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Youth Participation in UNESCO Biosphere Reserves: A Scoping Review

Yano Truyers [1, 2, *] and Bieke Abelshausen [1]

[1] Faculty of Psychology & Educational Sciences, Vrije Universiteit Brussel, Brussels, Belgium;
[2] Research Institute for Nature and Forest, Brussels, Belgium;
[*] Correspondence: yano.truyers@vub.be;

Abstract

Social-ecological systems have steadily evolved from expert-led management towards community involvement. In line with the upcoming engagement of youth as a separate stakeholder group within the UNESCO Man and the Biosphere Program, this scoping literature review provides an overview of studies currently existing in regard to youth within UNESCO biosphere reserves. By using a sequential and qualitative selection procedure, an analysis is made of the involvement of youth within UNESCO biosphere reserves. Hereby theoretical backgrounds and methodological approaches are clustered, and recommendations for future inquiry are made. Seven articles were selected for full-text in-depth analysis. In line with specific youth definitions and delineations found within the selected articles, most studies do not include high levels of participation in biosphere reserve research or praxis. Results show that it is considered essential to create a structured multi-method research plan adopting an adaptive research approach throughout the process of data collection and integrate a system theory approach to include all relevant contextual factors. The literature review concludes that there exists a research gap of youth within the UNESCO biosphere reserves framework. Thus, the recommendation is made for the explicit inclusion of the essential aspect of youth as explicitly stated and separate entities within future biosphere reserve research.

Keywords

Biosphere Reserve; Youth; Participation; Scoping Review.

1. Introduction

Youth as a valuable community asset is often overlooked when it comes to social-ecological system management. Whereas expert-led management of ecosystems has steadily evolved towards community involvement in social-ecological systems (Berkes, 2004), it is hypothesized that current literature does not explicitly distinguishes youth as separate stakeholders within the conservation and development perspective of social-ecological systems. However, in line with international engagements such as the UNESCO MAB program, literature and praxis is moving towards a more holistic approach in the recognition and involvement of youth in social-ecological system management.

In 1971 the United Nations Educational, Scientific and Cultural Organization (UNESCO) launched the Man and Biosphere Program (UNESCO, 2017c). This intergovernmental scientific program aims to establish a scientific basis for the improvement of relationships between people and their environment (UNESCO, 1996). By establishing a World Network of Biosphere Reserves, the Man and Biosphere Program aims at promoting solutions reconciling the conservation of biodiversity with its sustainable use (Ishwaran, Persin, & Tri, 2008; UNESCO, 2008, 2017d). Since the Seville Strategy (UNESCO, 1996) was developed, each biosphere reserve can be seen as a 'science for sustainability support site' in order to test interdisciplinary approaches to understanding and managing changes and interactions between social and ecological systems, including conflict prevention and management of biodiversity (UNESCO, 2017a, 2017b). Biosphere reserves are characterized by

three interrelated zones which aim to fulfil three complementary and mutually reinforcing functions. Whereas the core area(s) comprises a strictly protected ecosystem, a surrounding buffer zone includes and encourages development activities comprising scientific research, monitoring, training, and education (Ishwaran, Persin, & Tri, 2008). Thereafter, a transition area allows even more invasive activities like fostering economic and human development that is socio-culturally and ecologically sustainable (Ishwaran, Persin, & Tri, 2008).

Within the UNESCO Man and the Biosphere Program, youth as a separate stakeholder group is a key engagement. Youth can be identified as the age cohort between children and adults. However, composing an unambiguous definition of this rather familiar concept is complex. Whereas the UN Convention on the Rights of the Child describes a child as being under the age of 18 (UN, 1989), the UN, through their World Programme of Action for Youth, adopts a statistical definition of youth as persons between the age of 15-24 (UN, 2010). Hereby, it is stated that definitions have changed continuously in response to fluctuating political, economic, and socio-cultural circumstances of Member States (UN, 2010). Furthermore, several UN entities adopt alternative age ranges (Karkara, Ragan, & Solberg, 2012). UNESCO follows the UN age boundary of 15-24 (UNESCO, 2019). They state this definition to be flexible, context specific and fluid, as "the experience of being young can vary substantially across the world, between countries and regions" (UNESCO, 2019). In the context of biosphere reserves, the MAB strategy document only refers three times to the concepts of youth and young people, without giving a clear definition of both terms (UNESCO, 2017d).

The level of participation of youth in research and praxis is considered relevant as literature suggests that youth participation through for example participatory action research, both as research method and intervention, allows for the enhancement of youth empowerment and development (Kim, 2016). Levels of stakeholder participation (including youth) within the scope of biosphere reserves are based on an adapted version of Arnstein's ladder of participation, used in Roldan, Duit, and Schultz (2019). Four different, sequential levels are indicated: (1) information; the degree to which the Biosphere Reserve informs and consults local actors about its activities, (2) implementation; the participation of local stakeholders in day-to-day management and monitoring efforts, (3) involvement; the degree to which stakeholders partake in setting the goals for the BR, and (4) representation; if local stakeholders are being represented in the BR's steering committee or board. Participatory action research in specific is considered to be not defined by the methods used within the selected studies, but by the relationship between the researcher(s) and the participants (Newing, Eagle, Puri, & Watson, 2011). Three types of participation are identified, delineating this relationship: (1) adult-driven, (2) youth-adult partnership, (3) youth-driven research (Kim, 2016; Newing et al., 2011). Furthermore, an evolution toward a more innovative approach called 'Youth-led Participatory Action Research' (YPAR) can be noted. This approach focusses on youth empowerment and incorporates a range of methods to engage youth in sharing their perspective, i.e., empowering the voices of youth (Kim, 2016; McRuer & Zethelius, 2017). The involvement of youth within such collaborative research approaches is however not frequently reported (Powers & Tiffany, 2006).

2. Materials and Methods

This article provides insights into both research and praxis of youth within UNESCO biosphere reserves. It clarifies the research designs and research methods used to analyze the involvement of youth within UNESCO biosphere reserve research. Scoping review as a type of knowledge synthesis is acknowledged to be a methodology ideal to examine the extent, range, and nature, identify literature gaps, and summarize findings from knowledge that is methodologically heterogenous (Arksey & O'Malley, 2005; Pham et al., 2014; Tricco et al., 2018). Hence, the research undertaken as part of this scoping literature review addressed three key questions:

1. What is the conceptual and theoretical background of existing research of youth stakeholders within UNESCO biosphere reserves?
2. What are the methodological approaches taken and which empirical research methods were put into practice?
3. What are recommendations made for future research regarding youth stakeholders?

A scoping literature review regarding youth involvement within UNESCO biosphere reserve research is considered essential before conducting in-depth case studies and creating guidelines for future innovative approaches. Therefore, the hypothesis of this review is as followed: 'Youth is an underrepresented group of stakeholders within the research context of stakeholder participation in UNESCO biosphere reserve research'. We envision the need for a holistic in-depth research of youth involvement in biosphere reserve management. Hence, this scoping literature review is considered a background analysis for future academic research regarding youth as biosphere reserve research and management stakeholders.

Focusing on the broad concept of youth, this article aims to provide knowledge about their involvement as stakeholders within the international framework of UNESCO biosphere reserves. For the purposes of the literature review, all ethnicities and geographical scopes were included in the review, and no initial distinction was made on the basis of methodology. As part of these different boundaries and in line with the explorational objective of this literature review, no predetermined age-related delineation was set on the concept of 'youth' or

'young people'. On the contrary, to analyze the similarities and differences of definitions used within the selected articles, it was considered to be of specific value to this scoping literature review. Hence, the review focuses on all youth stakeholders throughout all biosphere reserves.

The literature search was conducted from November 2019 until the end of January 2020 and followed a stringent search and analysis strategy. With youth as stakeholders within UNESCO biosphere reserves as its focus of inquiry, and due to the global acknowledgment and use of the terms 'youth' and 'young people', no other synonyms or related terms were used. Based on those inclusion criteria, the following keywords and search combination for the literature search were derived:

["Biosphere Reserve*" AND (Youth OR "Young Peopl*")]

This search combination was used in two databases, i.e., Web of Science and Limo. First, Web of Science was consulted using the search combination 'ALL' field tag, which includes for example title and topic. Next, Limo was consulted using two extra rigorous criteria, (1) source type: article; (2) search area: the term 'biosphere reserve*' within article keywords and the term 'youth OR young people' within full document, to narrow search results.

Following this, each body of literature from the search process was analyzed in a sequential and qualitative way (see Figure 1). A brief checklist of quality criteria was developed to determine the quality and appropriateness of the information: (1) Is the reference a study within or related to one or multiple biosphere reserves recognized by the UNESCO MAB program, and (2) does the study include and/or focusses on youth/young people? If it was possible to answer both questions with 'yes', a full review of the literature item was carried out provided the full text was available. Only those articles which have come through the quality assessment, have been fully reviewed.

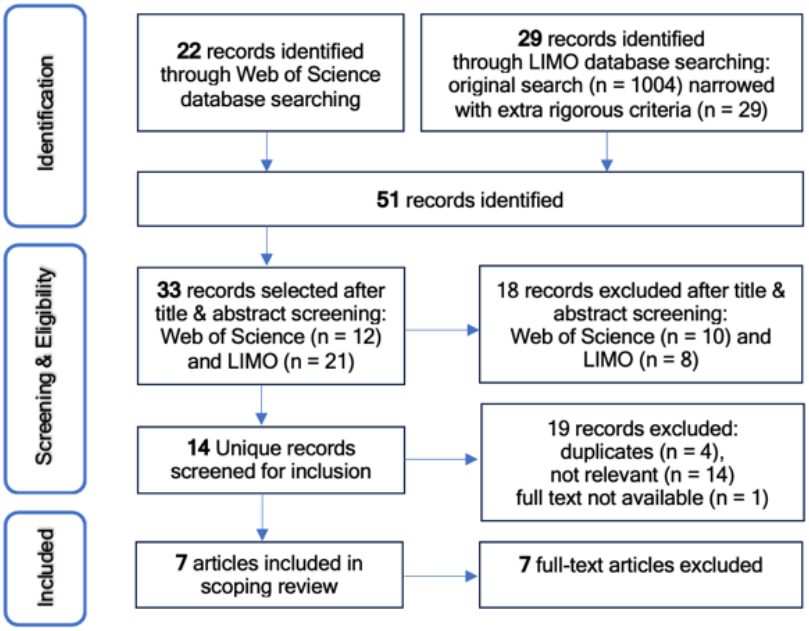

Figure 1. PRYSMA flowchart of study selection process.

4. Results

Using Web of Science and LIMO to survey academic literature on youth participation in Biosphere Reserves, subject to the rigorous quality checklist, resulted in a total of 7 unique records included in this review. Table 1 provides an overview of the selected papers that deliver useful information to address the three key questions of this research: the conceptual and theoretical background of existing research of youth stakeholders within UNESCO biosphere reserves; the methodological approach taken, and empirical research methods put into practice; the recommendations made for future research regarding youth stakeholders. Moreover, it summarizes relevant information and content of the selected articles, including (1) geographical scope, (2) overall objectives and research aim, (3) data collection methods, and a clear distinction between (4) research executors and respondents. Thereafter, Table 2 indicates the levels of participation in research and practice, which will be explained further.

https://doi.org/

Table 1. Included articles regarding youth within UNESCO biosphere reserve research.

Article reference	Geographical scope	Overall objectives & Research aims	Data collection methods	Executor (E) & Respondents (R)
Mendis-Millard and Reed (2007)	Clayoquot Sound BR & Redberry Lake BR - Canada	Overall objective: To engage biosphere reserve volunteer board members and general residents in determining the kinds, characteristics, and accessibility of local natural, social, economic, and human capital available to assist local people. Specific aim: - To assess how community-based research can effectively, and even help build, community capacity and inform the concept of ecosystem management.	- Semi structured in-depth interviews, focus groups, workshops	[E] Researchers [R] Local residents (e.g. youth)
Sylvester et al. (2016)	La Amistad BR - Costa Rica	Overall objective: To examine culturally specific relationships with wild food, the extent and frequency of wild food use in forests, and young people' s wild food consumption. Specific aims: - To gather information regarding (1) hunting and consuming wild meat, (2) harvesting and consuming wild plant foods, (3) wild resource sharing, and (4) gendered and generational harvesting [surveys]; - To gather information related to interviewees' engagement in wild food harvesting, consumption, and food sharing [interviews]; - To extend understanding of young people' s food consumption focusing on interactive activities related to Bribri food, including story telling by Elders, a show– and-tell about wild food [traditional food workshop & photography exposition].	- Participant observation, interviews, focus group discussions, household surveys & a traditional food workshop	[E] Researchers [R] Local residents, e.g. youth; Specific focus on high school youth during traditional food workshops.
Mammadova (2017)	Mount Hakusan BR - Japan	Overall objective: To assess the site-specific elements that links biological and cultural diversity of the region. Specific aims: - To assess intensive teaching activities, e.g. in-class activities for theoretical and methodological tools - To assess five fieldtrip activities.	- Informal interviews (during each course) - Post-fieldtrip-survey-reports - Post-activity-feedback, awareness & knowledge-survey (considered very basic)	[E] Academic students [R] Local villagers [E] Researchers [R] Academic students (n=21) [E] Researchers [R] Academic students (n=21)
Sedano et al. (2018)	the Urdaibai BR - Spain	Overall Objective: To study the effectiveness of activities carried out outside the school which boost pupils' motivation and promote concept learning. Specific aims: - The acquisition of information about the Basque youth´s attitude towards nature; - The assessment of the effectiveness in promoting interest in nature of visiting the Ekoetxea Interpretive Center.	- Pre-visit-survey & Post-visit-survey	[E] Researchers [R] Primary Education and Secondary School students

Mammadova (2019)	Volzhsko-kamsky BR, Baykalskiy BR & Far East Marine BR – Russia Mount Hakusan BR - Japan	Overall objectives: To evaluate the changes in students' knowledge, attitude, and skills towards each other's culture, after intercultural exchange and learning. - To examine how well BRs can be effective to increase intercultural cultural competence in youth. Specific aims: - To evaluate the intercultural competence elements like attitudes/awareness, knowledge, and skills on culture of each country	- Post-course-survey-reports	[E] Researchers [R] Japanese & Russian students
Mitrofanenko et al. (2018)	Salzburger Lungau & Kärntner Nockberge BR - Austria	Overall objective: To examine the motivations and barriers for participation of the youth and elderly women in processes and activities related to the implementation of the biosphere reserve. They hereby consider the potential for applying intergenerational practice (IP) as a means to increase their involvement. Specific aims: What are the perceptions of the biosphere reserve among the elderly women and youth, as well as the obstacles to and motivations for them to engage in biosphere reserve-related activities? What are the elderly and younger residents' perceptions of the other generation and intergenerational practice? Are the biosphere reserve managers aware of the potential held by the involvement of youth and elderly, and to which extent are they familiar with IP?	- Semi-structured interviews - Face-to-face interviews - World Café - Individual interviews and focus groups - Background analysis of existing reports, BR-websites, and participatory events	[E] Researchers [R] key-informants, i.e. BR managers, and process facilitators defined as five middle aged women [E] Researchers [R] young residents [E] Researchers [R] school classes [E] Researchers [R] Elderly women [E] Researchers
Grasser et al. (2016)	Grosses Walsertal BR - Austria	Overall objective: To identify present methodological details of participatory approaches in ethnobiological research. Specific aims: To document the diversity of wild plant species gathered by local people with state-of-the-art interdisciplinary methods; To highlight the close link between biodiversity and local culture; To actively support various local initiatives concerning the sustainable conservation of biodiversity and biosphere management by involving these actors in the research process and disseminating the results.	Phase 1: Freelist interviews & participant observation Phase 2: school workshops structured questionnaires Phase 3: Two 5-day participatory video workshops Phase 4 (evaluation): Semi-structured questionnaires/survey Participant observation	Phase 1: [E] First author [R] Local people Phase 2: [E] First Author [R] Students [E] Students/children [R] family members Phase 3: [E] Co-production children-researchers [R] Children interviewed local experts Phase 4: [E] Researchers [R] Children who took part in the video workshop (n=10) [E] Researchers [R] Children

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4.1. Geographical Scope

A geographical scope (see Table 1) that is (partly) labelled as biosphere reserves recognized by UNESCO was one of the quality criteria developed to determine the quality and appropriateness of the selected studies. Hence, all studies were conducted within a relatively similar administrative and internationally recognized status, i.e., a biosphere reserve. Nonetheless, these reserves still include a variety of terrestrial, marine, and coastal ecosystems (UNESCO, 2017b), management approaches, levels of community-involvement and levels of development. Moreover, each reserve is divided into a core zone, a buffer area, and a transition zone. Further indept analysis of those varieties and zones was not considered relevant in regard to the formulated research questions.

Results show ten different biosphere reserves across six different countries and three continents. Three out of the seven studies included multiple biosphere reserves as geographical scope in their research approach. Notably is the fact that one study, Mammadova (2019), was partly conducted in multiple acknowledged biosphere reserves. Other National Parks and one Nature Park were also part of their geographical scope. A biosphere reserve as geographical scope was not a fundamental element during their research.

4.2. Overall objectives and research aim in relation to youth delineation

An analysis of research objectives and aims in relation to youth delineation presupposes the inclusion of a youth definition or at least descriptive statement. In total, five out of seven articles define their youth participants as students. Sedano, Ortuzar, and Diez (2018) use Primary Education and Secondary School students as sample group. Mammadova (2017) focuses on educating youth, defined as students in general. In her intercultural education and exchange program, Mammadova (2019) examines Japanese and Russian students. Grasser, Schunko, and Vogl (2016) use the terms students and children to define their respondents. At last, Mendis-Millard and Reed (2007) and Sylvester, Segura, and Davidson-Hunt (2016) focus on local residents, including their implicit notion of youth. Hereby, Sylvester et al. (2016) targeted high school youth during the workshops. Yet, none of these studies include a clear exclusive and exhaustive outline of what these concepts include.

Only one out of the seven articles (Mitrofanenko, Snajdr, Muhar, Penker, and Schauppenlehner-Kloyber, 2018), includes an analysis of youth definitions in their article. Via their synthesis, they define youth participants as “20 years old and younger” and emphasize this adopted definition is used in intergenerational literature and is compatible with the official Austrian definition of youth as aged between 14 and 19 years (Mitrofanenko et al., 2018, p. 433).

In regard to the relation between adopted research designs (see Table 1) and multiple youth delineations, a wide variety in objectives and levels of participation and management competence can be found. Firstly, with the global loss of biodiversity as a starting point, Sedano et al. (2018) consider environmental education as a widely demanded and fundamental element to improve the situation of the ecosystems of the world. Therefore, their research assesses the efficiency of environmental education programs within a Spanish biosphere reserve, viewing young people, defined as students, as survey participants. Next, survey respondents were household heads in the study of Sylvester et al. (2016). Therefore, they indicate the possibility of misrepresented data in regard to younger generations. Although younger household members volunteered to respond to survey questions 26 percent of the time and some were present when surveys with adults were carried out, supplement surveys with other methods, e.g., individual interviews and discussions during a traditional food workshop, were necessary to ensure the representation of youth’s views. The authors argue that youth’s participation defined as research respondents, turned out to be crucial in order to understand the many factors that shape access and availability of wild food, including relationships with non-human beings, health, work, school and time constraints, and/or access to rifles or dogs, enabling them to triangulate their data as well as to enrich the understanding of short responses provided in their household surveys (Sylvester et al., 2016).

Another notable research approach can be found in the study of Mammadova (2019). In partnership with relevant stakeholder organizations, she created educational programs for Russian and Japanese students to evaluate the intercultural competence through learning of each other culture and nature inside the biosphere reserves. Mammadova (2019) conducted cross-cultural inbound courses to Japan for 14 Russian students and outbound courses to Russia for 50 Japanese students, by using the biosphere reserves as a platform to increase their intercultural competencies. The course objectives consisted of; (1) understanding the diverse cultural and natural differences of each country, (2) increasing the communication, creativity, and decision-making skills between Russian and Japanese students during BR’s natural activities, (3) learning about Human-Nature-Culture Interaction, and (4) using that knowledge for the regional revitalization of each country (Mammadova, 2019).

Notably is the research objective of Mitrofanenko et al. (2018). These authors examined the motivations and barriers for participation of both youth and elderly women in processes and activities related to the implmentation of biosphere reserves. The Intergenerational practice (IP) approach was applied as a means to increase

their involvement. This approach brings young and old age groups together in order to build more cohesive communities (Mitrofanenko et al., 2018).

4.2. Data collection methods

Five of the seven selected articles (Grasser et al., 2016; Mammadova, 2017; Mendis-Millard & Reed, 2007; Mitrofanenko et al., 2018; Sylvester et al., 2016) used multiple research methods to gather data. The remaining two (Mammadova, 2019; Sedano et al., 2018) only used surveys as they conducted research within the context of educational programs. In total, seven different research methods were found: questionnaire (Grasser et al., 2016), World Café (Mitrofanenko et al., 2018), survey (Mammadova, 2017, 2019; Sedano et al., 2018; Sylvester et al., 2016), participant observation (Grasser et al., 2016; Sylvester et al., 2016), workshops (Grasser et al., 2016; Mendis-Millard & Reed, 2007; Sylvester et al., 2016), focus group (Mendis-Millard & Reed, 2007; Mitrofanenko et al., 2018; Sylvester et al., 2016), and interview methods (Grasser et al., 2016; Mammadova, 2017; Mendis-Millard & Reed, 2007; Mitrofanenko et al., 2018; Sylvester et al., 2016). Note that both survey and questionnaire are considered different research methods. Represented analysis adopted the terms used in the referred studies. However, no definition of both survey and questionnaire was given within these studies. Therefore, the possibility of overlapping methods cannot be excluded.

In Mendis-Millard and Reed (2007), the concept of adaptive research methods appeared. This approach emphasizes the importance of flexible academic research and researchers themselves. Mendis-Millard and Reed (2007) observed that conducting community-based research combined with an adaptive approach require researchers to monitor their work constantly and to be sensitive to many research stakeholders on a regular basis throughout the process. Moreover, by stating funding agencies to be typically seeking research questions where outcomes are predictable rather than emergent, Mendis-Millard and Reed (2007) argue that it may prove difficult to promote this approach.

Although they don't quote the term adaptive research methods, also Sylvester et al. (2016) emphasize the value of being flexible throughout the research process:

> We did not plan to conduct a workshop on traditional food consumption but did so at our colleagues' recommendation. As our research illustrates, developing these methods can be context specific. At the same time, we found it helpful to start with general tools to gather information about wild foods (e.g., household surveys) and to modify these tools based on the advice of our research colleagues. (Sylvester et al., 2016, p. 459)

Throughout the use of sequential data collection methods, multiple authors argue it to be crucial to adopt a reflexive research practice (Mendis-Millard & Reed, 2007; Mitrofanenko et al., 2018; Sylvester et al., 2016). This approach refers to critical reflection throughout the research process that helps "sensitize the researchers to the cultural, social, political, and economic contexts of the research and to acknowledge multiple possible interpretations of the findings" (Mendis-Millard & Reed, 2007, p. 547).

Finally, a significant difference regarding the written conscious considerations in the choice of research methods is found between the study of Mitrofanenko et al. (2018) and all other selected articles. While most authors give a brief description of the chosen research method(s), the article of Mitrofanenko et al. (2018) gives a deeper and more specific explanation of the sequential selection procedure of research methods. Thereby, they include an overview (see Table 2, page 434 in Mitrofanenko et al., 2018) representing the interviewees. Moreover, they refer to other authors during their research method disquisition, indicating the conscious considerations during selection procedures.

4.3. Research Executers and respondents

Each empirical study in this literature review includes both research executors (i.e., the person(s) responsible for data collection) and respondents (i.e., the person(s) who provide raw data to be analyzed). An ad verbum overview of all research executors and respondents is outlined in Table 1. In line with the overview of, and separations between research executors and respondents, it is considered relevant to analyze levels of participation in academic research and biosphere reserve practice within the selected studies. This turned out to be crucial in order to understand adopted definitions of youth. Although not explicitly stated in the selected studies, the level of research participation and the embraced level of youth stakeholder participation in biosphere reserves was analyzed during literature analysis. Based on the levels of participation as stated by Kim (2016), Newing et al. (2011) and Roldan, Duit, and Schultz (2019),

Table 2 gives an overview of the levels of participation in both research and biosphere reserve praxis. Based on Kim (2016), the level of participation in biosphere reserve research, comprises (1) adult-driven research, (2) youth-adult partnership, and (3) youth-driven research. Based on Roldan et al. (2019), the level of stakeholder participation in biosphere reserve praxis encompasses (0) missing data; no implicit or explicit indication can be found, (1) information; the biosphere reserve informs and consults local actors about its activities, (2) implementation; the participation of local stakeholders in day-to-day management and monitoring efforts, (3)

involvement; stakeholders partake in setting the goals for the biosphere reserve, and (4) representation; stakeholders are being represented in the biosphere reserves steering committee or board.

Table 2. Levels of Youth Participation in Biosphere Reserve Research and Praxis.

	Level of participation in research (based on Kim, 2016)	Level of participation in praxis (based on Roldan et al., 2019)
Mendis-Millard and Reed (2007)	Youth-adult partnership	Involvement
Sylvester et al. (2016)	Adult-driven research	Information
Mammadova (2017)	Youth-adult partnership	Missing data
Sedano et al. (2018)	Adult-driven research	Missing data
Mammadova (2019)	Adult-driven research	Missing data
Mitrofanenko et al. (2018)	Adult-driven research	Implementation
Grasser et al. (2016)	Youth-adult partnership	Missing data

4.3.1. Levels of youth's research participation

Notably, only the studies of Mammadova (2017) and Grasser et al. (2016) included research methods in which young people adopted the role of executor. Academic students in the study of Mammadova (2017) only conducted informal interviews with local villagers as part of their own education program. Also, in Grasser et al. (2016), the "children" only partially adopted a researcher role when they interviewed local experts during participatory video workshops.

4.3.1. Levels of youth's stakeholder participation

Like stated above, only Mitrofanenko et al. (2018) specifically focus on defining youth as biosphere reserve stakeholders. Moreover, they argue that although stakeholder participation is considered of high importance in UNESCO biosphere reserves, certain groups, i.e., youth and elderly women, remain underrepresented. Mitrofanenko et al. (2018) hereby support this scoping review's hypothesis. Furthermore, they propose Intergenerational Practice (IP) as a means of involving both youth and elderly women and explore its options and barriers. Their results reveal obstacles and motivations to participating in biosphere reserve implementations and intergenerational activities and imply that much potential for IP exists in the Lungau and Kärntner Nockberge biosphere region in Austria. Hence, suitable solutions from the field of IP are proposed to overcome identified participation obstacles. Benefits of incorporating IP as a management tool into biosphere reserve activities are suggested. These consist of tackling the lack of understanding and information in order to create opportunities to inform youth and elderly about the reserve in general, and local people's potential in specific. Moreover, IP could make benefits visible and address power inequalities and hierarchy, lack of agreement and trust issues. This IP approach can be implemented into biosphere reserve management on several levels, including international, regional, and national levels (Mitrofanenko et al., 2018).

Furthermore, in the context of environmental education, Mammadova (2019) argue that biosphere reserves can be used as platforms to link cultural and biological diversity. They are considered to be helpful to develop new educational methodologies for both youth and other relevant stakeholders (Mammadova, 2019).

5. Discussion

This scoping review was conducted to explore youth participation within biosphere reserve research. The quantity of selected studies (n = 7) pinpoints the current literature gap of youth and young people as a separate stakeholder entity within participatory biosphere reserve research. In line, multiple considerations can be identified as possible review limitations. After the systematic selection procedure, only seven studies passed the selection criteria. Within the context of 701 biosphere reserves in 124 countries, this is considered remarkable. Furthermore, it is even more striking that two of the seven studies have the same author and were partially conducted within the same geographical scope.

A possible cause of this limited search result can be identified in the concept of biosphere reserves as geographical scopes. Like identified during the narrative synthesis, the study of Mammadova (2019) also included multiple areas in the geographical scope, going beyond the context of recognized UNESCO biosphere reserves. Hence, it is considered possible that youth-oriented research mainly adopts a broader or more specific geographical scope.

Despite the possibility of the aforementioned literature review limitations, our results highlight the need for a fundamental, clarified conceptual and theoretical framework of youth participation in biosphere reserve research. With the types of research participation of Kim (2016) and participation ladder of Roldan et al. (2019) in mind, it is clear that full participation, identified as youth-driven research and being represented in the biosphere reserve's steering committee or board, is far from common. Moreover, even if some type of research participation was applicable, a clear exploration remains exceptional, i.e., only three out of seven papers could be analyzed based on the participation ladder of Roldan due to incomplete or lack of information on the contextualization of youth involvement at hand. There is still a lot of progress possible to reach the goal of true youth participatory action research which ensures that research happens with instead of on youth, and practice-oriented approaches decolonize the so-called expert knowledge in order to empower local youth experiences (McRuer & Zethelius, 2017; Newing et al., 2011). A possible explanation can be found within the selected paper of Mendis-Millard and Reed (2007). Despite the success of a research method adaptation during their participatory research, Mendis-Millard and Reed (2007) struggled with tensions between appropriate academic research protocol and conducting community-based research. "Researchers who practice reflexivity, respectfully engage communities, and alter research methods to fit local needs and desires can leave some participants with a sense of empowerment and trust in the ability of research to provide positive outcomes" (Mendis-Millard & Reed, 2007, p. 555). Their experience underlines the importance of adopting both reflective attitudes as researchers and adaptive research methods and research methodology when conducting community-based research. In turn, Mammadova (2017) discusses the missing of prior evaluation of the local villagers before starting fieldtrips. With a main focus on educating the academic students, this research missed out on properly involving local villagers to enhance and deepen their research results. Hence, it is considered essential to create a structured research plan which adopts an adaptive research approach throughout the process of data collection.

In the selected cases, professionals' reports are based on collected data using young people as sample population. As indicated above and seen in Table 2, only two studies took a first modest step towards actively including youth in their research process. Further explorational or case study research might fill this gap. For example, by adopting an intergenerational practice (IP) approach, which has been proposed as one way of enhancing participation of youth (and elderly women) within biosphere reserves (Mitrofanenko et al., 2018). Furthermore, five out of the seven selected articles used multiple research methods. Using multiple methods to collect and analyze data in the context of conservation research from a social science perspective is acknowledged and encouraged in methodological literature (Bryman, 2016; Newing et al., 2011). Hence, it can be concluded that future research towards youth stakeholders within biosphere reserves must adopt a similar multi-method approach. More specific, semi-structured interviews seem to be an overall research method to explore contextual information and collect relevant in-depth data.

In regard to the different geographical scopes, a variety of terrestrial, marine and coastal ecosystems, management approaches, levels of community-involvement and levels of development form study-specific research contexts. Hence, all selected articles could undergo a more in-depth analysis regarding their geographical scope and its relationship with the perceived results. However, this was not considered relevant in regard to the scope of this review and corresponding research questions.

Based on this scoping literature review, further (in-depth) research on youth participation in biosphere reserve research and management in needed. Multiple authors included in this review, support this statement. For example, Mammadova (2019) claim to further evaluate how acquired intercultural skills can contributed to future employment of youth. They hereby retain their approach of youth as sample population. In the context of wild food consumption and access, Sylvester et al. (2016) recommend the need for further in-depth analysis of differences among young people or among members of other social groups. Mitrofanenko et al. (2018) in their turn suggest future research should include in-depth case study examples and evaluate applications of intergeneration practice approach in the context of UNESCO biosphere reserves and other protected areas. Moreover, they consider the testing of methods used in other contexts relevant in the contribution to theory development. In conclusion, all studies suggest further research explicitly involving youth stakeholder. Hence, the review hypothesis regarding youth as an underrepresented group of stakeholders within the context of stakeholder participation in UNESCO biosphere reserve research is supported.

6. Conclusions

This literature review focused on youth as the (under)represented group of stakeholders within the context of stakeholder participation in UNESCO biosphere reserve research. Our hypothesis envisioned the need for a holistic in-depth research of youth involvement in biosphere reserve management. Based on an in-depth review of seven papers, the hypothesis turns out to be valid. First, the conceptual and theoretical background of existing research of youth stakeholders within UNESCO biosphere reserves turns out to be rather limited. Second, the methodological approach taken, and empirical research methods put into practice are mostly adult-driven and youth-driven research was non-existent. Finally, further in-depth theoretical and case study-based research regarding youth stakeholders is recommended.

In regard to the overall objective defined as providing insights into both research and practice of youth within UNESCO biosphere reserves, this modest scoping literature review turns out to have three possible overall conclusions. Either it revealed a huge research gap of scientific research focusing explicitly on youth relevant research stakeholders within the context of UNESCO Biosphere Reserves, or the research and/or geographical scope of this review is too narrow. A comparative analysis between biosphere reserves and other geographical scopes might therefore be interesting. Furthermore, one can question the relevancy of discrepancy between such geographical scopes, as well as the possibility of generalizing results of youth participation in environmental research in general. Further research might elaborate on this.

In conclusion, this scoping literature review is considered an explorational background analysis for future academic fieldwork regarding youth as biosphere reserve management stakeholders. Hence, a more in-depth study including official UNESCO and biosphere reserve documents is considered essential. Collecting relevant studies and documents could hereby think beyond academic databases such as Web of Science and Limo and include both the UNESCO database and actively involving all current biosphere reserve managers in order to collect good-practice, local based studies conducted within their biosphere reserves. Further research can possibly rule out one or multiple of the limitations stated above and can increase both quality and quantity of the scoping literature review regarding youth in UNESCO biosphere reserve research.

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International Journal of UNESCO Biosphere Reserves

Flash flood drivers, devastations, and directions in UNESCO Biosphere Reserves: Evidence from a systematic map

Emmanuel Eze[1,2,3*] and Alexander Siegmund[1,2]

[1] Institute of Geography & Heidelberg Center for the Environment (HCE), University of Heidelberg, Heidelberg, Germany.
[2] Department of Geography – Research Group for Earth Observation (rgeo), UNESCO Chair on Observation and Education of World Heritage & Biosphere Reserve, Heidelberg University of Education, Heidelberg, Germany.
[3] Geographical and Environmental Education Unit, Department of Social Science Education, University of Nigeria, Nsukka, Nigeria.

* Correspondence: emmanuel.eze@stud.uni-heidelberg.de

Abstract

Background

Flash floods are devastating because of their abruptness. Moreover, scientists expect increased flash flood frequency from current precipitation extremes due to climate change. Such recurrence of flash floods has implications for biosphere reserves, which house varieties of plants, animals and micro-organisms and support residents' livelihoods.

Aims/objectives

Synthesised evidence of flash floods' causes, consequences and management within biosphere reserves is absent, hence this study. The primary question of this research is, what evidence exists on the drivers, devastations and directions of flash floods in biosphere reserves? Four other sub-questions ensue about flash floods in UNESCO Biosphere Reserves, which guide this study.

Methods

The Web of Science Core Collection (WoS) served as the primary data source for this study. In addition, separate searches of Google Scholar and one journal's database were conducted to identify literature not captured by the WoS search. Finally, two article screening stages were done: title/abstract and full-text screening. The pre-set criteria for including articles in the study was that such articles report flash flooding in a biosphere reserve.

Findings

The search in WoS, Google Scholar and the International Journal of UNESCO Biosphere Reserves database returned 226, 382 and zero articles, respectively. A total of 12 papers have been included in the study following the pre-set criteria and guiding questions. Lastly, coding and narrative synthesis of the papers were implemented to extract findings. There is evidence of both natural and anthropogenic drivers of flooding, its influence on the natural and built environments within the biosphere reserve, and commonly adopted management techniques.

Keywords

climate change;
flash flood;
systematic map;
UNESCO biosphere reserve

Highlights:

- Varied views exist on climate's role in flash flood occurrence in biosphere reserves.
- Flash floods primarily cause infrastructural damage and loss of human lives in biosphere reserves.
- Needs for monitoring, assessment, community sensitisation and integration of innovation emerge.

1. Introduction

Biosphere reserves are unique landscapes globally recognised by the United Nations Educational Scientific and Cultural Organization (UNESCO) to include a compatible blend of nature's conservation, cultural diversity and economic development. Acknowledged as sustainability models, biosphere reserves are composed of a

transitional zone, a core area, and a buffer zone, with low, lesser, and no human interference, respectively. They also serve as sustainability laboratories for scientists (Pavlova et al., 2022).

Flash floods are devastating because of their abruptness. The United Nations Office for Disaster Risk Reduction [UNDRR] (2020) pegs flash flooding at 44 % of reported disasters, affecting over 1.6 billion people worldwide. Natural and anthropogenic factors could drive them. Furthermore, scientists expect flash floods to occur more frequently with the current precipitation extremes due to climate change (Meyer et al., 2021). Such recurrence of flash floods has implications for biosphere reserves, which house varieties of plants, animals and micro-organisms and support residents' livelihoods.

Some systematic reviews have been conducted on flood research. For example, Kassim and Daniell (2021) synthesised papers to relate flood management with flood resilience, while Wagner et al. (2021) examined flood risk management in West Africa. Moreover, the systematic review of Alrehaili (2021) focused on emergency planning for flash flood response in Saudi Arabia. Whereas the study of Rehman et al. (2019) considered the approaches and methods used for flood vulnerability assessment, Moreira et al. (2021) assessed the methods used in constructing flood vulnerability indices and provided helpful guidance for subsequent studies. Other studies, such as Venkataramanan et al. (2019) and Friederike and Steinert (2021), considered floods' health and social outcomes. None of these studies has situated the reviews to the unique terrain of the 727 biosphere reserves globally, hence this study.

This paper synthesises relevant research on this topic by mapping the existing evidence on flash floods in biosphere reserves. It enables a clearer picture of critical areas of interest for further investigation. The results encompass research on flash floods from all biosphere reserves, allowing the Man and the Biosphere (MAB) Programme of UNESCO to utilise knowledge gained from different contexts around the globe.

1.1. Aims/objectives

Synthesised evidence of flash floods' occurrence, consequences and management within biosphere reserves is absent. Therefore, this systematic map's primary objective is to identify, collate and categorise what drives flash floods, what devastations they cause and how they are managed in biosphere reserves. Thus, this study demonstrates global literature trends and identifies knowledge gaps that researchers could improve.

1.2. Primary question and its definition

The primary question of this research is, what evidence exists on the drivers, devastations, and directions of flash floods in biosphere reserves? Other sub-questions thus ensue about UNESCO Biosphere Reserves: (i) What drives flash floods? (ii) what devastations are caused by flash floods? (iii) what are the direction or management strategies employed before, during and after flash floods? Finally, (iv) what knowledge gaps exist in flash flood research on biosphere reserves?

For simplicity of presentation, the research objective and primary question are decomposed using the 'Population'- 'Exposure' – 'Outcome' (P-E-O) structure. 'Population' includes all the 727 UNESCO biosphere reserves globally, 'Exposure' refers to flash flood events, and 'Outcome' represents flood drivers, devastations, and directions (management) captured.

2. Materials and Methods

This systematic mapping review conforms to the ROSES (RepOrting standards for Systematic Evidence Syntheses) of Haddaway et al. (2018).

2.1. Search strategy

2.1.1. Bibliographic databases

The literature search for this systematic mapping review was undertaken using the Web of Science Core Collection database. The University of Heidelberg provides access to the database (https://dbis.ur.de/dbinfo/detail.php?bib_id=ubhe&colors=&ocolors=&lett=fs&tid=0&titel_id=2142). The literature search was conducted in English on the "Topic" (TS) field to include article titles, abstracts, keywords, and Keywords Plus. All years of data are included. In addition, search results were exported in BibTeX format.

2.1.2. Supplementary searches

In addition to the Web of Science Core Collection search, separate searches of one web-based search engine (Google Scholar: https://scholar.google.com/) and one journal database (The International Journal of UNESCO Biosphere Reserves: https://biospherejournal.org/database/) were conducted to identify literature not captured by the primary bibliographic database search.

2.1.3. Search string

The search strings and links for the database searches are presented in Table 1.

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Table 1
Search strings and query links for database search

Database	Search string	Query links
WoS	(ALL=(biosphere reserve)) AND ALL=(flood*)	https://www.webofscience.com/wos/woscc/summary/1e0228f8-1926-4df8-9327-44929a5684c7-3c9f83e2/relevance/1
GSch	"flash flood" AND "biosphere reserve"	https://scholar.google.com/scholar?start=0&q=%22flash+flood%22+AND+%22biosphere+reserve%22&hl=en&as_sdt=0,5
IJBRD	"flood"	https://biospherejournal.org/database/

Notes: WoS = Web of Science; GSch = Google Scholar; IJBR = The International Journal of UNESCO Biosphere Reserves Database

2.2. Eligibility criteria for selected articles

2.2.1. Inclusion criteria following the P-E-O structure

- Population: only articles conducted in biosphere reserves are included in our systematic map.
- Exposure: studies to be included in our systematic maps focus on flash flooding. Hence, this systematic map excludes articles considering other forms of floods, such as coastal flooding or flood plains.
- Outcome: only studies that capture any or all of the sub-questions (i.e., the drivers, devastations and directions (management) of flash floods within the specified population are included.

2.2.2. Article screening

The BibTeX file generated from the Web of Science core collection search downloaded from the search string provided in Table 1 is loaded in 'revtools'. Revtools is an 'R' package developed by Westgate (2019) and has been used for deduplication and conducting title and abstract screening of downloaded articles for synthesis in this study. Papers are assessed based on the eligibility criteria presented in the earlier section. The record of included/excluded articles and reasons are compiled and showcased (Fig. 1).

2.3. Data coding

Descriptive analyses of included articles in this systematic mapping study present basic information such as the studied biosphere reserve, year of flooding, study type, and data type (Table 2). Next, thematic categories of crucial findings from included articles are created using the Citavi web. Finally, two steps are followed for coding results from the selected papers, namely the line-by-line reading of the full texts and assigning relevant portions of the papers to pre-assigned Citavi knowledge items corresponding to the sub-questions of this systematic map.

3. Results

3.1. Meta-information of included studies

This systematic map includes 12 records from the 608 identified articles from our database and web searches. In addition, the ROSES flowchart of Haddaway et al. (2017) depicts the screening process followed in this study (Figure 1). The included studies were carried out in Austria (n = 1), China (n = 1), Ecuador (n = 1), Germany (n = 1), India (n = 6) and Indonesia (n = 1). Also, 50 % of the studies were conducted in India, with 83.33 % of the included articles being case studies (Table 2).

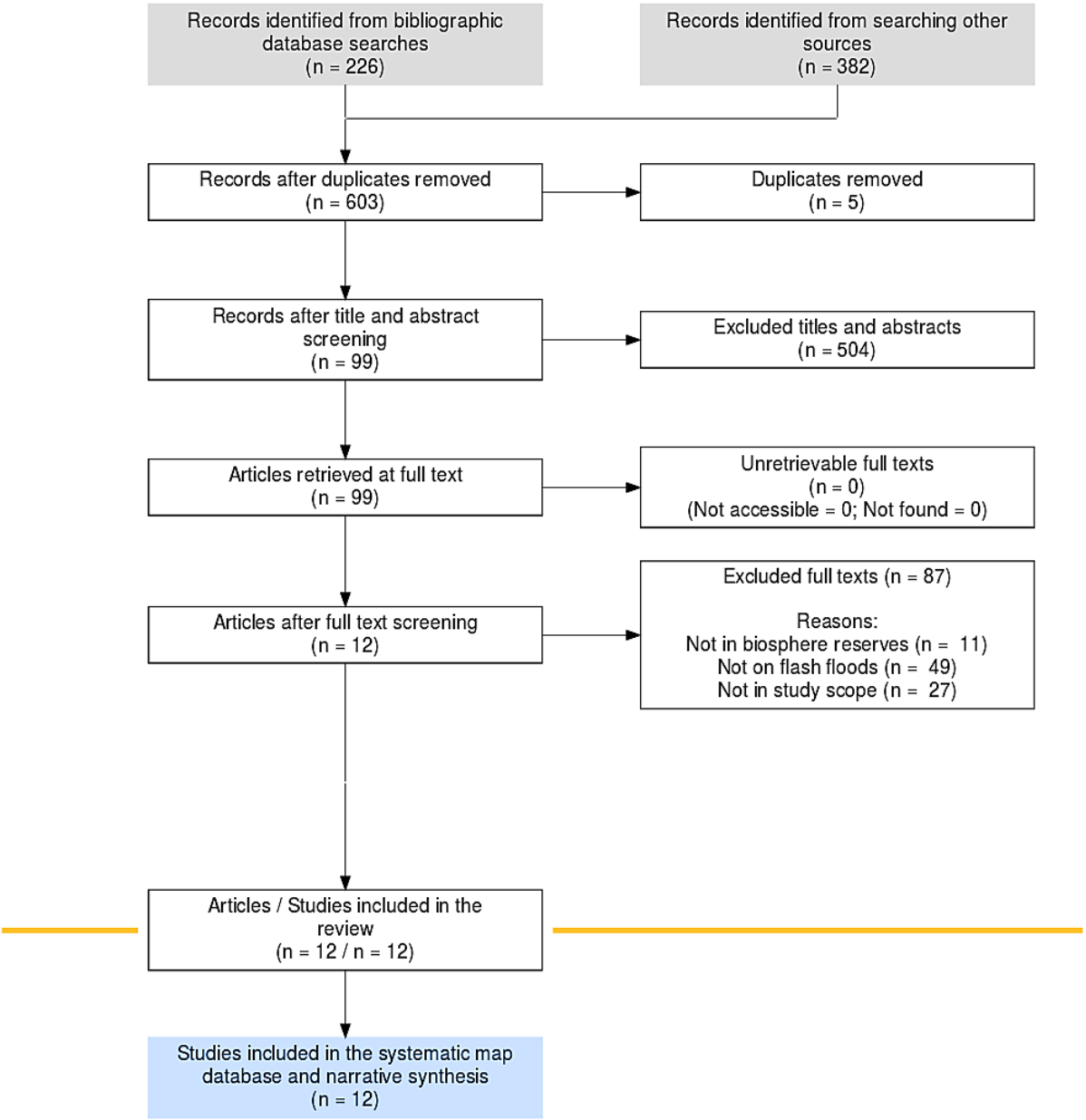

Figure 1: ROSES flowchart of the screening process.
Source: Authors' data

Table 2
Summary of included studies

Study	Biosphere Reserve (BR)	Year of flooding	Study type	Data type	Study participants/sample size
Aksa and Sinulingga (2022)	Gunung Leuser National Park (GLNP), Indonesia	2020	Cross-sectional survey design	Survey responses on disaster experience, risk perception, and flood disaster preparedness	208 respondents
Nyberg (2006)	Elbe River landscape, Germany	2002	Case study description		Case study

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Dandabathula, et al. (2021)	Nanda Devi BR, India	2021	Case study report	Geospatial data (e.g., multi-sensor satellite data, open-source Digital Elevation Models (DEM), space-borne Laser Altimeter and reanalysed weather data)	Case study
Mehta, et al. (2021)	Nanda Devi BR, India	2021	Case study report	Gridded climate data and field survey	Case study
Muñoz, et al. (2018)	Cajas National Park, Ecuador	Not applicable	Case study (Flash-flood forecasting with machine learning)	Data comprises precipitation and runoff hourly time series for a period of 2.5 years discharge time series	Case study
Rana, et al. (2021)	Nanda Devi BR, India	2021	Case study report	Remote sensing data, Flood inundation measurements; Digital Elevation Model; Photographs; Field observations	Case study
Sain, et al. (2021)	Nanda Devi BR, India	2021	Case study report	Google Earth imagery, ground-based and heliborne survey	Case study
Sati, (2022).	Nanda Devi BR, India	2021	Case study report	Agency reports, field observation and interviews	Case study
Taloor et al. (2022)	Nanda Devi BR, India	2021	Case study report	Remotely-sensed images	Case study
Thaler, et al. (2021)	Not specified	Not specified	Transdisciplinary research	Stakeholders interactions	Not specified
Tuniyev & Beregovaya (1993)	Caucasian State BR, Russia	Not specified	Field observations along transect routes	location, weather conditions, air and body temperature, and behavior of selected species; water sample; Ambient light; Feeding habits	Case study
Wang, et al. (2021)	The Jiuzhaigou National Nature Reserve, China	2017	Field investigation and numerical simulation	Remotely sensed images	Case study

3.2. Drivers of flood in biosphere reserves

Flash floods in biosphere reserves captured in this systematic map have diverse drivers (Figure 2). Various anthropogenic activities are reported as recurring drivers of flash floods, as almost half of the included studies (i.e., 41.67 %) describe. For example, Nyberg et al. (2006) identify the exposure of infrastructure developed in flood-prone areas and former river courses. Similarly, Taloor et al. (2022) mention that road and hydropower construction preceded flash flood disasters.

In addition, Sati (2022) connects the warming of the studied catchment to activities such as the construction of hydroelectricity power projects, quarrying and mining. He indicates that people constructed settlements along the banks of two rivers. Likewise, the establishment of over 300 homes and hotels along the Bahorok River and the massive deforestation of about 30,000 hectares of land in the last decade, according to Aksa and Sinulingga (2022), have worsened flash flood risks. For Mehta et al. (2021), the flash flood disaster was due to increased human developmental activities, which they did not mention. However, they did indicate that human construction structures now obstruct rivers' natural paths.

Furthermore, this study captures the evidence of other drivers of flash floods in biosphere reserves. Specifically, this study identifies natural factors, technical preparations, increased rainfall intensity and cascading disasters as non-anthropogenic drivers of flash floods in biosphere reserves. Topography, geologic and tectonic factors are natural factors that drive flash floods in biosphere reserves (Sain et al., 2021; Taloor et al., 2022).

For instance, drainage areas of mountainous river basins will quickly experience flash floods during heavy rainfall (Aksa and Sinulingga 2022).

Also, Dandabathula et al. (2021) report accelerated flow downstream due to slope. Furthermore, according to Nyberg et al. (2006), such floods will have a very high velocity. Also, slope favoured cascading disasters such as rolling detached rocks across glacial cliffs, which led to flash floods (Taloor et al., 2022).

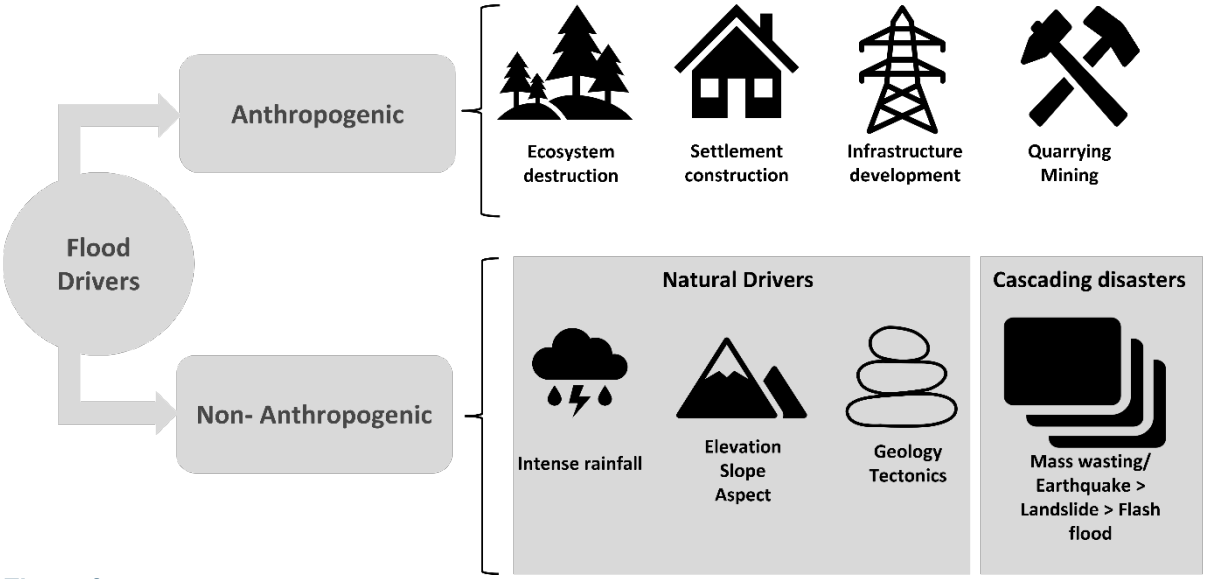

Figure 2: Flash floods drivers in biosphere reserves
Source: Authors' systematic review

Therefore, flash floods also occur in biosphere reserves due to cascading disasters. Landslides frequently precede flash floods. Aksa and Sinulingga (2022) report a high landslide hazard index for their study area. Dandabathula et al. (2021) show the case of a landslide, which generated heat energy leading to a flood-filled moraine hastening downstream. Mass wasting, avalanche and earthquakes sometimes trigger such landslides (Mehta et al., 2021; Rana et al., 2021; Sain et al., 2021; Sati, 2022; Taloor et al., 2022; Wang et al., 2021).

Climate is also a driver of flash floods in biosphere reserves. Whereas Mehta et al. (2021) explicitly blame global warming for the breaking and detachment of hanging glaciers, Taloor et al. (2022) conclude that the combination of climatic and geological factors led to flash floods in their study area. Conversely, Sain et al. (2021) deemed it premature to link flash floods to climate change.

3.3. Devastations of flood in biosphere reserves

This systematic map identified several devastations in biosphere reserves by flash floods (Figure 3). The most reported impact of flash floods in the included studies is infrastructural damages (66.67 %), followed closely by loss of human lives (58.33 %). Past flash floods destroyed transportation infrastructures such as roads, footpaths, train stations, railways, and bridges (Nyberg et al., 2006; Mehta et al., 2021; Sain et al., 2021). In addition to the destruction of road networks, Wang et al. (2021) record the ravaging of tourism infrastructure.

Two major hydroelectric projects with a joint capacity of ~534 megawatts were also wrecked by flash floods (Dandabathula et al., 2021; Mehta et al., 2021; Rana et al., 2021; Sain et al., 2021; Taloor et al., 2022). Sati (2022) presents these hydroelectric projects as both drivers and devastations of flash floods. Thousands of houses were damaged by flash floods too. The destruction of houses led to human displacement and forced migration (Wang et al., 2021; Aksa & Sinulingga 2022).

Human lives were lost to past flash floods. The authors of the included studies utilised different wording in their reports. Some studies, such as Dandabathula et al. (2021), Wang et al. (2021) and Sati (2022), used terms such as human loss, few fatalities, and human casualties, respectively. Other included studies specified the number of lives lost. Over 200 people were reported missing, swept away or trapped in tunnels within the Nanda Devi Biosphere Reserve, India, due to the 2021 flash floods (Mehta et al., 2021; Rana et al., 2021; Taloor et al., 2022). Livestock was also affected (Mehta et al., 2021). According to the report of Nyberg (2006), 38 people died from flash floods within the Elbe River landscape in Germany.

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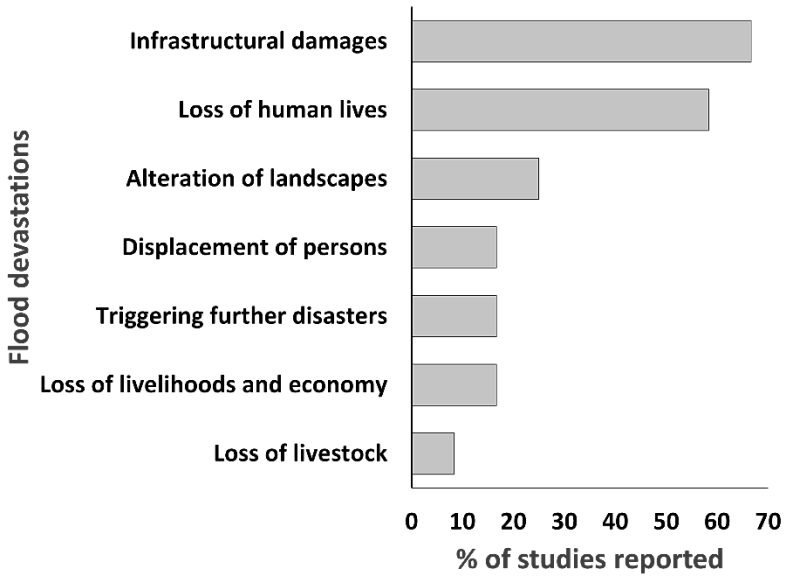

Figure 3: Flash floods devastations in biosphere reserves
Source: Authors' systematic review

The study of Aksa and Sinulingga (2022) assessed the 2020 Flood in the Gunung Leuser National Park (GLNP), Indonesia, and reported the loss of an unspecified number of human lives. However, they indicate 300 deaths, six deaths, and one in earlier floods of 2003, 2006 and 2014, respectively. Livelihoods were also affected by flash floods. Sati (2022) alluded to the loss of the economy, while Nyberg et al. (2006) reported that flash floods incurred economic damage of 11.6 billion Euros.

Flash floods reportedly altered natural landscapes and aquatic ecosystems. Although Mehta et al. (2021) captured the landscape changes in the Rishiganga and Dhauliganga valleys due to flash floods, they gave no detailed description of these changes. On the other hand, Wang et al. (2021) specified that floods significantly damaged the protected vegetation. Tuniyev and Beregovaya (1993) study recorded an increase in the concentration of Ammonium, Nitrites and Nitrogen in the aquatic environment due to flash floods. In addition to these increased chemical elements and compounds inhibiting aquatic life, flash floods destroy the eggs of studied toads (Tuniyev & Beregovaya, 1993).

Finally, flash floods contribute to cascading disasters. For example, flash floods triggered several landslides in the Jiuzhaigou National Nature Reserve, China (Wang et al., 2021). Similarly, flash floods increased the fragility and vulnerability of the Nanda Devi Biosphere Reserve, India, to landslides and debris flow (Mehta et al., 2021).

3.4. Directions/management of flood in biosphere reserves

This systematic map presents several flood disaster management techniques in the studied areas. The status of directions for flood management provided in the included studies was either before or after the disaster. Before the flood disaster, the Gunung Leuser National Park (GLNP) community was poorly prepared and unsupported by the government to build capacity. Flood risk perception and previous experiences with disasters affected individuals' preparedness (Aksa & Sinulingga 2022). In the case of the community at Nanda Devi Biosphere Reserve, India, platforms for prompt information dissemination were unavailable (Sati, 2022).

After a flood disaster, Dandabathula et al. (2021) adopted an integration of optical remote sensing and digital elevation models to assess the spatial constituents of a flood disaster at the landscape level. They recommend similar tools for undertaking disaster assessments in similar rugged topographies. Research efforts and inquiries must be collaboratively implemented to incorporate all relevant stakeholders across disciplines (Sati, 2022; Thaler et al., 2021).

Several crucial recommendations are presented by the studies included in this systematic map for managing flood disasters in biosphere reserves. Researchers have a role in providing relevant direction for flood risk management in biosphere reserves. Before disasters, glaciers should be monitored for developing early warning systems while surrounding communities ought to be sensitised for flood risk reduction (Sain, et al., 2021; Sati, 2022; Taloor et al., 2022).

Moreover, the need to conduct vulnerability assessments on susceptible areas is emphasised by Sati (2022); and Taloor et al. (2022). Also, researchers and practitioners should include debris flow and flash floods of rivers in hazard assessments, as well as assess geodiversity in the context of climate change to predict future

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floods (Rana et al., 2021; Taloor et al., 2022). Muñoz et al. (2018) advocate using machine learning techniques for flash-flood forecasting and hazard assessment.

Finally, governments have crucial responsibilities before and after flood disasters. Before disasters occur, the government should arrest increased development and urbanisation activities in rebuilding devastated areas (Mehta et al., 2021). Furthermore, environmental, and social impact analyses (E/SIA) should precede construction projects to determine safe areas (Sati, 2022). Policies should incorporate nature-based solutions such as large-scale afforestation, which are required in such fragile landscapes as biosphere reserves (Sati, 2022). Flood risk management sometimes excludes floodplain revitalisation and natural vegetation development, which follow ecological perspectives (Nyberg et al., 2006). Funding is also captured as the government's input to reparation and preparation for flood disasters. For example, after the 2002 flood, the German government established a national fund of around 10 billion Euros for infrastructure reparation and dike construction for flood protection (Nyberg et al., 2006).

3.5. Additional findings on the frequency of flooding

From the included studies, an additional result ensues. Some of the papers included the frequency of flash floods in the studied biosphere reserve. For example, Nyberg (2006) indicates that the Elbe River landscape in Germany witnessed flash floods in 1981, 1988, 2002, 2003, and 2006. Similarly, Aksa and Sinulingga (2022) listed previous flash floods in 2003, 2006, 2013, 2014, 2015, and 2020 within the Gunung Leuser National Park (GLNP), Indonesia. However, for the Nanda Devi Biosphere Reserve, India, only 2013 and 2021 are mentioned.

3.6. Limitations of the review

A limitation of this map is that it only included English-language articles. Some papers could have been missed based on their publications in languages other than English. The scarcity of available studies on flash floods in UNESCO biosphere reserves globally limits the depth, scope, and comprehensiveness of understanding this critical issue, posing challenges to effective risk assessment, management, and policy formulation in these sensitive areas.

4.0. Conclusion

This systematic map sought to synthesise the literature evidence available on flash floods in UNESCO-designated biosphere reserves. Flash floods in biosphere reserves occur from three significant causes – natural characteristics of the site, anthropogenic activities, and cascading disasters. Anthropogenic activities such as road, settlement, hydropower construction, quarrying and mining are reported as recurring drivers of flash floods. In addition, topography, geologic and tectonic factors are natural factors triggering flash floods in biosphere reserves.

There is a divergent view of the role of climate in the occurrence of flash floods in biosphere reserves. Generally, flash floods destroyed human and animal lives, livelihoods and infrastructure. Also, displacement of persons, alteration of the biosphere reserves' landscape and other disasters followed some flood events. Residents, researchers, and governments have roles in managing risks before a flood event.

This study revealed that researchers had understudied flash floods in biosphere reserves. Specifically, no study was found reporting the incidence of flash floods in Africa. Much work on flood assessments for risk management is required in Africa. Lumbroso (2020) acknowledges that floods have overtaken droughts based on the number of people affected while decrying the general lack of peer-reviewed journal papers and specific research on flood risk management in Africa.

Implications for policy/management

The evidence obtained in this map depicts that community preparation is necessary before flash flood events. Natural factors of these events (e.g., climate, topography, geologic and tectonics) are mostly constant. Therefore, it behoves the residents in these areas to be prepared. Furthermore, platforms for information dissemination from warning systems are required. A synergy is thus expected between the local management of the biosphere reserves and the government to achieve flood disaster preparedness.

Government support is required in sensitising the populace, especially those who have not witnessed flood events. In addition, the government must check unsustainable developmental activities in areas surrounding biosphere reserves and implement policies that favour nature-based solutions.

Implications for research

Identified evidence in this paper should shape future flood research in biosphere reserves globally. Integration of contemporary technologies, such as optical remote sensing, digital elevation models and unmanned aerial vehicles, is expected in assessing and monitoring rugged topographies. Moreover, collaborative, and

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transdisciplinary research is highly encouraged to develop effective early warning systems to reduce the number of affected persons during a flash flood.

Declarations

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CRediT authorship contribution statement

Emmanuel Eze: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Visualization. **Alexander Siegmund:** Writing – review & editing, Supervision.

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Biosphere Reserves and conservation of subterranean aquatic ecosystems in Brazil

Eleonora Trajano[1*], Full Professor

[1] Full Affiliation 1; Instituto de Biociências da Universidade de São Paulo (retired), São Paulo/SP, Brazil.

[*] Correspondence: etrajano@usp.br

Abstract

Subterranean systems and aquifers are functional units of karst, constituting habitat units for the aquatic fauna. These are open systems, under the influence of external factors controlling the internal processes. Major well-studied Brazilian karst areas, situated in diverse biosphere reserves, are briefly described with focus on total diversity (troglobites + troglophiles + trogloxenes) and diversity of troglobites, encompassing taxonomic, phylogenetic and genetic/morphological diversity. Different combinations of evolutionary and ecological processes are observed, producing unique diversity patterns. Consequently, the recognition of the importance of karst areas and their priority for conservation and management must be based on multiple criteria applied in a case-by-case analysis. Good practices for conservation and management of subterranean waters start with studies based on robust, scientifically sound criteria. The focus must be the subterranean systems, not caves per se, including the influence areas (recharge areas, the areas receiving their output, etc.), and results must be tested for sampling sufficiency. Biosphere reserves are a first step to ensure protection of subterranean waters and their ecosystems. At regional/local scale, their insertion in Conservation Units is an efficient tool for preservation if properly designed and managed.

Keywords

subterranean fauna; karst systems; conservation; good practices; Reserves of Biosphere

1. Introduction

Subterranean habitats are networks of interconnected heterogeneous spaces in the subsurface, filled with water and/or air, forming a continuum available for colonization by diverse organisms. Caves are the components of such habitats accessible to human.

In karst areas, the habitat unit for subterranean aquatic organism is the system. Karst systems are functional units, involving organized flow pathways forming a drainage unit with input-output zones and finite configurations (Gibert et al., 1994). A karst aquifer is an open system with a boundary defined by the catchment limits and input, throughput and output flows, and mechanisms and controls (Ford & Williams, 2007).

Recharge may be autogenic, when only karst rocks are found within the catchment and recharge is derived from precipitation falling directly on them, or allogenic, when waters from neighboring or overlaying non-karst rocks run into the karst aquifer. Karst systems encompass not only subterranean spaces (including caves in the human sense), but also recharge areas (fast and delayed infiltration zones and sinkholes) and catchment points along the system. Water may flow as fast-moving streams (lotic habitats, either permanent or temporary) to slow moving waters (lentic habitats). These conditions create quite diverse chemical and ecological scenarios.

External factors that control internal processes in karst systems constitute the system environment. When it is possible to recognize geographical boundaries to this environment, areas of influence are configured, which are physical spaces bringing together factors with a direct or indirect relevant influence to the system.

Energy and matter that enter the system leave it in a condition different from the original one. The geographic environment that receives and is stimulated by a given system output is also part of its area of influence (Berbert-Born, 2018). Areas of influence on caves and karst systems include not only recharge areas (delayed and fast infiltration zones, such as sinkholes) and the area receiving its output (that may include other karst systems downstream), but also foraging areas of trogloxenes (see below) such a bats. Matter and energy are exchanged between terrestrial and aquatic subterranean environment, therefore influence areas on aquatic systems include terrestrial elements and vice-versa.

An important feature of the karst is vertical zonation. From the subsurface to the deepest zones, one may distinguish the epikarst, open-channel stream passages including vadose tributaries and base-level streams, the zone of seasonal oscillations of the water table, the shallow (upper) phreatic zone (connected to the surface through inaccessible fissures, resurgences, regional sinkholes, wells, and caves), and the deep phreatic zone (Trajano, 2001a). There are aquatic organisms living in all of these zones, many of them showing specific adaptations to their habitats.

The epikarst (or subcutaneous zone) is a heterogeneous interface between unconsolidated material and altered carbonate bedrock, capable of delaying or storing and locally rerouting vertical infiltration to the deeper regional phreatic zone (Jones et al., 2004). Under certain circumstances, water is permanently stored in the epikarst, forming suspended aquifers, wherein aquatic populations may evolve.

2. Diversity of Subterranean Organisms

Subterranean organisms (cavernicoles sensu latu) are defined as evolutionary units responding to subterranean selective regimens; subterranean habitats provide resources (food, shelter, substrate, climate etc.) which affect survival/reproductive rates. In contrast, organisms introduced into caves by mishap, but which are unable to properly orient themselves and find food in this environment, eventually vanishing, are considered “accidentals” (Trajano & Carvalho, 2017).

The Schiner-Racovitza system (modified by Trajano, 2012 to incorporate the source-sink population model), classifies subterranean organisms into three categories: 1.Troglophiles are source populations (populations with excess production that would continue to grow if isolated; Jones et al., 2004), both in hypogean and epigean habitats, with individuals regularly commuting between these habitats and promoting the introgression of genes selected under epigean regimes into subterranean populations (and vice-versa). 2. Trogloxenes, with source populations in epigean habitats but using subterranean resources, for instance as shelter and food (there is no confirmed case of aquatic trogloxenes in Brazil). 3. Troglobites, which are exclusively subterranean source populations, usually characterized by troglomorphisms, i.e. autapomorphies that can be directly related to the subterranean selective regime; the commonest troglomorphisms of troglobites are the reduced visual structures and dark pigmentation (Trajano & Carvalho, 2017).

In general, troglobites living in phreatic waters are the most specialized, accumulating troglomorphisms such as complete anophthalmy and melanic depigmentation, enhancement of non-visual sensory systems, delicate and frequently elongated bodies, adaptations to food-poor and hypoxic environments etc. (Trajano, 2021).

Caves are transient features within karst cycles. According to the most common speleogenetic process, which originates most karst caves, the network of small fissures formed by dissolution during the initiation phases are progressively enlarged. When the water flow changes from laminar to turbulent, with erosion also contributing to conduit enlargement, fast-flowing waters become available for colonization by preadapted populations living in epigean lotic habitats. Eventually, in the cessation phasis, large subterranean spaces disappear due to breakdowns or filling by chemical or clastic sediments. This transient characteristic of karst cycles explain why stream-dwelling troglobites in general are less troglomorphic than the phreatobic ones – in the cessation phase, stream dwellers that have managed to adapt to the lentic conditions of the phreatic zone below may survive over a long geological period until the next cycle, frequently as relicts (Trajano, 2021).

The vast majority of researchers studying subterranean ecosystems focus primarily on the taxonomic diversity (species richness) of troglobites. However, taxonomic diversity, which only takes into account the number of species and their relative contribution, has little predictive power about the functioning of ecosystems. Phylogenetic diversity, a measure of diversity incorporating phylogenetic relationships among species, and functional diversity, which considers functional traits, are more sensitive to detecting responses of communities to environmental changes. The presence of relictual taxa increases phylogenetic diversity and may overcome taxonomic diversity in terms of relevance for conservation (Cianciaruso et al., 2009; Trajano et al., 2016).

Genetic diversity expressed as diversity and disparity of phenotypes correlates with phylogenetic and functional diversities, and increases with number and degree of troglomorphisms accumulated by troglobites. Hence, the loss of one species without close relatives leads to a greater loss of genetic information than the extinction of a species with close relatives. Therefore, the best conservation strategy is to protect areas with the highest

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phylogenetic diversity, preserving as much of this hierarchical variation as possible (Faith, 1992; Cianciaruso et al., 2009) and prioritizing those with the most divergent subterranean taxa.

Taxonomic diversity of troglobites is not necessarily correlated with total diversity, i.e.,diversity of troglobites + troglophiles + trogloxenes. General diversity seems to be mostly a response to ecological factors, such as habitat extension and heterogeneity, and availability of organic matter.On the other hand, diversity of troglobites and their degree of differentiation is better explained by historical factors leading to genetic isolation and divergence, especially vicariance, which may not be revealed by analysis of present-day conditions (Trajano, 2001b). Troglobites, troglophiles and trogloxenes interact among themselves, therefore interspecific interactions (competition, predation etc.) are independent of the status according to the Schiner-Racovitza classification.

If we want to conserve biodiversity effectively, we need to preserve representative samples of biodiversity to ensure ecological and evolutionary processes that allow this biodiversity to persist over time, and to set targets for the conservation of biodiversity features.

3. Caves, karst areas and brazillian biosphere reserves: spots of high diversity of aquatic organisms in brazil

The UNESCO Biosphere reserves are defined as ´learning places for sustainable development'. They are sites for testing interdisciplinary approaches to understanding changes and interactions between social and ecological systems, including conflict prevention and management of biodiversity, and aiming to provide local solutions to global challenges. Biosphere reserves are nominated by national governments and remain under the sovereign jurisdiction of the states where they are located. Their status is internationally recognized (https://en.unesco.org/biosphere).

Most Brazilian caves are within Biosphere Reserves, providing a better status for conservation (Fig. 1). Herein, I focus on carbonatic caves, which harbor the most relevant aquatic faunas, situated in large and well-studied karst areas: Campo Formoso, Chapada Diamantina, Serra do Ramalho (Bahia State) - Caatinga Reserve; São Domingos (Goiás) – Cerrado Reserve; Nobres (Mato Grosso) and Serra da Bodoquena (Mato Grosso do Sul) – Pantanal Reserve; Alto Ribeira (São Paulo) – Atlantic Forest Reserve. Part of these are in protected areas: Parque Nacional da Chapada Diamantina, Parque Estadual Terra Ronca (São Domingos area), Parque Nacional da Serra da Bodoquena, and Parque Estadual Turístico do Alto Ribeira + Parque Estadual Intervales (Alto Ribeira area).

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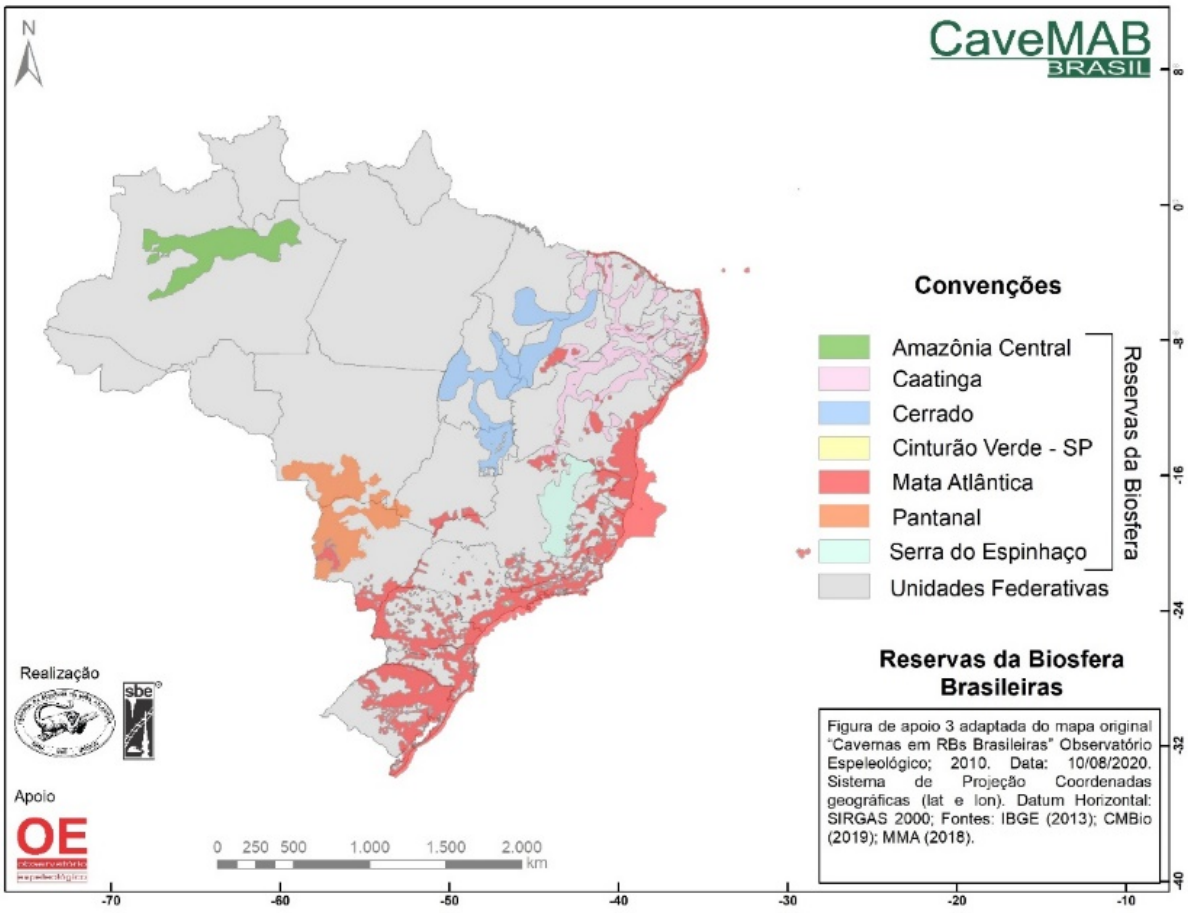

Figure 1A. Brazilian Reserves of Biosphere: Central Amazon (green), Caatinga (pink), Cerrado (blue), Atlantic Forest (red), Pantanal (orange), Serra do Espinhaço (light blue). Author: Frederico Lott, based on map from "Cavernas em RBs brasileiras", Observatório Espeleológico.

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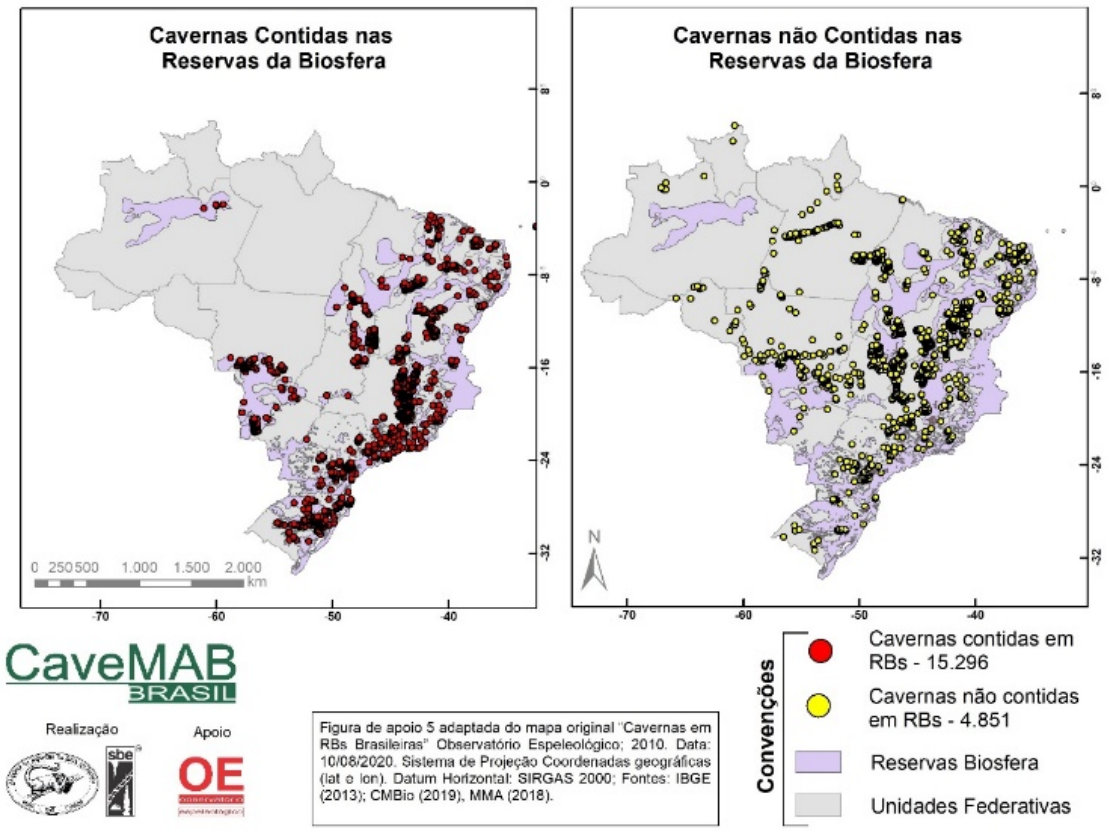

Figure 1B. Left: Brazilian caves (red dots) situated in Biosphere Reserve. Right: Brazilian caves (yellow dots) not in Biosphere Reserves. Author: Fredeeico Lott, based on based on map from "Cavernas em RBs brasileiras", Observatório Espeleológico.

These areas differ in total diversity and in taxonomic, phylogenetic and genetic diversity of troglobites, mostly due to the presence of highly specialized relicts in subterranean waters in the Caatinga Reserve. Such disparity is a consequence of historical events and of present-day geomorphology, hydrology and ecological circumstances.

The majority of subterranean habitats in the interior of Brazilian northeastern states are situated in the currently semiarid Caatinga. The Paleoclimate Model (Barr, 1968), based on the notion that wet phases of glacial cycles are times of colonization of subterranean habitats by epigean populations, which become isolated and differentiate in subsequent dry phases, explains the high diversity of troglobites, both aquatic and terrestrial, in the Caatinga (Trajano, 1995, 2001). Studies based on speleothem dating revealed relatively frequent, dramatic and abrupt changes in the available moisture during the Pleistocene (on average, one wet event every 20,000 yr for the past 210 kyr) (Wang et al., 2004).

Most permanent habitats currently available for aquatic organisms in the Caatinga subterranean habitats are represented by phreatic waters, connected to the surface through inaccessible fissures, resurgences, sinkholes, wells, caves etc., where highly specialized troglobites live. Many of these organisms are relicts, belonging to exclusively subterranean genera such as Spelaeogammarus (Amphipoda), Xangoniscus (Oniscoidea isopods, that may form amphibious populations) and Spiripockia (Gastropoda), or higher taxa (Calabozoa isopods) (Trajano et al., 2016). At least two species of highly modified catfishes of the genus Rhamdiopsis (Heptapteridae) live in this Reserve.

In addition, two highly specialized amphipods have been found in the Apodi area, Caatinga region, Rio Grande do Norte State: Potiberaba porakuara (Mesogammaridae) and Seborgia potiguar (the first Brazilian Seborgiidae) (Fiser et al., 2013).

Semi-aridity implies reduced superficial drainage, with mostly intermittent surface and underground streams, that may leave permanent pools and lakes where subterranean populations can survive and differentiate in isolation. As result of disruption of the epigean drainage, the input of nutrients into subterranean habits is generally highly limited and seasonal, resulting in low total diversity.

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In contrast, allochthonous high-energy epigean streams presently crossing the São Domingos karst area, in Central Brazil, carry large amounts of organic matter into subterranean habitats. As consequence, these caves are characterized by high taxonomic diversity and population abundance. Regarding taxonomic diversity of troglobites, there is an apparent discordance between invertebrates, which are rare, and fishes, with seven nominal species encompassing several differentiated lineages. São Domingos harbors the richest subterranean ichthyofauna in South America, including species adapted to life in the epikarst. Nevertheless, degrees of troglomorphism are medium to low, with intra and interpopulation variation, unlike that observed for Caatinga troglobites.

The São Domingos karst area is situated in a relatively stable region – according to a reconstruction of phytogeographic domains during the last glacial (18,000 to 13,000 yr ago - Ab´Saber, 1981), this area was in the Cerrado core area as it is today. Paucity of opportunities for isolation due to extinction of epigean congeners might explain the scarcity of troglobitic invertebrates in this area. However, the Paleoclimate Model does not explain the high taxonomic diversity of troglobitic fishes. In this case, the topographic model may apply: the high-energy streams crossing the area causes intense alluvial down-cutting lowering the regional water table and creating waterfalls inside and outside caves, which could isolate aquatic populations (Bichuette & Trajano, 2004; Reis et al., 2006, Trajano, 2021). Therefore, the São Domingos karst area represents a special situation, because different processes seem to explain the origin of troglobitic fishes and of invertebrates, respectively.

The Alto Ribeira karst area, southeastern Brazil, is a spot of high taxonomic diversity of troglobites in general, including aquatic species, such as Potamolithus gastropods, Hyalella amphipods and the catfish, Pimelodella kronei, the first described Brazilian troglobite (Trajano et al., 2016; Trajano, 2021). However, degrees of troglomorphism are in general medium, with population variability in most cases and, with few exceptions, belonging to genera also recorded in epigean streams. Dating of speleothems (Cruz-Jr et al., 2005) pointed to less abrupt and dramatic climatic paleo-oscillations, not as dominant as in the Caatinga. Thus, the PaleoclimateModel also applies, but shorter and less dramatic oscillations would result in less specialized troglobites.

The Bodoquena karst area in southwest Brazil, is distinguished by the presence of flooded caves, especially in the southern plateau. Many relictual aquatic invertebrates and fishes are found in this area, including Girardia planarians, oligochaetes (unidentified), Megagidiella amphipods, spelaeogriphaceans, and siluriform fishes (at least three Trichomycterus species, besides a Pimelodella catfish and an Ancistrus armored catfish), typically living in the upper phreatic zone (Cordeiro et al., 2014; Trajano, 2021). The Paleoclimatic model would explain the origin of troglobites such as the Trichomycterus species, without congeners recorded in epigean drainages. Adaptations to phreatic waters is explained by the progressive cave flooding from south to north, as consequence of the development of the Pantanal basin. Tectonic subsidence would be a major contributor to the relative uprising of the water table in the Bodoquena karst area due to the lowering of the regional base-level (Trajano, 2021).

It is noteworthy that, at the system level, fine-grained factors may be of influence, such as fragmentation at a local scale due to geological, geographic and/or hydrological barriers, topographic isolation caused by alluvial down-cutting, and ecological singularities (Trajano et al., 2016).

Best practices in protecting and managing cave and karst waters

Conservation aims to preserve representative samples of geo- and biodiversity, including patterns and processes that produced such diversity. As exemplified by the most intensively studied Brazilian areas, combinations of different evolutionary and ecological processes produce unique diversity patterns observed in different karst areas. Therefore, the recognition of the importance and priority for conservation, and management of karst areas and systems (and other cave areas as well, such as the siliciclastic and ferruginous ones, widespread in Brazil), must be based on multiple criteria applied in a case-by-case analysis.

The current Brazilian legislation regulating the use of subterranean resources for economic purposes, based on a classification of caves according to their degree of relevance, is intertwined with conceptual, logical and procedural flaws that compromise an effective conservation of these habitats (Trajano, 2020, 2022). A major problem is the focus limited to caves, not on karst systems, or equivalent in non-karst areas. Other serious problems are a consequence of deficient minimum requirements for environmental studies aiming to support the classification of caves. There is no demand for sampling sufficiency, thus the objective of preserving representative samples of diversity cannot be ensured. Likewise, case-by-case studies in areas of influence are not required. Moreover, the conservation and management of phreatic waters are hampered by the difficulty to perform hydrogeological studies aiming to uncover deep connections of slow-moving waters.

Good practices in protecting and managing subterranean waters and ecosystems, establishing priorities for conservation, begin with environmental studies based on non-negotiable, scientifically sound criteria:

- Caves are not isolated from their surroundings, therefore the study unit must be the karst system and associated aquifers, or the equivalent in other lithologies, as well as their areas of influence.

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- Sampling sufficiency that is properly tested (in the case of biological studies using, for instance, accumulating curves) must be required; temporal sufficiency requires at least three annual cycles to describe seasonality, and more for infra-annual cycles (cycles with a period superior to one year) (Trajano, 2018).

- Areas of influence on systems and aquifers, including suspended aquifers, must be studied on a case-by-case basis, with focus on areas of recharge (as in Gethner et al., 2003; i.e. the area receiving the system output), foraging areas of trogloxenes such as bats, etc.

- All kinds of diversity must be considered: total (troglobites + troglophiles + trogloxenes) and diversity of troglobites; taxonomic (species richness), phylogenetic, genetic, functional diversity.

Biosphere reserves are a first step to ensure protection of subterranean waters and their ecosystems at the regional/local scale. Insertion in Conservation Units ("Unidades de Conservação – Ucs") is an efficient tool for preservation, if properly designed and managed (which is frequently not the case).

Among the karst areas herein described, Campo Formoso and Serra do Ramalho (Bahia State), Apodi (Rio Grande do Norte State), and Nobres (Mato Grosso State) are not in protected areas. These areas are threatened by anthropic impacts, such as water exploitation, mining projects, pollution due to land use (agriculture, cattle farming), and uncontrolled cave visitation. The importance of these areas justifies the creation of Conservation Units with utmost urgency.

Even in the case of areas already in Conservation Units, protection is not completely assured because part of the influence areas are external to these Units. This is the case with PETER (São Domingos karst area), crossed by rivers coming from farming areas in Bahia State, with monocultures using pesticides and fertilizers. Land use is also a matter of concern for the PARNA Chapada Diamantina. Sedimentation due to deforestation for cattle raising at recharge areas of important karst systems is a major problem in the PARNA Serra da Bodoquena. In PETAR, pollution due to agriculture and mining in recharge areas have led to local extinction, or nearly, of populations of blind catfishes and Aegla decapods. In some cases, there are no licensed Management Plans and, when such Plans do exist, they have not been fully implemented. As a consequence, speleoturism is poorly controlled.

In conclusion, priority areas for conservation and management, recognized after reliable scientific studies and using multiple criteria, should be inserted in Conservation Units encompassing karst systems (or equivalent for non-karst areas) and their entire areas of influence.

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International Journal of UNESCO Biosphere Reserves

Updates to the EuroMAB Literature Database 2023

Mark Gledhill[1*]

[1] Mount Arrowsmith Biosphere Region Research Institute, Vancouver Island University, Building 305-442, 900 Fifth Street, Nanaimo, British Columbia, V9R 5S5, Canada
[*] Correspondence: Mark.Gledhill@viu.ca

Abstract

The International Journal of UNESCO Biosphere Reserves Literature Database has been significantly updated in 2022. This article details the changes that occurred to the database during March 2022 to December 2022.

Keywords

UNESCO, Biosphere Reserves, Update

1. Introduction

The International Journal of UNESCO Biosphere Reserves website contains an extensive Literature Database that is maintained by the Mount Arrowsmith Biosphere Region Research Institute (an affiliate of the UNESCO-designated Mount Arrowsmith Biosphere Region). This database offers a collection of academic and grey literature on Biosphere Reserves from around the world. This update details the work from March 2022 to December 2022 following the previous work from May 2021 to March 2022.

2. Status of the Database

Currently, the Literature Database consists of four thousand seven hundred and seven (4707) entries across one-hundred eight-nine (189) pages of viewable material. Additionally, one hundred and six (106) countries are now represented within the database from every continent in the world. As a result, the database now holds information for four hundred seventy-eight (478) Biosphere Reserves. No additional withdrawn biosphere reserves have been added in this update.

3. Updates to the Database

First, the database has a significant number of new entries of academic and grey literature. All of the newly reference materials can be found in the database.

4. New Countries

The database has been expanded with the addition of thirty-seven (37) new countries that previously were not part of the database. From the African Region these include: Burkina Faso, Congo, Democratic Rep. of Congo, Ghana, Kenya, Madagascar, Malawi, Mozambique, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Togo, Uganda, and Zimbabwe.

From the Asia and the Pacific region: Australia, Japan, Kazakhstan, DPR Korea, Republic of Korea, Maldives, Mongolia, Myanmar, Pakistan, Philippines, Sri Lanka & Uzbekistan are also now part of the database and represented within it.

From the Arab states region: Algeria, Egypt, Morocco, Qatar, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates & Yemen are also now part of the biospheres within the database.

5. Conclusion

The database will continue to be expanded as the research extends to new biosphere reserves and as new materials are published by biosphere reserve researchers, volunteers, and staff. This article details the significant progress that has been made in 2022. This includes many new entries, countries and biosphere reserves that further strengthen the database as an important place for research and information sharing.

6. Author Information

Corresponding Author

Mark Gledhill

Present Address

Mount Arrowsmith Biosphere Region Research Institute, Vancouver Island University, Building 305-442, 900 Fifth Street, Nanaimo, British Columbia, V9R 5S5. (Mark.Gledhill@viu.ca)

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