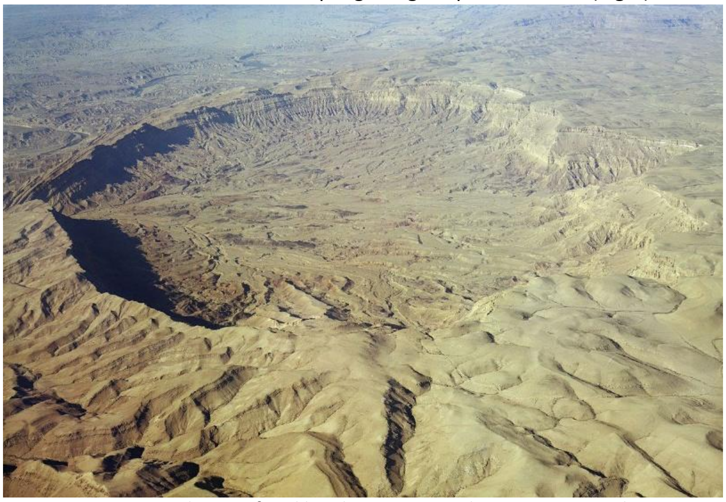

Fig. 1 – Areal view of Makhtesh Hazera, Northern Negev, Israel.

Makhtesh is an erosional crater formed by the unique stratigraphy, structure, and Geological history of Israel's Negev Desert. Makhtesh Hatira as well as any other Makhtesh is an outcome of very long complex multiple stages process.

Case 2: Fossils as a geoheritage phenomenon

Fossils are a central source of our ability to study, understand and reconstruct the cycles of marine and continent environments throughout the geological time and the macroevolution of life on Earth. Therefore, fossils are a central component of the heritage of our planet. Although the fossilization is a very complicated process and only few percent of the living organisms were fossilized along the earth history, fossils are well known phenomena in many sedimentary rocks' exposures all over the world (Fig.2 and Fig.3).

Fig. 2 – Upper Cenomanian Marine fossils of Har Avnon.

Fig. 3 – Ammonite Wall, Makhtesh Ramon.

QUESTIONS

1. What is the role of geoscientists in educating the society about the importance of fossils as a central part of the Earth heritage?
2. What is the role of geoscientists in educating the society about the need for the preservation of fossils?
3. How should geoscientists inform/communicate the public?
4. Who should prepare geoscientists how to communicate with the public?

PROCEDURE

Procedures concerning geoheritage - https://goal-erasmus.eu/wp-content/uploads/2020/02/IO4F-Machtesh_Ramon.pdf

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