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PERSPECTIVE

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Transforming youth engagement in disaster risk management and heritage conservation through adapting the concept of brain re-engineering and reimagination

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Abstract

The escalating intensity of global disasters and the growing vulnerability of cultural heritage require innovative solutions that actively engage youth as key stakeholders. Despite their potential for creativity, innovation, and technological proficiency, youth remain significantly underrepresented in disaster risk management (DRM) and heritage conservation efforts. This paper introduces the Brain Re-Engineering and Reimagination (BRECR) framework, adapted from its original use in agriculture, as a strategic approach to addressing these gaps and catalyzing youth-led initiatives. The BRECR framework comprises five pillars: perception change, ideation and enterprise, technological solutions, sustainability, and social equity in public policy. We argue that by reshaping societal narratives, fostering youth-driven innovation hubs, integrating advanced technologies, and emphasizing long-term capacity building, we demonstrate how BRECR can bridge critical gaps in policy, education, and practice. This paper proposes actionable strategies for enhancing youth engagement and empowerment, positioning them as leaders in building resilient communities and safeguarding cultural heritage. By reimagining youth as active changemakers, we can harness their creativity and technological expertise to establish inclusive, sustainable, and impactful solutions for future generations.

Keywords Disaster risk management (DRM), Youth engagement, Heritage conservation, Brain re-engineering and reimagination (BRECR), Resilient communities

1 Introduction

As the world confronts increasing environmental and socio-cultural pressures, the preservation of heritage is under threat. Heritage sites are deteriorating, not only due to physical hazards but also from a growing generational disconnect, as youth often view heritage as distant from their realities, lacking relevance to their aspirations in a fast-paced digital world. This gap signals the urgent need for innovative, youth-centered frameworks that reposition heritage as a living, evolving part of community identity and resilience.



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The escalating frequency and severity of disasters globally underscore the urgent need for transformative approaches to disaster risk management (DRM). Ghaffarian et al. [18] emphasize that integrating contemporary technological advancement in DRM can significantly enhance decision-making processes, enabling timely interventions that save lives, mitigate losses, and foster resilient communities. At the same time, heritage conservation faces parallel challenges. For example, Eze and Siegmund [12–14] highlight how heritage sites, representing the shared legacy of humanity and the natural world, are increasingly imperilled by disasters, urbanization, and climate change. As defined in the UNESCO's 1972 Convention, heritage encompasses cultural and natural assets of outstanding universal value, including monuments, archaeological sites, and natural habitats critical to biodiversity and conservation efforts [43].

Despite these pressing issues, youth (a demographic recognized for its innovative potential) remain underrepresented in both DRM and heritage conservation initiatives. Fernandez and Shaw (2015) describe youth as an underutilized resource in disaster risk reduction (DRR), while the United Nations Population Fund [45] underscores the unprecedented scale of today's youth population, estimated at 1.8 billion individuals aged 10 to 24. However, systemic barriers to youth engagement persist. Recent studies such as Heffernan et al. [19] reveal how adult-centred decision-making excludes youth from DRR initiatives, while Zhang et al. (2024) identify social, political, and economic factors (especially societal views towards youths, lack of legislative support for youth engagement, and low employment of youth respectively) as impediments to their active participation in heritage conservation. Thus, engaging young people in heritage conservation should be a strategic imperative that does more than merely include them in decision-making. This is because when youth are empowered to see heritage as part of their future, they become active custodians rather than passive observers.

Consequently, addressing these gaps necessitates a novel, integrated approach. Therefore, this paper introduces the Brain Re-Engineering and Reimagination (BRECR) concept as a theoretical lens to reframe youth engagement in DRM and heritage conservation (see Fig. 1). Originally the BRECR was conceived by Agbugba [2] to revolutionize youth involvement in agriculture, by addressing outdated perceptions, lack of innovation, and insufficient integration of advanced technological solutions through five essential pillars namely: perception change, ideation and enterprising, technological solutions, and sustainability. Notably, these pillars could offer a powerful framework for catalyzing youth-driven innovation and leadership in other spheres outside of agriculture. By adapting BRECR to the fields of DRM and heritage conservation, this paper proposes actionable strategies to harness youth capacities, paving the way for more inclusive, resilient, and sustainable systems. Although still emerging, the BRECR framework has demonstrated promising applicability across diverse contexts, particularly within African higher education institutions. For example, Agbugba and Okoye [4] detail how BRECR can be used to frame youth mentorship, entrepreneurship training, and academic development strategies for early career academics in Africa. While large-scale evaluations are pending, these early implementations affirm BRECR's relevance as a transdisciplinary model for fostering youth-led innovation, professional engagement, and context-sensitive capacity building.

This paper is therefore intended for policymakers, Non-Governmental Organizations (NGOs), educational institutions, researchers, and youth-focused networks who are

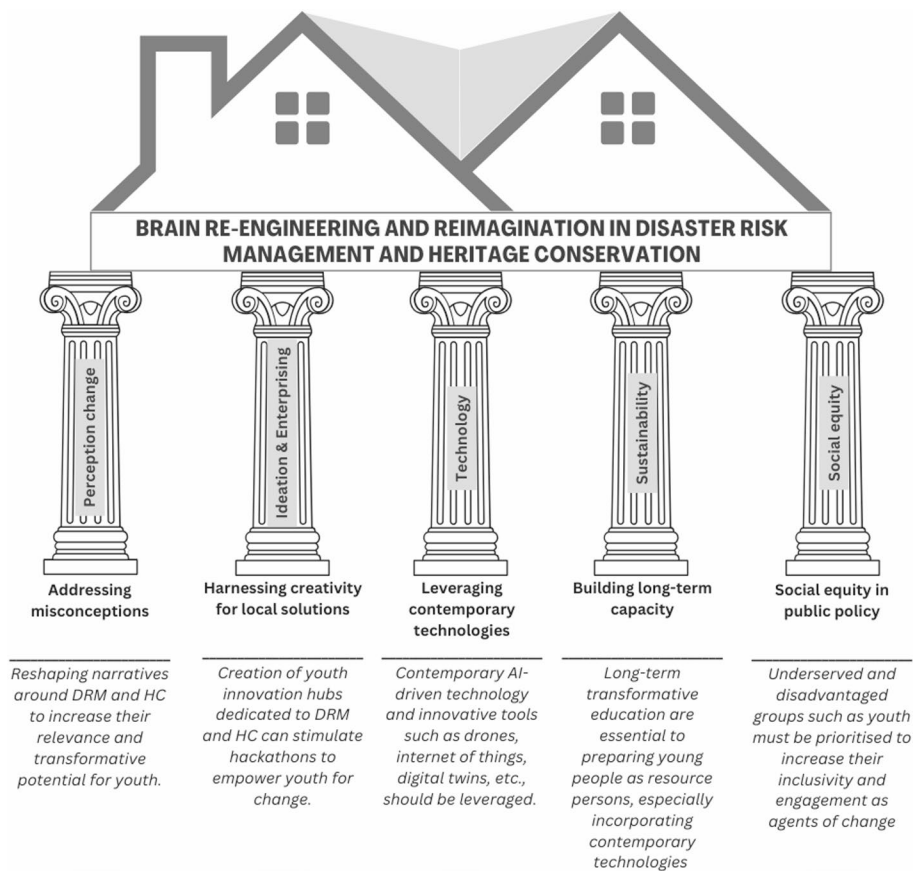


Fig. 1 The adapted BRECR concept in the context of disaster risk management (DRM) and heritage conservation (HC)

committed to future-proofing heritage and climate adaptation systems. It proposes the BRECR framework as a guiding model to mobilize young people as solution providers, advocates, and innovators in heritage conservation and disaster resilience planning.

2 Perception change: addressing misconceptions in DRM and heritage conservation

Youth engagement in DRM and heritage conservation is hindered by misconceptions, leaving young people uninspired to participate. For instance, Mitchell et al. [28] challenge the assumption that children and youth are incapable of actively contributing to risk communication, disaster prevention, and response. Cruz [8] reinforces this by identifying a strong positive correlation between youth participation and disaster preparedness, noting that communities often face poor preparedness due to expert-dominated planning processes that undermine youth-adult partnerships.

Similarly, a generational gap exists in heritage conservation. Eichler [10] describes young people's growing disinterest, disdain, or lost connection with cultural heritage, leading to their reluctance towards participation in its preservation. Research by Oladeji et al. [32] corroborates this gap, showing that older generations dominate heritage conservation activities. Furthermore, Madhury and Sarker [26] reveal that young people often lack knowledge of heritage sites' cultural and historical significance, which fosters indifference. This lack of awareness stems from insufficient exposure to these

topics during formative educational years, making perception change critical to reframing DRM and heritage conservation as inclusive and participatory fields for youth. Specifically, integrating disaster and heritage literacy into education, particularly through geography, can cultivate interest and skills among young people.

Geography education holds immense potential for fostering higher climate change awareness [33] and developing disaster literacy (i.e., the ability to access, understand, and apply disaster-related information according to [17]). However, its global low enrolment rates [25] remain a significant barrier. Limited visibility of geography in secondary schools curtails its role as a gateway to DRM and heritage conservation. Integrating these topics into secondary and undergraduate curricula combined with an adequate didactical approach could significantly enhance youth engagement. Kamil et al. [21] argue that teaching materials incorporating disaster knowledge from a geographic perspective strengthen students' understanding and interest.

Activating this perception change pillar of the BRECR framework can address these challenges by reshaping narratives around DRM and heritage conservation to highlight their accessibility, relevance, and transformative potential. Linking these fields to global issues such as climate change adaptation, social equity, and community resilience can position young people as central actors rather than passive observers. When heritage and disaster risk themes are contextualized within pressing global challenges, they become more relatable to youth. Such framing equips young people with an integrative worldview, enabling them to connect local histories with planetary futures. As such, they are empowered to take initiative, innovate, and lead in the co-production of solutions that safeguard cultural identity and strengthen community resilience. Additionally, reframing heritage conservation as a dynamic, economically empowering sector, by emphasizing its roles in tourism, job creation, and community identity, can make it more appealing to youth. Therefore, participatory workshops and youth-led social media campaigns showcasing successful initiatives can further amplify these efforts, fostering greater awareness and aspiration among the younger generation [3].

3 Ideation and entrepreneurship: harnessing creativity for local solutions

Youth are naturally inclined toward creativity and innovation, qualities that are critical for addressing the complex challenges of DRM and heritage conservation. The BRECR's second pillar, ideation and entrepreneurship, calls for creating platforms encouraging young people to generate and implement context-specific solutions [2]. Research highlights critical gaps in the application of innovative technologies and approaches to disaster risk reduction [13]. Addressing these gaps through youth-driven innovation can significantly reduce vulnerabilities, enhance coping capacities, and promote sustainable development [12]. As the first digitally native generation [36], today's youth possess unmatched technological skills, entrepreneurial mindsets, and confidence in their ability to drive change [7]. However, youth remain underrepresented in DRM efforts [15]. A participant in a youth photovoice study described the current state of youth involvement as akin to "talking into a microphone that is not plugged in" [35], emphasizing the urgent need for meaningful inclusion in disaster resilience strategies.

A promising pathway is the establishment of youth innovation hubs dedicated to DRM. These hubs can provide training in designing mobile applications for early warning systems, creating sustainable community-based disaster preparedness models, and

developing participatory monitoring frameworks for heritage sites at risk of disasters. Programs such as Youth Guardians by Natural Hazards Research Australia [31] serve as excellent examples, where youth-led engagement fosters disaster resilience and climate adaptation by leveraging local strengths. Similarly, the Youth Resilience Corps initiative, which provided tools for youth-led community resilience activities [1], demonstrates the untapped potential of youth in building resilience at the grassroots level.

Heritage conservation can also benefit significantly from youth-driven innovation. Earlier research by Spiridon et al. [41] emphasize the role of youth creativity in addressing challenges related to cultural heritage preservation, promoting inclusive and sustainable growth. Recently, Del Baldo and Demartini [9] highlight the regenerative capacity of youth, which, when effectively harnessed, can transform static “museum cities” into vibrant, living communities. Additionally, García-Mieres et al. [16] illustrate how inter-generational adult-youth knowledge exchange enhances rural resilience, reduces social isolation, and enriches sociocultural connections, especially for youth. This result aligns with Menkshi et al. [27], who recognize the importance of youth participation in maintaining archaeological sites, promoting cultural tourism, and engaging in local heritage projects. These initiatives not only raise awareness but also foster the preservation and adaptive management of cultural heritage.

To capitalize on these strengths, the ideation and enterprising pillar of BRECR implies offering targeted training in areas such as sustainable tourism, eco-friendly site management, and digital heritage documentation. These platforms might host innovation challenges and hackathons, enabling youth to develop creative solutions like virtual heritage tours or apps for cataloguing and monitoring at-risk sites. Hackathons are intensive, time-bound innovation events where teams co-develop solutions to real-world challenges. These are powerful platforms for youth to ideate and prototype heritage or climate-related initiatives, while developing skills such as teamwork, creativity, and rapid problem-solving under mentorship. Ultimately, reframing DRM and heritage conservation as dynamic and entrepreneurial fields will not only empower youth but also foster inclusive, sustainable, and lasting change.

4 Technological solutions: leveraging contemporary technologies

As disaster risks continue to evolve, emerging technologies provide vital tools for monitoring, assessing, and mitigating these challenges. Munawar et al. [29] highlight the importance of systematic disaster risk monitoring to inform adaptive risk management policies. Specifically, artificial intelligence (AI) technologies such as machine learning, natural language processing, and computer vision, as emphasized by Waykar and Yambal [48], have revolutionized geospatial data analysis, which enables precise risk prediction, vulnerability mapping, and the formulation of proactive disaster response strategies. Moreover, integrating AI with emerging trends, such as quantum computing and augmented reality, further expands the potential for innovation in DRM [48].

Similarly, unmanned aerial vehicles (UAVs), or drones, offer practical applications in disaster management. Equipped with real-time imaging capabilities, Kirpalani [24] explains that drones facilitate post-disaster damage assessment, search-and-rescue operations, and the delivery of essential supplies to inaccessible areas. In addition, autonomous systems can support debris removal, infrastructure inspection, and rapid decision-making during emergencies, while social media platforms, mobile applications,

and Internet-based technologies enhance coordination among responders, volunteers, and affected communities, creating a cohesive network for effective disaster response.

Furthermore, beyond DRM, contemporary technologies are being leveraged in heritage conservation. Shehata et al. [39] describe the role of tools like digital twins, 3D scanning, building information modeling (BIM), and the internet of things (IoT) in refurbishing and monitoring heritage sites. These technologies enable precise documentation, real-time monitoring, and immersive educational experiences, all of which enhance the protection and appreciation of cultural heritage. Additionally, blockchain technology, as indicated by Vacchio and Bifulco [47], ensures the provenance and authenticity of artifacts, facilitates tokenization and fractional equity, and offers robust digital rights management solutions.

Despite the potential of these tools, extensive competency gaps exist in their application, particularly in heritage sites. Eze and Siegmund [12–14] reveal critical deficits in the use of Geographic Information System (GIS), UAVs, telemetry systems, and disaster prevention technologies. We argue that the integration of advanced technologies, encapsulated in the third pillar of BRECR, is pivotal for attracting and fostering meaningful youth engagement in disaster risk management and heritage conservation. Hence, these gaps present a compelling opportunity to invest in capacity-building initiatives that empower youth to address these challenges effectively. Given that the transformative potential of contemporary technologies offers innovative pathways for addressing longstanding challenges in these domains, equipping youth with the skills to leverage these contemporary technologies, they can play a critical role in providing innovative pathways for addressing longstanding challenges to building resilience to disasters, conserving heritage, and advancing sustainable development goals.

Therefore, it is essential to establish educational, training and professional programs and partnerships that equip youth with hands-on experience in contemporary digital tools. Higher educational institutions, heritage organizations, and technology firms should collaborate to provide training in AI, GIS, UAVs, and blockchain applications,¹ with a focus on addressing real-world challenges. These programs should prioritize practical skills development and innovative problem-solving approaches among youth. Furthermore, targeted policy advocacy is needed to integrate youth-focused technological initiatives into national DRM and heritage conservation strategies. Hence, governments and funding agencies should prioritize investments in technology-driven youth engagement programs, recognizing their potential to enhance resilience, protect cultural heritage, and promote sustainable development.

5 Sustainability: building long-term capacity

The increasing frequency and intensity of disasters due to climate change underscore the urgent need for enduring systems that empower youth to play a transformative role in disaster risk management (DRM) and heritage conservation. As Khatiwada [22] highlights, equipping young people with relevant knowledge, skills, and innovative ideas

¹Blockchain applications refer to decentralized, tamper-proof digital systems that enable secure recording, tracking, and verification of transactions or data. In the context of DRM and heritage conservation, blockchain can be used to authenticate cultural artifacts, track heritage site restoration progress, ensure transparent funding flows for youth-led projects, and support the fractional ownership or tokenization of heritage assets. These tools appeal to digitally literate youth and can strengthen trust, participation, and innovation in conservation and resilience-building efforts.

fosters mutual learning, creates a sense of ownership, and improves outcomes in minimizing climate change impacts.

This fourth pillar of BRECR emphasizes creating enduring systems that establish youth as key stakeholders in DRM and heritage conservation through sustained education, collaboration, and resource management, all rooted in the principles of capacity development. Capacity development, as defined by the United Nations General Assembly [44], represents a long-term, systematic process encompassing not only education and training but also the development of institutions, political awareness, financial resources, and enabling environments. This broader framework ensures that youth are equipped not just for immediate involvement but for enduring contributions to DRM and heritage conservation.

Thus, transformative education and training are foundational to preparing young people as resource persons for DRM and heritage management. According to Khorram-Manesh [23], "adjusted knowledge" compensates for youth's initial capacity gaps, enabling them to transition from a vulnerable demographic to an invaluable resource for DRM. Akeyo [5] similarly posits that capacity-building is essential for sustainable DRM initiatives. Moreover, Zhang et al. [51] categorize youth participation in heritage practices into three pathways, namely: awareness-raising, capacity-building, and empowerment. Combining these approaches fosters the cultivation of civic capacity and meaningful community connections far more effectively than passive education alone [51].

Consequently, policy reform and curriculum integration would play a pivotal role in embedding sustainability within youth engagement frameworks. However, as Bang [6] notes, gaps persist in the integration of disaster risk reduction (DRR) education into high-level policy discussions. The inconsistent discourse on DRR during decades of Ministerial and Consultative Meetings in Africa reveals an urgent need for systematic incorporation of DRR components into risk management discussions, especially in this vulnerable region. The University of Winchester [46] advocates for engaging diaspora youth in policymaking and project design to diversify perspectives, enrich capacity-building, and enhance youth participation. Additionally, Mutasa and Munsaka [30] emphasize that embedding DRR education into primary school curricula can consolidate community capacities, leveraging children as effective information disseminators. Similarly, Selim et al. [38] also stress that evolving youth engagement from one-off interactions to sustained practices within educational systems is key to long-term success.

Furthermore, sustainability within BRECR also recognizes the importance of localized, tailored solutions. Hemstock et al. [20] advocate for regionally accredited qualifications to professionalize disaster response, empower local communities, and reduce reliance on external expertise. Such localized efforts, however, must align with international frameworks and standards to ensure their scalability and effectiveness. As Pal et al. [34] observe, disaster education's interdisciplinary nature can simultaneously address DRR, human security, and sustainable development goals. Practical, community-oriented approaches to education, as described by Ekwesaranna et al. [11], are crucial for fostering environmental stewardship and empowering youth as agents of change in addressing environmental challenges. The fourth pillar of BRECR therefore calls for a comprehensive and integrated strategy for building long-term capacity. By aligning transformative education, policy frameworks, and localized solutions with global standards, this

approach ensures that youth remain central to DRM and heritage conservation efforts, driving sustainable outcomes for generations to come.

6 Social equity in public policy

Social equity within the BRECR framework addresses systemic inequalities that limit youth participation in disaster risk management (DRM) and heritage conservation. Drawing on the principles outlined by Saja et al. [37], social equity is defined as equal access to diverse resources, skills, and services, inclusive resilience initiatives; and equity for individuals with specific needs in disaster contexts. These principles are characterized by fair access to basic needs and services, community inclusiveness, and a diverse skill set and workforce [37], elements directly relevant to youth engagement in DRM and heritage conservation. We believe that policies that emphasize these characteristics can foster environments where youth contributions are recognized and valued. Such recognition enables young people to play active roles in preserving cultural heritage and strengthening disaster resilience, thereby addressing vulnerabilities rooted in socio-economic and other disparities.

Despite some progress, youth engagement in DRM and heritage conservation remains inadequate on a global scale. Sucunza and Berehe [42] point out that youth-focused offices, such as the Office of the Secretary-General's Envoy on Youth and the United Nations Youth Office, were established relatively recently (in 2013 and 2022, respectively). Initiatives such as the IUCN Youth Strategy 2022–2030, a commendable global effort to institutionalize youth participation in conservation and environmental governance, have also emerged only in the past few years. Sithole et al. [40] note that despite increasing recognition of youth as environmental change agents, structural inequities continue to limit their influence within governance spaces. This late prioritization of youth highlights their historical exclusion from global policymaking. Also, persistent challenges, including limited financial support, tokenistic and superficial representation continue to undermine meaningful participation. Moreover, Yatsenko [50] finds that increased youth inclusion in metalevel governmental and institutional decision-making processes enhances their sense of trust and engagement. To address these systemic barriers, direct and indirect participatory platforms should be created, where young people can present innovative solutions and influence policy development in DRM and heritage conservation.

Also, we believe that the realization of social equity within the BRECR framework is intrinsically linked to the effective integration of its four preceding pillars Agbugba & Okoye 2024 [4]. Changing societal perceptions about youth incapacity [28] in DRM and heritage conservation, as highlighted in pillar one, establishes a foundation for equity by recognizing the unique contributions of young people. Similarly, creating youth-driven innovation hubs and encouraging creative problem-solving abilities, as posited in pillar two, further advances inclusivity. Moreover, the adoption of contemporary technology, emphasized in pillar three, bridges critical gaps by equipping youth with tools to contribute meaningfully to resilience-building efforts. Finally, sustained policy reforms and transformative curricular adjustments, as described in pillar four, ensure that youth possess the up-to-date skills and knowledge required for active, continuous participation in DRM and heritage conservation. Together, these pillars create a comprehensive framework for empowering youth as essential stakeholders in these fields.

Therefore, to effectively operationalize social equity within the BRECR framework, we suggest that governments and international organizations should allocate dedicated funding for youth-led initiatives and capacity-building programs in DRM and heritage conservation, prioritizing underserved and disadvantaged groups and communities, including youth [2]. Similarly, developing countries should invest in training programs for contemporary technologies, including artificial intelligence (AI), robotics, digital geomedias, and geospatial technologies. These tools are critical for amplifying youth impact and achieving social equity. Furthermore, youth perspectives should be systematically integrated into resource allocation, planning, and administration strategies for DRM and heritage conservation. Also, the value of Indigenous knowledge and traditions must be recognized to attract deeper youth engagement and strengthen the sustainability of localized DRM heritage conservation efforts.

7 Conclusion

Youth engagement is essential in addressing the pressing challenges of DRM and heritage conservation in an era of heightened global vulnerabilities. The BRECR framework offers a transformative approach to dismantling systemic barriers and unlocking the potential of youth as innovators, leaders, changemakers, and collaborators. By integrating its five pillars (i.e., perception change, ideation and enterprise, technological solutions, sustainability, and social equity) we use the BRECR to reframe the fields of DRM and heritage conservation as inclusive and dynamic opportunities for young people. Therefore, transformative education and capacity-building initiatives are critical to fostering disaster literacy and heritage appreciation, while innovation hubs and technological training can harness youth creativity to develop context-specific solutions. Sustained investments in youth-focused programs, supported by cross-sectoral partnerships and enabling policies, are essential to building resilient systems of conservation and disaster management. To achieve these, intentional collaboration among governments and their agencies, NGOs, educational institutions, technology developers, and heritage organizations is crucial to creating environments where youth can thrive. By empowering the next generation, this approach not only strengthens disaster preparedness and heritage preservation but also advances broader sustainability and equity goals. Ultimately, BRECR calls for a paradigm shift by recognizing youth not as passive beneficiaries but as active architects of a resilient, equitable, and sustainable future. While BRECR offers a promising integrative model, its implementation is still in early stages. The framework has so far been applied in limited settings and requires further validation across diverse socio-cultural contexts. Additionally, institutional inertia and limited youth access to resources may pose barriers to scaling. Future work should explore how BRECR can be localized, digitized, and embedded into formal curricula and policymaking for sustained impact.

Author contributions

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This paper did not involve human participants and/or animals and did not require ethics approval.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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