Brief for GSDR 2015

The scientific and socio-economic importance of karst and caves and their vulnerability

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Introduction

The karst landscape takes its name from a region comprised between northeast Italy and Slovenia, dominated by outcrops of carbonate rocks. Karst refers to an ensemble of morphological and hydrological features and the dominant process responsible for them: dissolution of soluble rocks (mostly carbonates and gypsum, but also halite and quartzite) (Gutierrez *et al.*, 2014). In karst landscapes surface and subsurface rock dissolution largely overrules mechanical erosion, leading to a distinctive morphology and hydrology. Over 20% of the earth crust is characterized by epigean and/or hypogean karst phenomena (Ford and Williams, 2007).

Finally karst processes, along underground pathways, may give rise to the formation of three-dimensional systems of conduits, sometimes forming huge, long and extremely complex caves (White, 2002).

The importance of karst and caves

Karst and caves have high cultural and historical values. Many artifacts documenting early human development have been preserved in karst areas: most of our knowledge on our ancestors is based on cave findings (Sherwood and Simek, 2001). Karst and caves are extremely valuable natural resources, hosting a wide variety of often unique ecological niches (Pipan and Culver, 2013). Besides the often extremely rich variety of plants and animals, including endemic species, found in karst areas, caves are also unique microbiological habitats. Ongoing research on new cave dwelling species and microbiological communities might allow the discovery of new substances useful for medical purposes (Barton and Northup, 2007).

Speleothems are the most detailed natural archive of our planet. Climatic and/or environmental changes, earthquakes, tectonic movements, sea level changes, volcanic eruptions, etc. are recorded in the growing layers of the speleothems over thousand or even million years (Forti, 2009). Karst systems act as natural sinks for carbon dioxide (CO_2) (Liu *et al.*, 2011), thus helping to mitigate climate change.

Karst & Caves: facts & figures

- Over 20% of the earth surface consists of karst terrains.
- Around 25% of the world's drinking water comes from karst aquifers.
- Over 100 million people work directly or indirectly in karst and cave tourism.
- Karst and caves host unique ecosystems often restricted to single locations.
- Cave deposits are among the best natural archives for paleo-environment and paleo-climate studies.
- Over 50 karst and cave locations are already inserted in the UNESCO World Natural Heritage List.
- Karst and caves are extremely vulnerable and their protection worldwide must be greatly enhanced.

Source: Author' compilation

According to UNESCO "*Groundwater in karst aquifers represents the most significant as well as the safest source of drinking water*" (Aureli, 2010). It is estimated that karst aquifers presently supply about 25 % of the world's drinking water (Ford and Williams 2007). This percentage will increase in the near future due to human pollution of water sources in non-karst areas.
Finally, show caves have been open to the public for over 400 years. Almost all countries with karst areas presently host at least one, and often dozens of show caves. An estimated 250 million

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visitors yearly pay a ticket to visit show caves. If all the activities related to the operation of a show cave (transportation, lodging, etc.) are considered, some 100 million people directly or indirectly make their income from show caves.
These figures should be at least doubled taking into consideration surficial and deep karst within geoparks. Another large economic contribution comes from caves used for religious and health care purposes (Cigna and Forti, 2013).

The vulnerability of karst and caves

Karst and caves are extremely fragile environments and they are affected by specific hazards and impacts, largely related to their endemic geomorphological, hydrological and ecological peculiarities. In lowland karst, due to the scarce relief and the subdued features, many landforms may be lost due to anthropogenic activities such as intense quarrying (Parise and Pascali, 2003).

Land use changes also result in degradation of the epikarst (Williams, 2008), which provides a vital function for karst ecosystems (Pipan and Culver, 2013). The direct connection between the surface and the underlying aquifer makes underground karst waters extremely vulnerable to pollution, which may very rapidly reach wells and springs (Covington *et al.*, 2009).

Karst also has the ability to store sediments and water underground, including pollutants, which may be released during severe flow events (Mahler *et al.*, 1999). The intrinsic vulnerability of karst aquifers to pollution may be assessed through the hydrogeological and geological parameters that determine the sensitivity of groundwater to contamination by human activities (Molerio-León and Parise, 2009), and is independent of the nature of the contaminants and how they enter the system.

The expansion of urban areas in karst is leading to an increasing number of pollution events, with severe consequences on karst ecosystems (De Waele and Follesa, 2004) and their abilities to serve as CO_2 sinks. Tourism in karst may have high adverse impacts if not conducted after careful evaluations of the deriving effects (Cigna and Forti, 1988).

Actions must therefore be undertaken to assess and minimize the negative impacts of the increasing pressure on the fragile karst and cave environments.

All of the resources and ecosystem services supplied by karst and caves cannot be considered in isolation because they are intensely interconnected. Due to these complex feedback mechanisms, impacts on individual elements of karst ecosystems can have unexpected impacts on other elements or even on the entire ecosystem (Fig. 1).

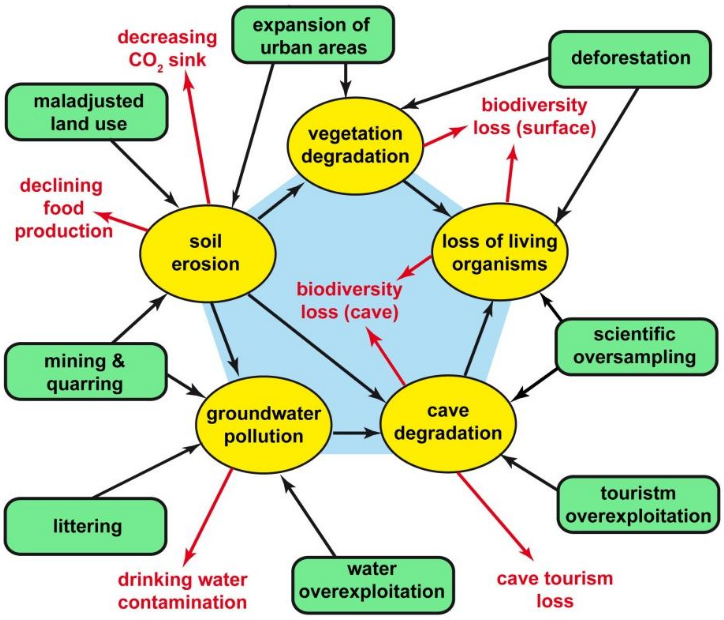

Fig. 1 – Sketch of the interconnected impacts affecting karst and cave ecosystems (After Goldscheider, 2012).

Alongside specific vulnerability assessments, the complexity of karst environments requires a more holistic approach to comprehensively assess the potential resulting impacts (Van Beynen, 2011). Protection of karst and cave environments requires specific approaches and measures (Veni, 1999), and it is a mandatory step to maintain, safeguard and transmit its extreme richness and biodiversity to future generations.

Over 50 karst and caves are presently listed in the UNESCO World Natural Heritage List, but many more areas worldwide have the potential to be included there, or to be designated as national parks or for some other type of high protection status, based on their biodiversity, freshwater resources, unique geomorphology or valuable caves.

This latter measure will help to increase public awareness of karst, which is another crucial point: the public and policymakers need to be informed about the scientific significance, heritage values and vulnerability of karst.

Issues for further consideration

The following issues are suggested for consideration by policymakers:

- Promote safeguarding karst and cave areas throughout the world
- Improve understanding on the functioning of karst and cave aquifers and ecosystems

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