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SERIOUS GAMES FOR DISASTER RISK REDUCTION: ENHANCING COMMUNITY PREPAREDNESS FOR SUSTAINABLE FUTURES

Udayangani Kulatunga[1] and H. Tariq[2]

ABSTRACT

Disaster-resilient communities are essential to ensure sustainable futures, particularly in regions vulnerable to disasters. Traditional disaster risk reduction training methods often struggle to engage communities effectively, limiting their ability to apply knowledge in real-world scenarios. This study explores the potential of Serious Games as an innovative educational tool for enhancing disaster risk reduction, particularly in developing countries where such approaches remain underutilised. Through game-based workshops, participants engaged in immersive, scenario-driven learning experiences that integrated global and local disaster risk reduction knowledge, expert insights, and peer learning. Nine games were played during the workshops with community members and university students in the Eastern Province in Sri Lanka. A pre- and post-evaluation questionnaire, focus groups, and observations were used for data collection, analysed through statistical comparison and content analysis. Findings indicate that Serious Games not only improve risk awareness and strategic thinking but also improve collaborative learning and social responsibility. The study also highlights the ability of Serious Games to convey sensitive information in an engaging manner, making disaster education more accessible and impactful. Additionally, it highlights the importance of gender-sensitive approaches, emphasising the role of women in strengthening community-driven disaster risk reduction strategies. By offering an interactive learning approach, Serious Games contribute to effective disaster risk reduction and ultimately create sustainable futures.

Keywords: *Awareness; Collaborative Decision Making; Interactive Learning; Disaster risk reduction; Serious Games.*

1. INTRODUCTION

In recent years, disastrous incidents have been increasing drastically, resulting in extensive damage, disruption, and possible fatalities, leaving people unable to function (Inoguchi et al., 2021; Wang & Taylor, 2014). Disasters can impact lives in multiple ways, including fatalities, injuries, diseases, and adverse effects on physical, mental, and social well-being (Perry & Lindell, 2003). Additionally, disasters create property damage, asset destruction, service disruptions, socio-cultural and economic instability, and

[1] Professor, Department of Building Economics, University of Moratuwa, Sri Lanka, ukulatunga@uom.lk
[2] Research Fellow, Department of International Public Health, Liverpool School of Tropical Medicine, UK, Hisham.tariq@lstmed.ac.uk

environmental degradation (Ali & Mannakkara, 2024). Given these far-reaching consequences, effective disaster preparedness strategies are essential to mitigate the risks associated with future disasters (Wells et al., 2013), as they can significantly reduce the impact of disasters by ensuring that communities, emergency responders, and relevant institutions are ready to respond effectively (Herstein et al., 2021).

It is widely recognised that regular training sessions and simulation exercises are crucial in enhancing disaster preparedness among professional responders and the public. Through continuous practice, individuals can develop critical skills, improve decision-making under pressure, and gain familiarity with emergency protocols (Alexander, 2000). Such training also ensures that communities are better prepared to protect themselves and minimise risks when faced with real-life disaster scenarios (Perry & Lindell, 2003).

Disaster management practitioners have increasingly recognised the potential of 'Serious Games' as an innovative and effective tool for disaster preparedness training (Kankanamge et al., 2020; Solinska-Nowak et al., 2018). Serious Games are designed not only for entertainment but also to facilitate learning by engaging users in immersive and interactive experiences (Gee, 2003; Wouters et al., 2013). Therefore, Marsh (2011) asserted that Serious Games have the fundamental principle of 'playing for a purpose' beyond entertainment. These digital or physical simulation-based games provide an opportunity for players to acquire, test, and reinforce critical disaster-related knowledge in a risk-free environment, enhancing their ability to respond effectively in real-life emergency situations (Chittaro & Ranon, 2009). Serious Games can influence the player (disaster responder) to achieve a common goal (rescue and relief of the affected community) while facing the disruptions of the disaster. Therefore, Serious Games can improve decision-making, problem-solving skills, and situational awareness, making them a valuable supplement to traditional disaster preparedness programs (Fleming et al., 2020).

While Serious Games have proven to be an effective tool in enhancing disaster preparedness and risk management in developed nations, their adoption in developing countries faces several barriers that hinder their widespread success due to socio-economic, infrastructural, and cultural challenges (Solinska-Nowak et al., 2018). This is due to the unfamiliarity with the concept of using 'games for learning', particularly for serious topics like disaster preparedness (Mahamood et al., 2024;). Further, in many developing countries, disaster management is traditionally viewed as a highly formalised and hierarchical process led by government agencies or international bodies. Serious Games, which typically require a more interactive, collaborative, and individualised approach, may not be aligned with such formalised approaches (Popescu et al., 2011). This gap in understanding can reduce the acceptance and uptake of Serious Games among both policymakers and the target populations who might benefit from them (Fleming et al., 2020).

Accordingly, this study examines the role of Serious Games in disaster risk reduction in a South Asian developing country, Sri Lanka. Among the developing countries, Sri Lanka has gained significant attention due to its vulnerability to various disasters, including high winds, floods, landslides, tsunamis, and droughts, which have caused widespread devastation throughout its history (Ali & Mannakkara, 2024; Weerasekara et al., 2021). These disasters pose severe threats to the population, infrastructure, and economy, highlighting the critical need for effective disaster risk management and preparedness to create a sustainable future in the country. The study seeks to assess the effectiveness of

Serious Games in improving disaster education, raising awareness, and strengthening crisis response capabilities in multi-cultural settings. Further, drawing insights from the global experiences on how Serious Games can be tailored and integrated into existing disaster risk management practices will also be investigated.

2. CHARACTERISTICS OF SERIOUS GAMES

The modern history of Serious Games initiated in the late 1950s, which emerged as an effect of 'war gaming' and developed into an active contribution of learning to improve active participation in learning (Kolb, 1984; Wilkinson, 2016). Salen & Zimmerman (2004) claimed that Serious Games are different from general games designed previously focused on enjoyment or competition, whereas Serious Games aim to offer their users the opportunity to learn actively. The idea of 'purposing play' has been resonating with the use of Serious Games (Ardley, 1967). Accordingly, Serious Games have been used to cultivate cultural and social values and to communicate desired behaviours.

Serious Games provide the opportunity for the players to practice the skills and lessons learnt during the game to improve their performance within the game (Vlachopoulos & Makri, 2017). This training would be helpful to enhance the social dimensions of players while planning for the next disaster (Solinska-Nowak et al., 2018). Further, a positive emotional response can be established in players' minds through Serious Games, which provide them with a challenging, memorable, and fun learning experience (Mahamood et al, 2024). In this way, people can enhance the process of remembering information regarding each disaster, and they may get excited about the new social situation due to the disaster without having negative emotions. Moreover, serious games emphasise creating a safe learning environment where individuals can engage in 'experiential learning, i.e., learning through mistakes without experiencing the devastating consequences that would occur in real-life scenarios (Chittaro & Ranon, 2009). According to Babu et al. (2016), Serious Games provide the players with situational awareness, making them aware of the disaster's type, scope, impact, and complexity. Collaborative learning through collective playing is another feature of Serious Games, which offers more space for building relationships, practising negotiations and conflict resolution, and exchanging information or sharing experiences that are important in community handling during challenging scenarios (Wilkinson, 2016).

Further, Serious Games often include adaptive learning pathways, where the difficulty or content adjusts in response to players' choices and performance, supporting personalised learning experiences that match diverse needs and skill levels (Gee, 2003). They also facilitate reflective learning by prompting players to evaluate their decisions, discuss alternative strategies, and consider the ethical or social implications of their actions, and deepen critical thinking and preparedness (Perera et al., 2015). Narrative and storytelling elements embedded in Serious Games create engaging, context-rich scenarios that help players to retain the knowledge they gained from the game (Popescu et al., 2011). Moreover, Serious Games support assessment and feedback mechanisms, enabling trainers and learners to monitor progress, identify gaps, and tailor future learning efforts (Wouters et al., 2013). Serious Games can be deployed widely, reaching diverse and remote populations with limited resources. Further, Serious Games can promote intercultural understanding and empathy by exposing players to different perspectives and community needs (Salen & Zimmerman, 2004). Therefore, it can be argued that Serious Games provide a powerful and innovative approach to learning and problem-solving, bridging the gap between knowledge and practice in an engaging, impactful way.

3. RESEARCH METHODOLOGY

The study's main aim was to investigate the role of Serious Games in enhancing disaster risk reduction in developing countries by assessing their effectiveness in improving disaster education, raising awareness, and strengthening crisis response capabilities in multicultural settings. Accordingly, this study adopted a mixed-methods research approach, employing pre and post-evaluation questionnaires, focus groups, and observations as data collection techniques The primary reason for selecting a mixed-methods research approach was to gain an in-depth understanding of various communities' and stakeholders' perceptions, experiences, and attitudes towards using game-based learning for disaster preparedness, while quantitatively assessing the knowledge gain after playing the game. In developing countries like Sri Lanka, integrating Serious Games into disaster risk reduction is a relatively novel concept, and there is a need to understand how local communities, policymakers, and disaster management professionals perceive and adapt to the use of games for disaster awareness and preparedness. Within this context, the mixed-methods research approach enabled the exploration of key issues such as cultural readiness, technological accessibility, and educational preferences (Creswell, 2013; Denzin & Lincoln, 2011; Saunders, 2019), which may impact the effectiveness and acceptance of Serious Games as a tool for disaster risk reduction. The research design of this study consisted of 4 phases, as described below.

3.1 PHASE 1: DESK STUDY

A desk study was carried out to review the Serious Games currently available for disaster risk reduction. The primary purpose of the desk study was to identify the characteristics of Serious Games for disaster risk reduction in general and to investigate the criteria that must be considered in developing an interactive board game within the context of Sri Lanka, concerning cultural, social, economic, and technological dimensions. Accordingly, Serious Games such as Disaster Mitigation Action Card Game (Kaneko et al., 2018), RISKLand board game (UNICEF/Red Cross), Games4Sustainability, HAZAGORA (Michellier et al., 2019; Mossoux et al., 2016) and STOP Disasters online game (UNISDR) were reviewed. The review criteria used during the desk study included the disasters represented in the game and their relevance to Sri Lanka, simplicity and ease of understanding of the game for the public, relevance of the game characteristics/characters to the Sri Lankan community and availability of facilities/resources to run the game. Following the above review, the HAZAGORA game (Michellier et al., 2019; Mossoux et al., 2016) was selected as the basis for developing a suitable board game for the Sri Lankan context.

3.2 PHASE 2: CONTEXTUALIZING THE GAME TO THE SRI LANKAN CONTEXT

To adapt the Hazagora board game for Sri Lanka, modifications were made to reflect local contexts and increase relevance. To support this contextualisation, a documentary review identified relevant disasters, and two expert consultations with local authorities helped confirm the disasters to include and the location for the game's test run. Accordingly, floods, tsunamis and droughts were chosen as the disasters to include in the game by considering their severity (ACAPS, 2024). The Northeast region of Sri Lanka was chosen as the location to test-run the game, as this region was severely hit by the Tsunami in 2004, as well as the presence of floods and droughts.

Next, the original Hazagora materials were reviewed and customised. Some of the character roles were adapted to represent typical livelihoods found in Sri Lankan villages, such as fishermen, carpenters, and community leaders. In consultation with local experts and drawing on resources published by the Disaster Management Center of Sri Lanka, locally relevant disaster risk reduction strategies and guidelines were integrated into the gameplay. To ensure accessibility, all game materials were translated into Sinhala and Tamil. The format and layout of the adapted game are given below (refer Figure 1):

- The game can be played for a set duration or a fixed number of rounds, with 5–8 players in one group.
- At the start, players are assigned roles representing rural community members (e.g., fisherman, carpenter, village leader) along with resource and protection cards
- In the first round, players collect additional resources by rolling a dice; in subsequent rounds, they develop assets, build infrastructure and/or take measures to protect families from hazards
- The 'game master' introduces a disaster scenario with specific magnitude and impact that affects the players according to their preparedness measures (e.g., safer construction, insurance).
- After the disaster event, the village leader convenes a meeting where a 'notice' is read, summarising key disaster risk reduction lessons and future preparedness strategies.

Figure 1: Layout of the game

3.3 PHASE 3: PILOTING THE GAME

Two (02) pilot games were conducted with people from different ethnic groups and subject disciplines, such as gaming, disaster, and built environment to ensure the context and game rules are applicable to Sri Lanka. Following the pilot games, some of the game rules were changed to simplify and reduce the overall time of the game.

3.4 PHASE 4: CARRYING OUT WORKSHOPS IN SRI LANKA

Nine (9) games were played in the North-Eastern province of Sri Lanka, as shown in Table 1 below. Following the game, participants' opinions about knowledge enhancement were explored through focus group discussions. These discussions were analysed using content analysis to investigate the knowledge gains and their views regarding the game. Both deductive and inductive coding were applied to identify the key themes from the focus group discussions (refer to Figure 2 for the cognitive map prepared

based on these themes). Additionally, during the gameplay, the research team recorded evidence of knowledge enhancement (e.g. players choosing to build homes in safer, less disaster-prone areas) using observation forms. Pre- and post-evaluation questionnaires with structured questions were also administered to quantitatively assess changes in participants' disaster preparedness knowledge.

Table 1: Profiles of the games played

No	Location	Participants
Game 1, 2 and 3	Trincomalee	Community Leaders and members
Game 4 and 5	Trincomalee	University students
Game 6 and 7	Batticaloa	University students
Game 8 and 9	Batticaloa	Community Leaders and members

4. DATA ANALYSIS AND DISCUSSION

The following section presents observations made and feedback received from different members who participated in the game.

4.1 IMPROVEMENT OF KNOWLEDGE AND UNDERSTANDING

Participants showed a clear improvement in their knowledge and understanding of disaster mitigation as they progressed through the game, particularly evident in their active sharing of personal disaster experiences. For example, one participant noted, "*As I am originally from the middle of the country, I have never experienced floods, but after listening to my fellow community members today, I learned many aspects regarding floods and the methods we need to follow*." This aligns with Ronan et al (2001), who highlight the value of community-based learning in disaster education.

The game structure simulated real-life disaster scenarios and encouraged collaborative decision-making. After each disaster event, a community meeting was held where a Village Leader read a 'notice' outlining best practices before, during, and after disasters. Grounded in global guidelines but tailored to the Sri Lankan context, this approach mirrors effective community-driven disaster preparedness (Gautam, 2010). Participants acknowledged the practical knowledge gained, such as safeguarding essential documents and medicine for quick evacuation, as reflected in participant feedback. Serious games reinforced critical disaster mitigation practices often overlooked in real-world planning (Lindell & Perry, 2004). Overall, participant feedback indicated successful knowledge transfer, consistent with literature emphasising serious games' role in fostering practical skills (such as identifying alternative evacuation routes).

Experiential learning emerged as a key outcome, with participants learning through gameplay and mistakes, for example, relocating homes to safer areas after experiencing simulated disasters. This aligns with Kolb's (1984) experiential learning theory and Kiili's (2005) emphasis on learning through safe experimentation and immediate feedback. Following Gee's (2003) idea of 'pleasantly frustrating' experiences and Vygotsky's (1978) theory of learning through challenge, participants refined their strategies, considering measures like purchasing insurance and building hospitals in safer locations.

4.2 GOAL ORIENTED

Unlike casual games, which aim primarily to entertain, Serious Games are purposefully designed to achieve specific learning outcomes or behavioural changes (Chittaro & Ranon, 2009). The game in this study was structured to promote engagement in disaster risk reduction activities by mimicking real-life scenarios. For example, players navigated emergency response situations by selecting evacuation routes and prioritised preparedness actions such as following building codes and avoiding hazard-prone areas. As they progressed, players met performance targets such as implementing effective mitigation measures, optimising resource management, and demonstrating collaborative decision-making during crises.

4.3 LEARNING IN AN ENJOYABLE WAY

Even though the term Serious Games suggests a serious nature, these games incorporate an element of fun while facilitating learning (Michael & Chen, 2006). This enjoyable approach to learning was evident during the project. For instance, one university student remarked, *"We thought we would come for a three-hour session on disaster risk management, but this turned out to be completely different—we learned about disasters in a much more enjoyable way."* Similarly, a disaster management field worker observed that in traditional disaster risk reduction events, facilitators typically engage in continuous lecturing. However, within the game environment, facilitators introduce the game and its rules, after which the players take ownership of the experience, making learning more interactive and engaging.

4.4 COMMUNICATING SENSITIVE MESSAGES WHILE BEING IN A SAFER ENVIRONMENT

Simulating disasters can be sensitive due to participants' past experiences (Crookall, 2010). Participants may have had distressing experiences related to past disasters, which could affect their emotional well-being. However, incorporating disaster simulations within a board game creates a safe and controlled environment for learning. This aligns with the findings of Gee (2003), who argues that games provide 'psychological safety', allowing players to experiment, make mistakes, and reflect without real-world consequences.

The role of serious games in fostering emotional resilience and preparedness has been widely discussed in disaster education literature. For example, Wouters et al. (2013) found that Serious Games enhance both cognitive and emotional engagement, helping learners process complex or distressing topics in a more manageable way. Similarly, game-based learning can support emotional regulation by enabling players to interact with risk scenarios at a comfortable pace, reducing anxiety while still reinforcing critical decision-making skills (Tsai et al., 2020). This was evident in participant feedback from this study. One participant remarked, *"I was able to practice real-world disaster scenarios while being in a safe, risk-free environment. This game enabled me to better prepare for challenges I may encounter in my personal life."* This supports Backlund & Hendrix's (2013) view that serious games offer an immersive yet emotionally safe environment, helping players build confidence in real-world scenarios. One participant, previously reluctant to discuss their tsunami trauma, felt secure enough during the game to share their experiences openly.

4.5 KNOWLEDGE TRANSFERRING

One of the primary objectives of this game was to enhance public awareness of disaster risk reduction. To achieve this, a diverse group of participants was selected, including community leaders, disaster management field workers, university students, community members from various livelihoods and ethnic backgrounds, and schoolteachers. This diverse representation aimed to facilitate the continuous transfer of disaster risk reduction knowledge across different sectors of society. For instance, university students could share their learnings with their families, disaster management field workers could integrate insights into their ongoing work, and schoolteachers could educate their students. A schoolteacher commented, *"I am definitely going to use this in my teaching to educate school children about disaster risk reduction."* This reflects the concept of social learning, as Tsai et al. (2020) described, where individuals acquire and spread knowledge through observation, interaction, and shared experiences. Further, the disaster management field offices and community leaders suggested developing similar Serious Games for other critical issues in Sri Lanka, such as Dengue control, to improve the awareness of the community regarding such diseases.

4.6 GENDER PERSPECTIVES

During the game, an interesting trend emerged among the women participants: stockpiling essential supplies using their game cards. They actively stored food, water, and other critical commodities necessary for an effective disaster response. This behaviour aligns with real-world disaster preparedness patterns, where women often take on key roles in household and community resilience-building. Research shows that women, due to their caregiving roles and responsibility for the well-being of families (Enarson, 2000), are more likely to stockpile supplies and adopt proactive risk reduction behaviours (Cvetković et al., 2024), a pattern reflected in the game.

This observation in the game also reflects the concept of *anticipatory adaptation*, where individuals and communities take proactive actions to mitigate disaster impacts (Kelman & Gaillard, 2010). By stockpiling resources, the women participants demonstrated an understanding of disaster cycles and the importance of preparedness, reinforcing findings from previous research that women play a crucial role in ensuring food security and resource management in times of crisis.

4.7 INNOVATIVE IDEAS

As the game progressed, a clear transformation in the participants' decision-making patterns was observed. Initially, players focused on individual survival strategies, making decisions primarily aimed at securing their safety and resources. However, as the game unfolded, players began to adopt a more collective approach, prioritising the entire community's well-being. This shift toward community-oriented thinking was particularly evident in their collaborative efforts to establish shared resources for disaster response. This was evident in their creation of an “insurance pot,” a communal fund to aid vulnerable members after disasters, reflecting real-world resilience strategies that pool resources to reduce individual impacts. Players also discussed long-term preparedness, such as building a hospital on safer land, demonstrating an understanding of disaster risk reduction principles, such as locating critical infrastructure away from high-risk areas and the importance of building community-level resilience.

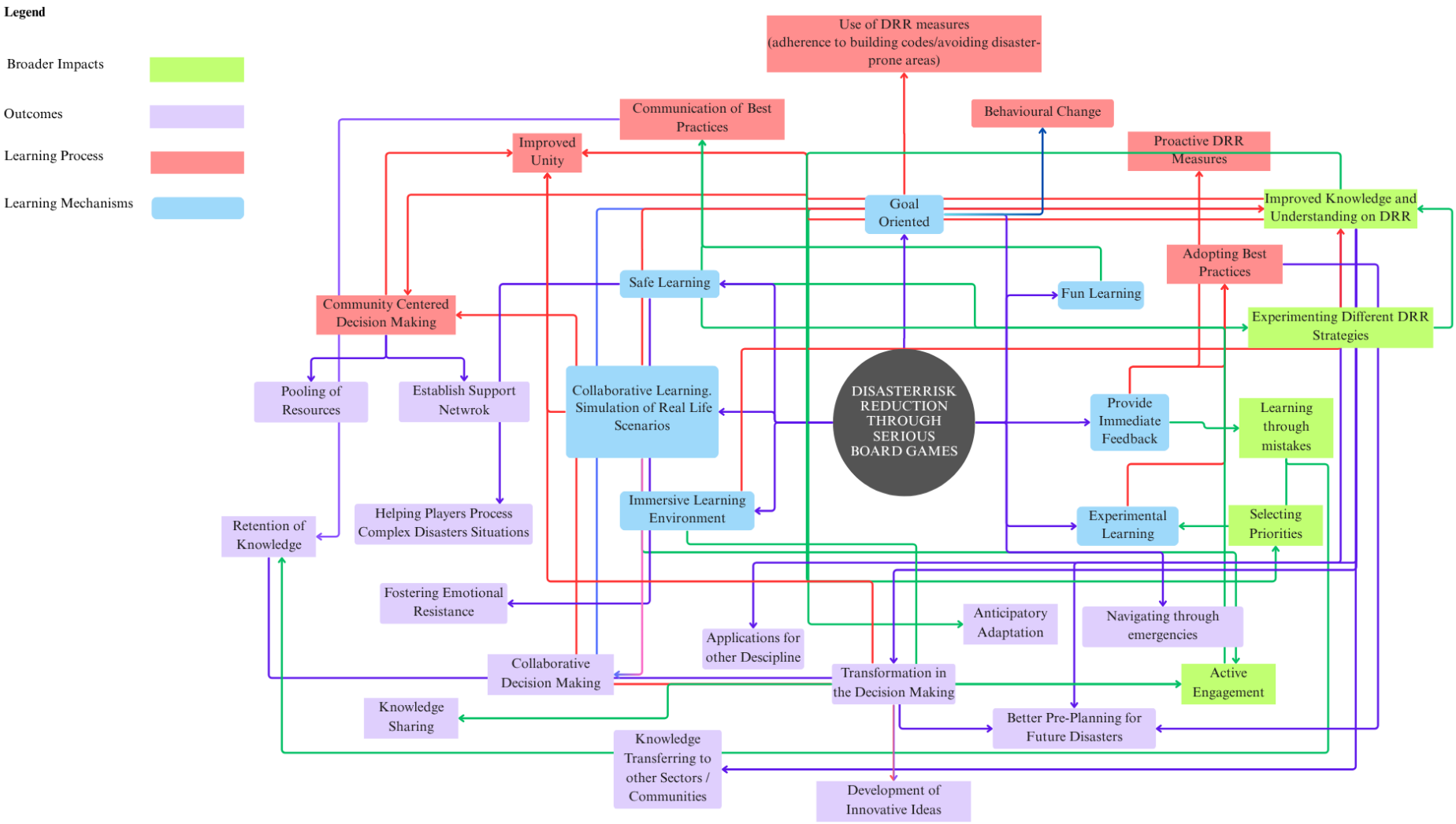

Figure 2: Influence of Serious Games for disaster risk reduction

4.8 VISUALISING SERIOUS GAMES FOR DISASTER RISK REDUCTION

Considering the above discussions, Figure 2 has been added to visualise how Serious Games could influence disaster risk reduction. Figure 2 illustrates how Serious Games can enhance disaster risk reduction by linking learning mechanisms, processes, outcomes, and broader societal impacts. At its core, the model highlights the characteristics of Serious Games such as immersive and experimental learning, goal-oriented nature, fun learning, etc., as key mechanisms that foster engagement, collaboration, and feedback within the simulated disaster scenarios. These learning experiences facilitate safe environments for users to process complex situations, adopt best practices, and develop emotional readiness for real-life disasters.

Through this process, it shows a pathway from individual learning to collective action. Outcomes such as improved decision-making, emotional resilience, and community collaboration are connected to long-term impacts like the development of proactive disaster risk reduction measures, behavioural change, and better pre-disaster planning. The diagram effectively captures the cyclical and interconnected nature of learning in disaster risk reduction, emphasising that serious games not only transfer knowledge but also shape attitudes, foster innovation, and support adaptive capacities in disaster-prone communities.

5. CONCLUSION

This study was carried out to investigate the role of Serious Games in enhancing disaster risk reduction in developing countries by considering Sri Lanka as a case study. The findings reaffirm the established understanding that Serious Games are powerful educational tools, providing experiential learning opportunities, immediate feedback, and a safe environment for trial and error. By immersing participants in realistic disaster scenarios, these tools enhance decision-making, strategic thinking, and behavioural change, key competencies for building sustainable and disaster-resilient communities. Additionally, this study highlights the unique ability of Serious Games to balance emotional sensitivity with experiential learning, peer interaction, and long-term knowledge retention, surpassing traditional disaster risk reduction awareness methods.

One of the study's insights is the significance of integrating gender-sensitive approaches into disaster education and preparedness initiatives. Recognising and strengthening the role of women in disaster response and preparedness can lead to more inclusive and equitable risk reduction strategies, ensuring that sustainability efforts are socially justified and community-driven. Moreover, the observed shift from individualistic to community-oriented decision-making underlines the potential of Serious Games to foster collective action and social responsibility, core principles of sustainable futures. Sustainable resilience is not only about reducing disaster risks but also about strengthening social cohesion, resource-sharing, and proactive community participation, which were evident and strengthened through this study.

This study demonstrates the feasibility of using Serious Games for disaster risk reduction awareness, particularly in developing countries where such approaches are not yet widely recognised. The findings align with global research supporting the use of Serious Games to motivate behavioural change and enhance disaster preparedness, all essential for creating sustainable, resilient, and adaptive communities. One of the study's limitations is its focus on only three prevalent disasters in Sri Lanka, leaving room for future research

to explore the applicability of Serious Games across a broader range of disaster scenarios, healthcare challenges, such as dengue and sustainability challenges.

This study contributes to theory by expanding the conceptual understanding of Serious Games as tools, not only for individual learning but also for cultivating collective, community-based disaster preparedness in developing country contexts. It advances theoretical models of experiential learning in disaster risk reduction by integrating social dimensions such as gender sensitivity and community participation, demonstrating that effective risk reduction education requires addressing social equity and inclusivity. From a practical perspective, the study demonstrates how games can deliver cost-effective, engaging, and inclusive training that enhances decision-making and community preparedness. By highlighting gender-sensitive approaches and collective action, it provides a model for designing disaster risk reduction interventions that are locally relevant, equitable, and sustainable.

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