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REVIEW ARTICLE

Man-Made Impacts on Emerging Geoparks in the Asian Region

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Abstract
Geotourism is an emerging sub-sector of nature-based tourism that attracts a growing number of tourists to geoparks worldwide. Among these, Asian geoparks have become an attractive destination for visitors to experience geological landscapes. To date, there are limited studies available on the environmental impacts of geotourism in Asian geoparks. Here, we present a quantitative review of 26 peer-reviewed publications on geotourism impacts in Asia and discuss how to minimise them. The majority of these studies (64%) originated in China and reports on observational research (68%) rather than experimental research (11%). Data were mainly qualitative (48%) rather than quantitative (19%). Impacts accrued from an inadequate provision of conservation measures and infrastructure (leading to soil erosion), associated agriculture and urbanization, a lack of legislative frameworks and a lack of knowledge of visitors and local communities on how to behave in sensitive geosites. Management measures that appear promising were discussed such as the establishment of frameworks and policies to govern geotourism development along with visitor education and the critical importance of systematic quantitative studies. Both should support the rapidly growing geotourism industry in the Asian region.

Keywords Geotourism · Geoparks · Man-made impacts · Overtourism · Asia

Introduction

Geotourism is a rapidly growing tourism market attracting approximately 7.8 million geo-tourists to geotourism destinations worldwide (Cheung 2015). The development of this industry relies upon geological landscapes as attractions (Hose 2000; Dowling and Newsome 2010; Wang et al. 2014a). Geotourism has emerged in the mid 1990s (Ollier 2012), underpinned by various definitions (Hose 1995; Dowling and Newsome 2010; National Geographic 2012) that stress three elements of geotourism: (a) travel to a place characterised by geology, (b) education and learning and (c) geological appreciation (Fung and Jim 2015; Hose 1995; Joyce 2006). There is also a certain overlap with the concept of nature-based tourism (Koizumi and Chakraborty 2016). Koizumi and Chakraborty (2016) drew attention to a conceptualisation as "geo-ecotourism" that amalgamates understandings of geotourism with those of ecotourism (Gray 2011; Newsome et al. 2012). The currently presiding definition of geotourism by Dowling and Newsome (2010) is that of a form of "sustainable tourism with a primary focus on experiencing the Earth's geological features in a way that fosters environmental and cultural understanding, appreciation and conservation, and is locally beneficial" (Dowling and Newsome 2010).

Geodiversity, meaning the diversity of geological, geomorphological, soil and hydrological features, is playing a vital role in the development and promotion of geotourism across the world (Ollier 2012; Chen et al. 2015; Gray 2013). A place that integrates all desirable geodiversity characteristics is referred to as a *geopark*, a site that people visit to appreciate and experience geology (Ibrahim 2000; Azman et al. 2010). As a result, worldwide geopark programs have been introduced to many countries for promoting geotourism such as on the Gwanmae Island of South Korea (Dingwall et al. 2005; Koh et al. 2014). Efforts were made to connect geoparks (UNESCO 2006) which resulted in the first geological network called "European Geopark Network" in 2000 (Zouros 2004). This was expanded in 2004 into the "Global Network

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of National Geoparks" (GGN) with the assistance of the UNESCO (Eder and Patzak 2004; UNESCO 2014). Since 2015, this network is managed under new label UNESCO Global Geoparks. The establishment of this network highlights the importance of geodiversity in the Asia Pacific region which encompasses critical linkages within the global geopark network. This was also recognised through the area-specific "Asian Pacific Geoparks Network" (APGN).

Geoparks typically provide sightseeing tour facilities and recreational activities, along with science and education programs, and enhance the local economy by attracting geotourists (Farsani et al. 2014; Dowling 2010). World geoparks facilitate the conservation of geoparks on local to global scales (Yeung 2008; Erikstad 2013; Wang et al. 2014a; Dong et al. 2014) to the betterment of the geotourism industry (Hose 2000; Hose and Wickens 2004; Zouros 2010a, b; Jin and Ruban 2011; Bruno and Perrotta 2012; Farsani et al. 2012; Gordon et al. 2012; Hose and Vasiljevic 2012).

The marketing of geoparks and the development of 'geo-experiences' has increased visitor numbers in geoparks around the world causing severe environmental impacts (Buckley and Pannell 1990; Cole 2009; Monz et al. 2010; Spellerberg 1991; Lima et al. 2017). Geoparks are known for their geodiversity encompassing landscapes of significant value formed over a period of 4.6 billion years (Cowie and Wimbledon 1994; Song et al. 2010). Because of their significant natural value, the planning and management of geoparks, their conservation and understanding of impacts, the monitoring and establishment of impact management strategies need to be vital components of a sustainable geotourism industry including in Asia (Henriques et al. 2011; Brilha 2016; Marion and Leung 2001; Prosser et al. 2011; Lima et al. 2017). This involves a concerted effort of scientists, scholars and related stakeholder agencies such as government and non-government organizations targeting geological conservation (Li et al. 2012; Chen 2003; Song et al. 2010). Here, we present a timely review of geotourism impacts in Asia and discuss research gaps and future research directions.

Geotourism and Geoparks in Asia

Geotourism is a developing tourism sector across the world (Wang et al. 2014b). It is considered a novel means for conserving geoheritage/geodiversity assets while promoting them under the banner of tourism (Fauzi and Misni 2016) with the added financial benefits for local communities (Kiernan 2013). This is particularly relevant for emerging geotourism ventures in developing countries such as Indonesia, Malaysia, Thailand, Vietnam, Taiwan and Iran that seek ways to alleviate poverty and generate new income streams (Table 1) (Dowling 2010; Dowling and Newsome 2010). Geotourism is an important industry sector for developing countries in terms of economic incentives and as a means to foster social and community well-being by establishing livelihoods for those in need, and also to conserve geodiversity. It therefore can play an important role in the sustainable development of specific regions (Badang et al. 2017). East and South Asia are both rich in geoheritage and home to designated UNESCO Global Geoparks and National Geoparks. China in particular has numerous National and UNESCO Global Geoparks (Fuming et al. 2015; Lianyong 2007). Many other potential geotourism sites have been identified in Asia, but planning is still in its initial stages (Amrikazemi and Mehrpooya 2006). Rural communities in recognised geosites are known to gain income-generating activities such as providing accommodation, various service facilities and selling local products, while engaging in conservation activities through geotourism and geoproducts (Farsani et al. 2014; Lianyong 2007; Shahhoseini et al. 2017).

Table 1 Number of UNESCO Global Geoparks and National Geoparks located per total land area in the six principal Asian countries for geotourism

Country	Land area km^2	Number of sites
Korea	97,480	28
China	9,388,211	218
Japan	364,560	43
Malaysia	328,550	30
Vietnam	310,070	30
Indonesia	1,811,570	60
Iran	1,648,195	01

Chakraborty et al. (2015) highlighted that in China, 19 million people visit geoparks annually, and scholars and researchers have identified that Asian geoparks face numerous challenges concerning their sustainability in the future (Zhong et al. 2005; Wang et al. 2015). Therefore, this study aims to determine the geotourism impacts across the Asian region and identify research priorities and management strategies to minimise visitor impacts at geoparks in Asia.

Method

We applied a systematic quantitative literature review which has proven effective at generating a quantitative summary of the field (Pickering and Byrne 2014). An electronic database was built pertaining to research papers about geotourism published in peer-reviewed English language journals between 2000 and 2018.

The articles were searched using the following databases: Science Direct, ProQuest, Web of Knowledge, Sage, Google Scholar, Google and Murdoch University, by using the

following keywords to search original articles: 'geodiversity', 'geoconservation', 'geotourism', 'geopark', 'geoeducation', 'geoheritage', 'Asia Pacific geoparks network', 'geopark', 'geodiversity site', 'National Geopark', 'assessment', 'sustainable development', 'UNESCO Global Geopark', 'monitoring', 'carrying capacity', 'impact' and 'endangered geoheritage'.

The study followed the recommendations of PRISMA, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, to select relevant papers for this review. Firstly, identified were all papers matching the keywords, plus any additional studies recognised on reference lists. Excluded were books, book chapters, industry reports and other grey literature. All studies were screened by studying the topic, abstract and conclusions and those deemed irrelevant to evaluate geotourism impacts in Asia were excluded, and so were papers where it was difficult to gather information on the key variables collated for each article in the final selection, namely, publication details, geographical location (study area and country), study design, methods used, data type; type of impact, and management recommendations (Table 2). For final selection of papers, the following six variables were recorded in a database (Table 2).

Result

Of the 26 original journal papers on man-made impacts of geotourism in Asia, 17 were published after 2012 (Table 3) which underpins the increasing importance of this field in recent years. The journal *Geoheritage* has published the highest number of papers (10) in this field, followed by *Catena* (4) and *Quaternary International* (4).

'Observation' was the widely used methodology in these publications, and it was mainly qualitative data that were collected.

The maximum number of studies originated in China (64%), followed by 1–2 studies from each of six other countries, including India and Bangladesh even though these were yet to be the members of the Asia Pacific geotourism network. China was instrumental in driving geotourism research, generating the first publication (within our study time frame) in 2000. Other than that, Japan, Malaysia and India have published articles for each country. Most of these investigations were conducted in National Geoparks and to a lesser extent in UNESCO Global Geoparks (Fig. 1).

Type of Impacts

The primary reasons for man-made impacts relating to geotourism in Asia included the lack of adequate conservation measures and infrastructure, agriculture and urbanization that followed geotourism development, the lack of a legislative framework and ignorance/lack of knowledge (Table 4). Erosion was the main impact where adequate infrastructure was lacking and inadequate or no measures of soil and tread conservation had been implemented.

This issue was exacerbated with increasing visitor numbers. Geotourism was associated with impacts of urbanization through an increase in infrastructure such as commercial shops and the need for garbage disposal.

Agriculture developed around geotourism sites to sustain growing numbers of community residents who had followed geotourism development, and that entailed impacts relating to soil fertilization and disposal of toxic substances. Impacts due to the progressive development of urbanization and agriculture associated with geotourism development were especially prominent in China, India and Bangladesh.

Another reason why impacts occurred was the lack of a suitable legislative framework to govern the process of geotourism development. This also aggravated impacts associated with agriculture and urbanization, as uncontrolled development was a side effect of a missing legislative

Table 2 Variables collected from a selected sample of research papers about the impacts of geotourism in Asia

Category	Variable	Data type
Publication	Author(s)	Text
	Title	Text
	Publication year	Numeric
	Journal	
Geographic	Country	Categorical
Methods	Observation, Experimental, Predictive	Categorical
Data type	Quantitative, Qualitative, Mixed, GIS, photography	Categorical
Type of impact	Erosion, Agriculture & Urbanization, Lack of legislative framework, Ignorance	Categorical
Management	Regulation, Non-regulation	Categorical/text

Table 3 Details of the 26 reviewed studies that examined the impact of geotourism in Asia

Category	Total
All papers	26
Post 2012	17
Journal type	
Geoheritage	10
Catena	4
Quaternary International	4
Proceedings of the Geologists' Association	1
ASERS	1
Journal of Arid Environments	1
Agriculture, Ecosystems & Environment	1
Journal of Archaeological Science	1
Environ Earth Sci	1
International Journal of Sustainable Development & World Ecology	1
Asian Pacific Journal of Tourism	1
Methodology	
Observation	17
Experimental	3
Predictive	5
Data type	
Quantitative	5
Qualitative	12
Mixed	4
GIS	2
Photography	2

foundation for development of geotourism sites. It followed on from a promotion of nature-based tourism activities in general, and geotourism in particular, and leads to uncontrolled impacts in the face of non-existing or inadequate management plans and guidelines (Musa 2002). Closely related, ignorance or lack of knowledge had an impact through for instance inappropriate waste disposal, trampling and vandalism that, however, could be managed efficiently if policies and management plans were established.

Discussion

Geotourism Challenges

Geoparks/geosites are unique and fragile places situated in sensitive geological environments. Increased tourist numbers in these areas are known to generate human impacts (Newsome et al. 2012). Erosion that is caused by the inadequate establishment of conservation measures and the lack of appropriate infrastructure that mitigates impacts from trampling for instance was noted as one impact following geotourism activities in Asia (Lima et al. 2010, 2017; Kamel et al. 2017; Avelar et al. 2018). Dowling and Newsome (2006) noted that erosion might occur due to the pressure of increasing visitor numbers at geopark.

The main issue the geotourism practicing countries are facing, however, relates to secondary impacts associated with the expansion of agriculture and urbanization (Lima et al. 2010, 2017; Larwood et al. 2013; Avelar et al. 2018), especially where population pressures are great such as in China and India.

Past studies of geotourism in Asia have highlighted that impacts at geoparks accrue from lack of policies and legislation and ignorance. Geoparks in the reviewed literature appear not to be forthcoming as far as mitigating and controlling the impact of visitors is concerned. Such impacts entail unplanned

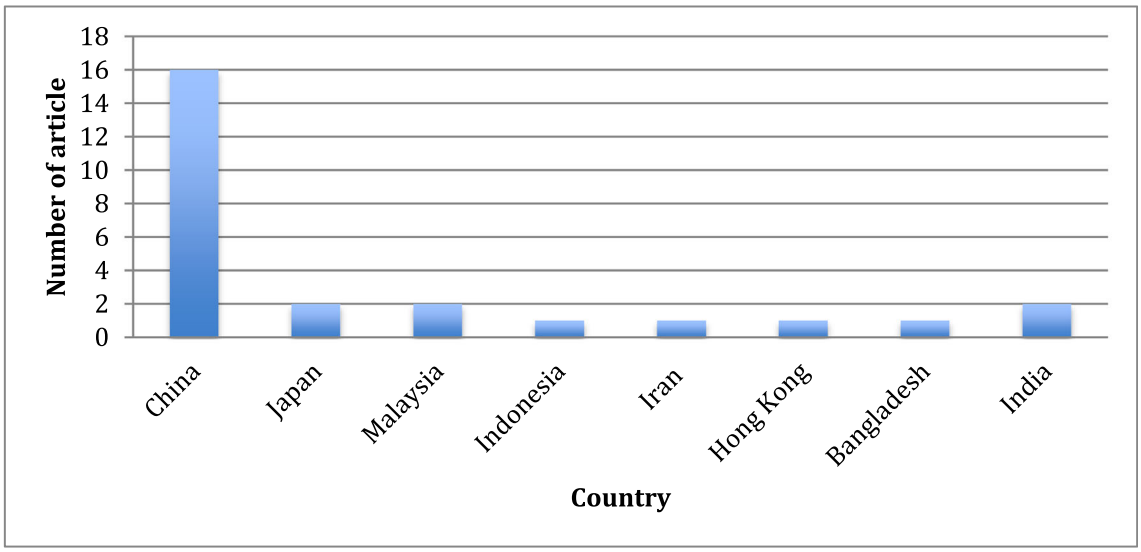

Fig. 1 Number of published articles on impacts of geotourism by Asian country

Table 4 Man-made impacts of geotourism in Asia

Main reasons for impacts	Description	Key references
Inadequate conservation measures and lack of appropriate infrastructure	Erosion	Hoang et al. (2003); Sidle et al. (2004); Shi and Shao (2000); Vasiljević et al. (2014); He et al. (2003); Dong et al. (2014); Yang et al. (2012); Paskeh and Khoshraftar (2011)
Agriculture and urbanization	Rapid increase of shops Garbage disposal Fertilizer and toxic waste disposal	Hoang et al. (2003); Wei et al. (2006); Li et al. (2012); Vasiljević et al. 2014; Vasiljevic et al. 2011); Dong et al. (2014); Sheth et al. (2017); Hossain and Nahar (2014); Chakraborty et al. (2015); Paskeh and Khoshraftar (2011)
Lack of a legislative framework	Legislation	Vasiljević et al. (2014); Hose (2007, 2008); Dong et al. (2014); Wang et al. (2014a); Hossain and Nahar (2014); Chakraborty et al. (2015)
	Policies	Dong et al. (2014); Wang et al. (2014a)
Ignorance	Waste disposal	Vasiljević et al. 2014); Sheth et al. (2017)
	Trampling and tourist activities	Vasiljević et al. (2014); Hossain and Nahar (2014); Chakraborty et al. (2015)
	Vandalism and littering	Chakraborty et al. (2015); Farsani et al. (2012)

waste disposal, trampling, vandalism and littering. Other countries in the world such as Portugal identified similar impacts as a result of promoting geotourism (Kubalikova and Kirchner 2016; Avelar et al. 2018; Lima et al. 2010, 2017; Kubalikova and Kirchner 2016). Relatedly, some of the negative impacts are caused by irresponsible professional souvenir hunters through the hammering, digging and collecting of fossils and minerals (Dowling and Newsome 2006; Mathieson and Wall 1982). These impacts may occur in high demand sites in the region.

Management

Most impacts observed for geosites in the Asian region are noted elsewhere in the world. However, based on the present situation, the impacts could be minimised by setting up a legislative framework and policies at sites; further through visitor education and expansion of methodologies to include systematic quantitative studies of impacts and the GIS-based studies to address location and spatial extent of impacts, along with a better understanding of people's perception of impacts and acceptable uses of land for geotourism. Most studies highlighted that these measures are desirable to conserve geotourism sites.

Establishing legislation for minimising impacts around urbanization near geoparks is a critical first step to minimise impacts of geotourism (Yeung 2008; Wang et al. 2015). Our review showed that in these initial legislative stages and underpinnings of planning efforts, a better understanding needs to be sought of the value of geo-landscapes to be conserved in the future (Chan and Godsey 2016; Burek and Prosser 2008). This needs to be accompanied by creating an inventory and ranking of geosites in accordance with their scientific importance and obliteration of possible risks (Brilha 2016; Chan and Godsey 2016; Yalgouz-Agaj et al. 2010). A critical component in this planning stage is the monitoring of adverse impacts of geosites.

Our review revealed that educating visitors and the local community at particular sites significantly minimises the impacts of geoparks/geosites. Creating a public understanding, through education and conservation promotion, is an effective way to address and minimise the impacts accrued from lack of knowledge (Newsome and Johnson 2013; Gray 2004; Hose 2005; Wang et al. 2015; Dunbar 2007; Loon 2008). Visitor education on geodiversity that emphasises the uniqueness of the geopark is vital. Education should further be easy to understand and deliver the essence of the concept of geoconservation/geotourism (Hose 2000, 2006, 2011; Dong et al. 2014) and should at best be delivered via a strong interpretation system internationally, regionally and locally to be fully functional. A range of interpretation tools should be implemented such as interpretative panels, guided tours and more modern tools to meet visitor expectations (Wolf et al. 2013). Ultimately, interpretation activities need to meet visitor expectations to contribute to a sustainable use of geosites while simultaneously enhancing knowledge and conservation (Erikstad 2013). Finally, education also needs to extend to the local community and this requires developing a good relationship with geopark management to practice sound geotourism at the local level (Shafiei et al. 2017; Farsani et al. 2017).

Considering the potential of visitor education, a streamlined approach was suggested with a standard format for interpretative boards and panels to deliver messaging around sustainable geotourism. The standard format included (a) a National or Global Geoparks Network logo, (b) a concise and interesting heading, (c) a short explanation of the main

geopark features, (d) diagrams illustrating the formation of the features, (e) a representative photo of the feature, (f) a map showing the geotrail and location of the panels along the trail, (g) the code number of the geopark and (h) a mark indicating the location of the panel (Wang et al. 2015).

The European geoparks have already implemented visitor education programs to minimise visitor impacts. Partnerships between the government, universities, private sector and non-government agencies and improving the educational system constitute integral parts of this (Frodeman 1995; Orion and Thompson 1996; Orion 2001; Dodick and Orion 2003). The European geoparks have organised environmental awareness programs on the sustainable development of geoparks (Zouros 2004; Piranha et al. 2011) and stressed new opportunities for the local economy and benefits to the local community. Organising such a structured approach would also be essential for Asian geoparks. Although geo-education appears to be an indirect yet effective tool to minimise impacts of geotourism (Newsome and Dowling 2010; Hose 2011), to date, little has been achieved in this direction for Asian geoparks.

Similarly, there remains little research compared to the number of Asian geoparks. Our research here provided guidance on the reasons and types of impacts to focus on, along with management actions to evaluate. To fully grasp the impact of geotourism, future research needs to capitalise on a broader range of methodologies. In particular, experimental studies are needed that relate causal factors with actual impacts. For instance, questions should be asked how to create smart infrastructure that minimises visitor impacts at geoparks while facilitating satisfying visitor experiences. Consequently, experimental designs could vary specific infrastructure features and at the same time measure visitor satisfaction and impacts. This requires the collection of systematic quantitative data.

Similarly, impacts on geoparks are inherently spatial, and therefore, GIS-based studies are needed that visually clarify the spatial extent of impacts and how they relate to geological and other landscape features and management actions. GIS-based studies are also critical for monitoring impacts over time and evaluating the effectiveness of management actions.

Another tool that would be of great benefit in this context and which has not been applied in the context of geoparks is a public participatory geographic information system (PPGIS). PPGIS is known to be of great value for building knowledge on appropriate uses of landscapes, landscape values, visitor conflict and visitor management (Wolf et al. 2015; Wolf et al. 2018; Brown and Raymond 2007). In the context of Asian geoparks, information is needed on how the public perceives the use of geoparks, its benefits and impacts and what management actions are deemed effective and acceptable. It should further clarify how potentially conflicting land uses (tourism, agriculture, urbanization, conservation) can be reconciled to the benefit of all stakeholders involved and in line with sustainability considerations.

Conclusion

Increasing numbers of visitors are flocking to geoparks and geosites around Asia. Due to the limitations of available studies on geotourism impacts, this study aimed to review geotourism research about impacts on geoparks and geosites due to human activities in the Asian region. The aim was to discuss impacts and possible management avenues.

The findings reveal that, firstly, with the exception of China, Asian countries have not been much involved in the investigation of geotourism impacts at geosites in their countries. Secondly, erosion was the most highlighted man-made impact due to lack of appropriate geosite and surrounding urban infrastructure in Asia. Thirdly, impacts are more effectively managed by raising awareness of relevant agencies and fostering inter-agency collaborations, especially with local community groups, and developing appropriate legislation as the foundation for planning. Fourthly, this review made a compelling case for educating both visitors and local communities to manage impacts at geosites.

Future research should capitalise on a systematic quantitative data collection as part of experimental designs to relate causes of impacts with their effects, as most research to date is largely observational and rather ad hoc. It should further integrate GIS methods that visualise impacts and allow for monitoring over time and acknowledge the inherently spatial nature of man-made impacts in geoparks. Finally, public participatory GIS will garner insights from the public about acceptable usage of geoparks and their benefits. It will further increase the acceptance of management measures as they emerge from a public consultation process.

As the data are too sparse to meta-analyse across Asian countries, expanding the geographical scope of research beyond China is a critical step in enhancing our understanding of geotourism impacts. Further value will be gained from studying the impacts of geotourism accounting for varying specific ecological and socio-economical context. Further studies need to be concerned with the perception of the host community and of visitors of the impacts of geotourism at geoparks and geosites at the Asian region.

In conclusion, this review increased our understanding of the main impacts and reasons for impacts of geotourism activities in Asia. Management should strongly focus on establishing policies and guidelines to govern uncontrolled development of geoparks, and it should focus on developing education measures and facilities that are accessible to a specialist and a lay audience. Education content will need to be site-specific to be meaningful as geosites are typically very unique both geologically and ecologically, and so are the threats and

site management needed to conserve sites. To encourage sensible behaviour and a sustainable enjoyment of the benefits of geotourism sites, a collaboration needs to be established between the local community and other stakeholders to draw from different perspectives needed to make decisions on geosite management. Novel research methodologies should be added to the existing arsenal, thereby broadening our understanding of the complex system of benefits and impacts of geotourism in geological landscapes of great significance for humanity.

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References

Amrikazemi A, Mehrpooya A (2006) Geotourism resources of Iran. In Geotourism. Routledge, pp. 120–160

Avelar S, Vasconcelos C, Mansur KL, Anjos SC, Vasconcelos GF (2018) Targeting sustainability issues at geosites: a study in Regiao dos Lagos, Rio de Janeiro, Brazil. Geoheritage 10:1–9

Azman N, Halim SA, Liu OP, Saidin S, Kimoo I (2010) Public education in heritage conservation for Geopark community. Procedia Soc Behav Sci 7:504–511

Badang D, Ali CA, Komoo I, Leman S (2017) Sustainable geological heritage development approach in Sarawak Delta, Sarawak, Malaysia. Geoheritage 9:443–462

Brilha J (2016) Inventory and quantitative assessment of geosites and geodiversity sites: a review. Geoheritage 8(2):119–134

Brown G, Raymond C (2007) The relationship between place attachment and landscape values: toward mapping place attachment. Appl Geogr 27(2):89–111

Bruno DE, Perrotta P (2012) A geotouristic proposal for Amendolara territory northern ionic sector of Calabria, Italy. Geoheritage 4: 139–151

Buckley R, Pannell J (1990) Environmental impacts of tourism and recreation in national parks and conservation reservation reserves. J Tourism Stud 1(1):24–32

Burek CV, Prosser CD (2008) The history of geoconservation: an introduction. Special Publications

Chakraborty A, Cooper M, Chakraborty S (2015) Geosystems as a framework for Geoconservation: the case of Japan's Izu Peninsula Geopark. Geoheritage 7(4):351–363

Chan MA, Godsey HS (2016) Lake Bonneville geosites in the urban landscape: potential loss of geological heritage. In: Oviatt C.G., Shorder J.F. (eds), Lake Bonneville. A scientific update. Dev Earth Surf Process 20:617–633

Chen A (2003) Some problems about the construction of National Geological park of China. Resour Industries 1:58–64

Chen A, Lu Y, Ng Y (2015) The principles of geotourism. Springer, Berlin

Cheung LTO (2015) The effect of geopark visitors' travel motivations on their willingness to pay for accredited geo-guided tours. Geoheritage 8(3):201–209

Cole DN (2009) Ecological impacts of wilderness recreation and their management. In: Dawson CP, Hendee JC (eds) Wilderness management: Stewardship and protection of resources and values. Fulcrum Press, pp 395–438

Cowie JW, Wimbledon WAP (1994) The world heritage list and its relevance to geology. In: O'Halloran D, Green C, Harley M, Stanley M, Knill J (eds) Geological and landscape conservation. Geological Society, London, pp 71–73

Dingwall P, Weighell T, Badman T (2005) Geological world heritage: a global framework, a contribution to the global theme study of world heritage natural sites, Protected Area Programme, IUCN

Dodick J, Orion N (2003) Geology as an historical science: its perception within science and the education system. Sci Educ 12:197–211

Dong HM, Song YG, Chen T, Zhao JB, Yu LP (2014) Geoconservation and geotourism in Luochuan loess national geopark, China. Quat Int 334–335:40–51

Dowling R (2010) Geotourism's global growth. Geoheritage 3(1):1–13

Dowling RK, Newsome D (2006) Geotourism. Elsevier, Oxford

Dowling RK, Newsome D (2010) Geotourism a global activity. In: Dowling RK, Newsome D (eds) Global geotourism perspectives. Good fellow Publishers Limited, Oxford, pp 1–17

Dunbar PK (2007) Increasing public awareness of natural hazards via the Internet. Nat Hazards 42:529–536

Eder FW, Patzak M (2004) Geoparks – geological attractions: a tool for public education, recreation and sustainable economic development. Episodes 27(3):162–164

Erikstad L (2013) Geoheritage and geodiversity management – the questions for tomorrow. Proc Geol Assoc 124:713–719

Farsani NT, Coelho COA, Costa CMM (2012) Geotourism and geoparks as gateways to sociocultural sustainability in Qeshm rural areas, Iran. Asia Pacific J Tourism Res 17(1):30–48

Farsani NT, Coelho COA, Costa CMM, Amrikazemi A (2014) Geo – knowledge management and geoconservation via geopark and geotourism. Geoheritage 6(3):185–192

Farsani NT, Mortazavi M, Bahrami A, Kalantary R, Bizhaem FK (2017) Traditional crafts: a tool for geo-education in geotourism. Geoheritage 9:577–584

Fauzi NSM, Misni A (2016) Geoheritage conservation: indicators affecting the condition and sustainability of Geopark – a conceptual review. Soc Behav Sci 222:676–684

Frodeman R (1995) Geological reasoning: geology as an interpretative and historical science. GSA Bull 107:960–968

Fuming L, Fang W, Heigang X, Zhaoguo W, Baofu L (2015) A study on classification and zoning of Chinese Geoheritage resources in national geoparks. Geoheritage 8:247–261

Fung CKW, Jim CY (2015) Segmentation by motivation of Hong Kong Global Geopark visitors in relation to sustainable nature-based tourism. Int J Sustain Deve World Ecol 22(1):76–88

Gordon JE, Barron HF, Hansom JD, Thomas MF (2012) Engaging with geodiversity – why it matters. Proceedings of the Geologists' Association, China, pp 1–6

Gray M (2004) Geodiversity valuing and conserving abiotic nature. John Wiley & Sons

Gray M (2011) Other nature: geodiversity and geosystem services. Environ Conserv 38(3):271–274

Gray M (2013) Geodiversity: valuing and conserving abiotic nature, 2nd edn. Wiley Blackwell, Chichester

He X, Li Z, Hao M, Tang K, Zheng F (2003) Down-scale analysis for water scarcity in response to soil–water conservation on Loess Plateau of China. Agric Ecosyst Environ 94(3):355–361

Henriques MH, Reis dos RP, Brilha J, Mota T (2011) Geoconservation as an emerging geoscience. Geoheritage 3:117–128

Hoang FMH, Messing I, Wen ZM (2003) A participatory approach for integrated conservation planning in a small catchment in Loess Plateau China: part II. Anal Findings Catena 54:271–288

Hose TA (1995) Selling the story of Britain's stone. Environ Int 10(2): 16–17

Hose TA (2000) European "geotourism"–geological interpretation and conservation promotion for tourists. In: Barettino D, Wimbledon WAP, Gallego E (eds) Geological heritage: its conservation and management. ITGE, Madrid, pp 127–146

Hose TA (2005) Geo-tourism – appreciating the deep time of landscapes. Niche Tourism: contemporary issues, trends and cases. London
Hose TA (2006) Geotourism and interpretation. In: Dowling R, Newsome D (eds) Geotourism. Elsevier, London, pp 221–241
Hose TA (2007) Geotourism in Almeria Province Southeast Spain. Tourism 55(3):259–276
Hose TA (2008) Towards a history of geotourism: definitions, antecedents and the future. Special Publications, The Geological Society of London, pp 37–60
Hose TA (2011) The English origins of Geotourism (as a vehicle for Geoconservation) and their relevance to current studies. Acta Geogr Slovenica 51(2):343–359
Hose TA, Vasiljevic DA (2012) Defining the nature and purpose of modern geotourism with particular reference to the United Kingdom and South-East Europe. Geoheritage 1–2:25–43
Hose TA, Wickens E (2004) Typologies, tourism locations and images: meeting the real needs of real tourists. In: Weber S, Tomljenovic R (eds) Reinventing a tourism destination: facing the challenge. Institute for Tourism, Zagreb, pp 103–114
Hossain I, Nahar M (2014) The Eocene Sylhet Limestone of Jaflong and adjoining areas, Sylhet: an endangered Geoheritage in Bangladesh. Geoheritage 6:317–333
Ibrahim K (2000) Conservation geology: a multidisciplinary approach in utilization of earth resources without destruction. In: Ibrahim K, Tija HD (eds) Geological heritage of Malaysia – resource development for conservation and nature tourism. Lestari UKM Publication, Bangi
Jin Q, Ruban DA (2011) A conceptual framework of tourism crowding management at geological heritage sites. Nat Nascosta 43:1–17
Joyce EB (2006) Geological heritage of Australia: selecting the best for Geosites and World Heritage, and telling the story for geotourism and Geoparks. ASEG Extended:1–4
Kamel MY, Hassan SB, Wafik GM (2017) The challenges of geotourism in Egypt: A case study of Wadi Al-Hitan. Int J Hosp Tourism Syst 2(10):32–46
Kiernan K (2013) The nature conservation, geotourism and poverty reduction Nexus in developing countries: a case study from the Lao PDR. Geoheritage 5:207–225
Koh Y, Oh K, Youn S, Kim H (2014) Geodiversity and geotourism utilization of islands: Gwanmae Island of South Korea. J Mar Island Cult 3(2):106–112
Koizumi T, Chakraborty A (2016) Geoecotourism and environmental conservation education : insights from Japan. GeoJournal 81(5): 737–750
Kubalikova L, Kirchner K (2016) Geosite and geomorphosite assessment as a tool for geoconservation and geotourism purposes: a case study from Vizovická vrchovina Highland (eastern part of the Czech Republic). Geoheritage 8:5–14
Larwood JG, Badman T, McKeever PJ (2013) The progress and future of geoconservation at a global level. Proc Geol Assoc 124(4):720–730
Li X, Sun N, Dodson J, Zhou X (2012) Human activity and its impact on the landscape at the Xishanping site in the western Loess Plateau during 4800–4300 calyr BP based on the fossil charcoal record. J Archaeol Sci 39(10):3141–3147
Lianyong W (2007) Multi-designated geoparks face challenges in China's heritage conservation. J Geogr Sci 17:187–196
Lima E, Nunes J, Costa M, Porteiro A (2010) Main geosites of the Azores Geopark project. In: Lamolda MA (ed) Geoevents. Geological Heritage and the Role of the IGCP, Caravaca de la Cruz, pp 227–229
Lima A, Nunes JC, Brilha J (2017) Monitoring of the visitors impact at BPonta da Ferraria e Pico das Camarinhas Geosite (São Miguel Island, Azores UNESCO Global Geopark, Portugal). Geoheritage 9:495–503
Loon AJV (2008) Geological education of the future. Earth Sci Rev 86(4):247–254
Marion JL, Leung Y (2001) Trail resource impacts and an examination of alternative assessment techniques. J Park Recreat Adm 19(3):17–37
Mathieson A, Wall G (1982) Tourism: economic, physical and social impacts. Longman, Harlow
Monz CA, Cole DN, Leung YF, Marion JL (2010) Sustaining visitor use in protected areas: future opportunities in recreation ecology research based on the USA experience. Environ Manag 45(3):551–562
Musa G (2002) Sipadan: a scuba-diving paradise: an analysis of tourism impact, diver satisfaction, and tourism management. Tour Geogr 4(2):195–209
National Geographic (2012) what is geotourism? Center for Sustainable Destinations. Online: www.nationalgeo- graphic.com/travel/sustainable, 15.06.2012
Newsome D, Dowling RK (2010) Geotourism: the tourism of geology and landscape. Goodfellow Publishers, Oxford
Newsome D, Johnson CP (2013) Potential geotourism and the prospect of raising awareness about geoheritage and environment on Mauritus. Geoheritage 5(1):1–9
Newsome D, Dowling R, Leung Y (2012) The nature and management of geotourism: a case study of two established iconic geotourism destinations. Tour Manag Perspect 2(3):19–27
Ollier C (2012) Problems of geotourism and geodiversity. Quaestiones Geographicae 31(3):57–61
Orion N (2001) Education in earth sciences: from theory to practice-implementation of new teaching strategies in different learning environments. In: Marques L, Praia J (eds) Geosciences in basic and secondary education curricula. University of Aveiro, Department of Didactics and Educational Technology, pp 93–114
Orion NDB, Thompson KC (1996) Earth sciences education: an extra dimension to science education in schools. Caderonos IG/UNICAMP 6:122–133
Paskeh HS, Khoshraftar R (2011) the Maragheh geosite: a key geopark from Iran. 10th European geoparks conference, Norway
Pickering C, Byrne J (2014) The benefits of publishing systematic quantitative literature reviews for PhD candidates and other early-career researchers. High Educ Res Dev 33:534–548
Piranha JM, Del Lama AE, de La CBD (2011) Geoparks in Brazil—strategy of geoconservation and development. Geoheritage 4:289–298
Prosser CD, Bridgland DR, Brown EJ, Larwood JG (2011) Geoconservation for science and society: challenges and opportunities. Proc Geol Assoc 122(3):337–342
Shafiei Z, Farsani NT, Abdollahpour M (2017) The benefit of geo-branding in a rural geotourism destination: Isfahan, Iran. Geo J Tourism Geosites 1(19):96–103
Shahhoseini H, Modabberi S, Shahabi (2017) Study of factors influencing the attitude of local people toward geotourism development in Qeshm national park. Geoheritage 9:35–48
Sheth H, Samant H, Patel V, D'Souza J (2017) The volcanic geoheritage of the Elephanta Caves, Deccan Traps, Western India. Geoheritage 9:359–372
Shi H, Shao MA (2000) Soil and water loss from the Loess Plateau in China. J Arid Environ 45(1):9–20
Sidle RC, Taylor D, Lu XX, Adger WN, Lowe DJ, De Lange WP, Newnham RM, Dodson JR (2004) Interactions of natural hazards and society in Austral-Asia: evidence in past and recent records. Quat Int 118(119):181–203
Song Y, Shi ZT, Fang XM, Nie JS, Naoto I, Qiang XK, Wang XL (2010) Loess magnetic properties in the Ili Basin and their correlation with the Chinese Loess Plateau. Sci China Earth Sci 53:419–431
Spellerberg I (1991) Monitoring ecological change. Cambridge University Press, Cambridge
UNESCO (2006) Global Geoparks network. Geoparks Secretariat, Global Earth Observations Section, Division of Ecological and Earth Sciences, UNESCO, Paris

UNESCO (2014) Guidelines and Criteria for National Geoparks Seeking UNESCO's Assistance to Join the Global Geoparks Network (GGN), pp 1–13

Vasiljevic DA, Markovic SB, Hose TA, Smalley I, Basarin B, Lazic L, Jovic G (2011) The introduction to geoconservation of loess-palaeosol sequences in the Vojvodina region: significant geoheritage of Serbia. Quat Int 240(1–2):108–116

Vasiljević DA, Marković SB, Hose TA, Ding Z, Guo Z, Liu X, Smalley I, Lukic T, Vujicic D (2014) Loess-palaeosol sequences in China and Europe: common values and geoconservation issues. Catena 117: 108–118

Wang LL, Tian MZ, Wen XF, Zhao LL, Song JL, Sun M, Wang H, Lan YH, Sun M (2014a) Geoconservation and geotourism in Arxan-Chaihe Volcano Area, Inner Mongolia, China. Quat Int 349:384–391

Wang LL, Tian MZ, Wang L (2014b) Geodiversity, geocinservation and geotourism in Hong Kong Global Geopark of China. Proc Geol Assoc 123:426–437

Wang L, Tian M, Wang L (2015) Geodiversity, geoconservation and geotourism in Hong Kong Global Geopark of China. Proceedings of Geologist'Association, China, pp 426–437

Wei J, Zhou J, Tian JL, He XB, Tang KL (2006) Decoupling soil erosion and human activities on the Chinese Loess Plateau in the 20th century. Catena 68:10–15

Wolf ID, Stricker HK, Hagenloh G (2013) Interpretive media that attract park visitors and enhance their experiences: a comparison of modern and traditional tools using GPS tracking and GIS technology. Tour Manag Perspect 7:59–72

Wolf ID, Wohlfart T, Brown G, Bartolomé Lasa A (2015) The use of public participation GIS (PPGIS) for park visitor management: a case study of mountain biking. Tour Manag 51:112–130

Wolf ID, Brown G, Wohlfart T (2018) Applying public participation GIS (PPGIS) to inform and manage visitor conflict along multi-use trails. J Sustain Tour 26(3):470–495

Yalgouz-Agaj AG, Ardebil L, Karimdoust S (2010) Identification of some of the geotourism sites in Iran. World Appl Sci J 11(11): 1342–1347

Yang G, Tian M, Zhang X, Chen Z, Wray RAL, Ge Z, Ping Y, Ni Z, Yang Z (2012) Quartz sandstone peak forest landforms of Zhangjiajie Geopark, Northwest Hunan Province, China: pattern, constraints and comparison. Environ Earth Sci 65:1877–1894

Yeung KM (2008) Geodiversity – a new challenge for nature conservation in Hong Kong. Proceedings of Asia-Pacific Seminar on Geological Conservation and Sustainable Development, Hong Kong, pp 47–58

Zhong X, Rongjun Z, Ming L (2005) An exploration into the construction and management of geoparks in Henan Province. Henan Land Resour 10:12–13

Zouros N (2004) The European Geoparks Network. Geological heritage protection and local development. Episodes 3(27):165–171

Zouros N (2010a) Lesvos Petrified Forest Geopark, Greece: geoconservation, geotourism, and local development. George Wright Forum J 27:19–28

Zouros N (2010b) Geotourism in Greece: a case of the Lesvos Petrified Geopark. In: Dowling RK, Newsome D (eds) Global Geotourism Perspectives. Good fellow Publishers, Oxford, pp 215–229