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Original paper

The Role of Theatre with Eco-feminist Approach in Combating COVID Pandemic

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Abstract The present COVID-19 pandemic disaster has brought new challenges to women and shown why the environment needs more benevolent treatment. This study argues that Eco-feminism prescribes an effective way to mitigate the problems of women and the environment, by addressing the two problems together. As Eco-feminism is an activist movement, awareness about its core ideas is essential for its successful implementation. This study explores the tribal (Santhal) population in the village 'Baragora' situated at the Purulia District in the State of West Bengal, India, to investigate the effectiveness of theatre as a medium for creating awareness about the core ideas of Eco-feminism. On the basis of some simple statistical analysis, it observes that there exists an overwhelming preference towards theatre for creating awareness irrespective of gender and irrespective of existing concepts about the core ideas of Eco-feminism. Theatre can promote the core ideas about eco-feminism, as an important tool for tackling the COVID-19 situation present and forthcoming.

Keywords: theatre, eco-feminism, COVID Pandemic, risk

1. INTRODUCTION

Among the many disastrous outcomes of the COVID-19 pandemic, two observations are of particular interest in the present study. On one hand, the world is experiencing a massive increase in violence against women especially domestic violence. On the other hand, due to lockdowns in factories and restrictions on commutations, the environment has become less polluted and has regained much of its long-forgotten colors. These two conditions underline

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the fact that the world has been benevolent neither to women nor to the environment. The feminist perspective addresses the case of women while the environmentalist perspective addresses issues and problems related to physical environment. Eco-feminism addresses both these issues simultaneously and perhaps more effectively. Eco-feminism (see Annexure for a brief introduction to this concept) is a school of thought that emphasizes deprivation or subordination of women as well as nature by patriarchal society. Eco-feminism emerged both as an academic and activist movement (Lorentzen 2002) during the 70s. Being an activist movement for resolving the issues of women and nature simultaneously, eco-feminism requires awareness of its core ideas and propositions at the mass level.

The present study, investigates theatre as a tool for raising or creating awareness about eco-feminism. Using simple statistical methods, the present study strives to determine whether the raising awareness can vary over gender and over pre-existing conception about the core ideas of eco-feminism. The context of gender is important because the patriarchal attitude may not accept a feminist idea whole-heartedly. If people with no prior knowledge about the core ideas of eco-feminism reject theatre as the most powerful medium for creating awareness, then using theatre for creating awareness will hardly be fruitful. Thus the effectiveness of theatre should be judged independently over gender and pre-existing conception about the core ideas of eco-feminism.

This study surveys 205 adult tribal people from Baragora village located in Purulia, West Bengal, India. All the people surveyed in this study belong to the tribe ‘Santhal’. The tribal people are the marginalized and indigenous section of the society. Their pre-existing perception about the core ideas of eco-feminism and their choice of the most powerful medium for creating awareness is little influenced by the modern ideas and arguments of the metropolis-centric media. While COVID19 pandemic has also gradually spreading to these distant localities, far from the madding urban crowd, eco-feminist awareness can possibly be handy to combat such a menace and theatre perhaps can play a great role in spreading such awareness.

2. OBJECTIVES OF THE STUDY

The present study investigates the influence of theatre over other media in spreading awareness about eco-feminism, gender-wise and over different pre-existing awareness levels about eco-feminism. The propositions of this study are –

IF

(i) greater awareness about eco-feminism can address the present and forthcoming COVID19 threat as a part of disaster management;

AND IF

(ii) theatre can successfully promote awareness about eco-feminism;

THEN

(iii) theatre as an effective awareness creation mechanism of eco-feminism can help tackle the COVID19 pandemic situation as disaster management.

Proposition (i) above is evident from the existing literature discussed in the next section. The objective of the present paper then rests on investigating if proposition (ii) above holds or not. If the present study can prove the proposition (ii) above, then proposition (iii) can be concluded.

The present study aims to understand how effective theatre is as a medium of creating awareness on eco-feminism for fighting the existing and emerging COVID19 pandemic across gender and across existing perceptions on eco-feminism.

On the basis of the collected data, we shall investigate the following six key questions:

1. What is the nature of the subjects' pre-existing awareness about eco-feminism?
2. What is their choice of medium as the most powerful medium for spreading awareness?
3. How does the awareness about eco-feminism vary over gender?
4. How does the opinion about theatre as *the most powerful medium* for spreading awareness vary over gender?
5. How does the opinion about the most powerful medium for spreading awareness vary among different types of pre-existing awareness about eco-feminism in general?
6. How does the opinion about the most powerful medium for spreading awareness vary among different types of pre-existing awareness in terms of gender differences?

3. LITERATURE REVIEW

3.1 Women and Environment in the time of Corona

The Corona virus outbreak started in December 2019 in Wuhan, China (WHO 2020) and it was declared a pandemic in March 2020 (WHO 2020(i)). As of 14 October 2020, the total number of deaths worldwide due to this pandemic stands at about 1.87 million, whereas this virus has infected 38.2 million people. The pandemic as on this date has taken the cruelest form in US, India and Brazil (COVID-19 Dashboard by the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University).

Women worldwide have suffered more than before due to their gendered identity. To cite a few cases – in Jianli County in Hubei, China, one police department reported a tripling of domestic violence in February 2020 in comparison to February 2019, estimating that 90% cases were related to the COVID-19 spread. In the UK, deaths from domestic abuse between 23 March and 12 April, 2020 more than doubled compared to the average rate in the previous 10 years (Roesch *et al*. 2020). In Russia, the number of calls to hotline numbers dedicated to domestic violence leapt from just more than 6,000 in March to more than 13,000 in April 2020.

In Malawi, Africa 46% of girls are married before age 18 and 9% before age 15 in general times. In one of the poorest countries, a spike in child marriages was observed when lockdowns began in March (Seo 2020). This evidence points to the fact that this pandemic perhaps has become a more severe disaster for women.

On the other hand, due to the lockdowns of factories and restrictions on many other economic activities of daily life, the environment worldwide has regained its freshness to a great extent. To cite a few cases, a study in India shows that "…COVID-19 has brought a fearful, devastating scourge for human being but it has emerged as a blessing for natural environment providing it a "recovery time". …The environmental degradation caused by humans is not totally irreversible. In just 1–2 months, "recovery of nature" is being witnessed by everyone. This is a signal for us to understand and react." Additionally, it finds that after this lockdown "the Air quality index (AQI) in all the states of India is now in two figures (indicating moderately good quality of air). Not only air but the rivers of India like Ganga, Yamuna, and Cauvery, *etc*. have become clean and clear and marine life is visible." (Lokhandwala and Gautam 2020). Another study in Ecuador found a "reduction in NO2 of up to 22–23% in the most highly populated cities in Ecuador (Quito and Guayaquil) after the lockdown caused by the outbreak of COVID-19" (Pacheco *et al*. 2020).

On the one hand the COVID-19 pandemic has increased violence against women but on the other hand, has forced patriarchy to reduce its violence against nature. Increased violence against women calls for the feminists to fight more forcefully. Reduced violence against nature calls for the environmentalists to show people how inadvertently civilization has dealt with the nature in which it has grown up. As many countries have started 'unlocking' their economic activities, nature may now go back to the perilous condition it was in before the lockdown. Tackling the disaster caused by the COVID-19 with the eco-feminist approach will improve the condition of women and simultaneously safeguard nature from the patriarchal exploitation slowly reappearing with 'unlock'.

3.2 Eco-feminism

Eco-feminism is a combined product of the women's liberation movement and the ecological protection movement (Guan 1996). Eco-feminism, a new school of thought was pioneered by the French feminist writer Francoise d' Eaubonne in the early 1970s. It grew during the 1980s and 1990s amongst women from the anti-nuclear, environmental and lesbian-feminist movements (Lorentzen and Eato, 2002). Eco-feminism as an academic discourse did not develop until the mid to late 1980s (*e.g.* Salleh 1984, Plumwood 1986, Warren 1987). Eco-feminism identifies a variety of approaches through which one can establish or find a connection between the domination of women and domination of nature.

Eco-feminism emerged as a school of thought which tried to solve the ecological crisis from the perspective of gender. Eco-feminism was born when the ruling mode of a totalitarian state

had been compromised (Ling 2014). Eco-feminism emerged as a critic of modern industrial civilization. Eco-feminism puts much importance on the cultural values of society. Eco-feminism is a field bridging ecological ethics and feminism that seeks to explore the conceptual connections between environmental degradation and sexist oppression (Warren 1997). As eco-feminists claim that ecology is not complete without feminism similarly feminism is incorporeal without the ecological perspective. Ynesta King describes eco-feminism as a holistic way of thinking (King 1989).

Vandana Shiva and Maria Mies are of the opinion that the Western Development Model has converted both nature and women into consumer goods (Braidotti, *et al*. 1994). Gender, class, reproductive power, and resource distribution have contributed to the development of the inter relation between nature and women (Agarwal 1992).

Sherry B.Ortner first discussed the relationship between nature and women. In her essay "Is Female to Male as Nature is to Culture?" Ortner points out that nature and women are always associated with some cultural symbols (Ortner 1974). "There are at least eight sorts of connections that eco-feminists have identified. These alleged connections provide sometimes competing, sometimes mutually complementary or supportive, analyses of the nature of the twin dominations of women and nature. A casual perusal of these eight alleged connections helps to identify the range and variety of eco-feminist positions on woman-nature connections" (Warren 1991).

Eco-feminism identifies a variety of approaches through which one can establish or find a connection between the domination of women and domination of nature. Maria Mies states that women have always raised their voices or gone for mass movements whenever there was threat of devastation created either naturally or due to atomic the patriarchal society is equally oppressive towards women and nature (Mise 1993).

Women and nature are connected through domination by patriarchal society. In her book *Theorizing Patriarchy*, Sylvia Walby calls "patriarchy a system of social structures and practices in which men dominate, oppress and exploit women" (Walby 1990). In a patriarchal society, women and nature both are controlled by the patriarchal system. Eco-feminism is an 'awareness' that begins with the realization that the exploitation of nature is intimately linked to Western Man's attitude toward women and tribal cultures…" (Birkeland 1993). Women are the primary sufferers of environmental degradation and forest resource depletion (Louise Fortmann and Dianne Rcheleau 1985).

Eco-feminists believe that it is the "logic of domination", in association with value-hierarchical thinking and value-dualisms that sustains and justify the twin domination over women and nature (Warren 1990). Eco-feminist theory highlights the connection between the oppression of women and the oppression of nature to understand "why the environment is a feminist issue", as well as "why feminist issues can be addressed in terms of environmental concerns" (Gaard 1993). It is important to realize the nature of these connections to

comprehend the oppression of women and nature. All feminist theories should include an ecological perspective and vice versa (Warren 1987).

From the literature surveyed above, it is evident that violence against women (VAW) and violence against nature (VAN) have not only similarities, but must be resolved simultaneously for the sake of both woman and nature. And since eco-feminism is also an activist movement, awareness about the core ideas proposed by eco-feminism is also essential. The concepts of Violence against Women (VAW) and Violence against Nature (VAN) are briefly described in the Annexure.

3.3 Eco-feminist Approach in combating the COVID-19 Pandemic

The COVID-19 situation is so novel that little if any, academic research is available that use eco-feminist approach.

In her article published in feminismindia.org on 1 April 2020, Srishti Gupta summarizes the relation between the COVID-19 outbreak and the eco-feminist approach to deal with it: "The COVID-19 outbreak has exposed the mistreatment of the nonhuman. However, a sweeping indictment of humanity for ecological stress and deterioration internalizes prejudices perpetuated by power structures of capitalism, imperialism, and patriarchy. Eco-feminist thought, therefore, cautions against knee-jerk eco-centric reactions to crises that hurt the marginalized. Instead, it holds the power structures accountable for exploiting both the nonhuman and human. An eco-feminist approach furthers the idea of environmental justice that takes in its fold social and cultural differences" (Gupta 2020).

In explaining the role of eco-feminism in the COVID-19 pandemic, Aryan Rai, a freelance writer, states "The objective is to morph the male-dominated society into a space that acknowledges not only its homogeneous dependency on women and nature but also the damages its patriarchal practices have caused over many decades" (Rai 2020).

3.4 Theatre for Awareness

Governments in different countries use theatre for spreading awareness on different issues, like countering HIV AIDS, using the scientific sanitary system, using gas stoves, *etc*. Theatre has also been used for propaganda and as a form of resistance, a voice against the ruling class. There have been many academic studies on the effectiveness of theatre as a means for promoting awareness.

Christa Blackmon, an American human rights researcher, and educator observes that "human rights activism relies on an ability to tell stories to diverse audiences that will inspire action toward justice. Distributing information through journalism, whether it be traditional or new media, is the standard method of raising awareness" (Blackmon 2017). Favoring theatre over

other media for creating awareness, she observes, "Live theatrical performances in particular offer an exceptional form of audience engagement that human rights organizations may find more meaningful than the circulation of films or literature. The theater is also a highly adaptable medium, able to be molded over and over according to the vision of its social and cultural location" (Blackmon 2017). On how and why theatre influences people, she remarks, "…in order to achieve both the goals of art and activism, the artists and the audience must be treated as agents of change. Whether the production is commercial or charitable in nature, creators and actors are engaged in the act of speaking truth to power. At the same time, the "spectators" maintain the possibility of relating what they've witnessed outside of the theater" (Blackmon 2017). A study on the effectiveness of theatre as a means to create awareness about VAW "…reveals that the theatre processes… develops cultural values and awareness in communities" (Khan 2017).

Another study on the effectiveness of participatory theatre in sensitizing people about LGBT individuals found that "…participatory theatre has the potential to promote positive change in attitudes toward LGBT individuals" (Logie *et al*. 2018).

Since ancient times theatres in India have played an immense part in communicating messages, creating awareness against social evils, and even ushering in a revolution. One of the earliest records of theatre in India goes by the name of Natyaveda. It dates back to the Vedic age, where these ancient plays chronicled the events of cosmic creation. These plays, rich in euphonious music, spectacular dance and drama, were full of intricate rituals which were performed by priests, sages, seers and hermits and recreated the early days of the young universe. The first-ever theoretical treatise of these age-old plays was compiled and recorded by a renowned ancient Indian sage known as Bharatmuni. He named his treatise Natyashastra (Science or study of theatre). As days, years, centuries, and millennia went by, the society evolved and so did the theatre. The simple societies gave way to complex social structures that resulted in multiple challenges. The theatre portrayed socio-economic inequality, the caste system, and the plight of tribes like the Santhals. In India, street theatre has played a significant role in spreading awareness of social issues (Gangopadhyay 1996). Some of the works in this field have been done by such groups as the Bengal-based Bahurupee, who staged a Bengali adaptation of Henrik Ibsen's play, A *Doll's House* (*Putul Ghar* in Bengali). This play touched on such topics as women seduction and deprivation by patriarchal society. (Gangopadhyay 1996)

From the ancient period, male-dominated society used women as a commodity in the name of religion or politics. Theater has addressed this kind of commodification. Rudraprasad Sengupta wrote a play titled 'Jagyaseni Agnikannya' based on the Kannada play 'Uriya Uyyale' written by H. S. Venkatesh Murthy. Recently Kasba Arghya produced 'Urubhangam', which enthralled the audience.

The pioneer of Third Theatre, Badal Sircar was a visionary playwright who highlighted the plight of the Santhals and the women in those societies who faced seemingly endless acts of fiendishness (Anuradha 2019).

Under the aegis of Partha Gupta, the director, and designer, the Santhali theatre produced a few outstanding plays viz. Rabindranath Tagore's Red Oleanders and Hnasa Ora Ria Sereng (The song of the Earthen Cottage) which brilliantly depicted the Bengali and Santhali traditions of theatre, rituals and language (Riaz 2019).

A multitude of folk dance and drama groups which were, at times, even antithetical in nature greatly contributed to the enrichment of India's and, therefore, Bengal's theatrical heritage. Chau is a form of folk drama associated with the heritage and culture of Purulia. It is famous worldwide. The specialty of Chau is its informal way of presentation and simplicity. In Chau, the audience has the feeling of oneness with the performer. In the present time, Chau is practiced and enjoyed in this region although not as widely as it used to be in the past.

Theatre is a powerful medium for creating awareness, not a prejudice cherished over the ages; rather, it is a truth established scientifically. Besides, although many studies have been carried out on the effectiveness of theatre in raising awareness about different issues, there is no prior work assessing the impact of theatre on raising awareness, particularly on eco-feminist ideas.

Consequently, in this study, the extent to which theatre is the most powerful medium for creating eco-feminist awareness is investigated on the basis of the opinion of the respondents. this seems justified as a host of previous studies on the effectiveness of theatre in raising awareness show why theatre should be considered as a medium of raising awareness about the core ideas of eco-feminism.

3.5 Natural Environment in Purulia

Deforestation has occurred since humans started building their own houses and settling hamlets. By the 19th century, India's population had increased drastically, leading to scale of deforestation, sufficient to change our climate and ocean currents. Environmental destruction across the globe did not spare places like Purulia, a district in the state of West Bengal, India, which hitherto, had enjoyed Mother Nature's blessing.

In 1999, an NGO, known as the Tagore Society for Rural Development along with local residents of the village of Jharbagda in Manbazar-1 block, started planting trees of seventy-two varieties, including fruits, medicinal herbs, timber wood *etc*. (Sing 2020). Under the auspices of the Japanese government, the process continued for three years until 2002. People from neighboring villages' viz. Kumardih, Birsinghdih, Cheliama, Radhamadhobpur also joined in. The total of 326,000 trees planted during this time possibly reversed the climate-change impacts that have occurred over the past two decades. These measures allegedly brought down

the mercury level in these areas, reduce soil erosion, ameliorating the quality of the soil, conserving rain water, and bringing back wildlife.

In order to address the immediate effects of deforestation, the near-extinction of indigenous nomadic tribes like Santhal, Savars, Birhors, the disruption of water management, the shortage of food, migration to cities from the villages and the threat to tribal women by human traffickers and flesh traders, the above success story needs to be replicated all over the region The people in the area of study have an idea about violence against nature and why it should be addressed. The environment and ecology play a big part in keeping the social fabric of a place intact and particularly, women safe.

4. METHODOLOGY: A brief description of the field

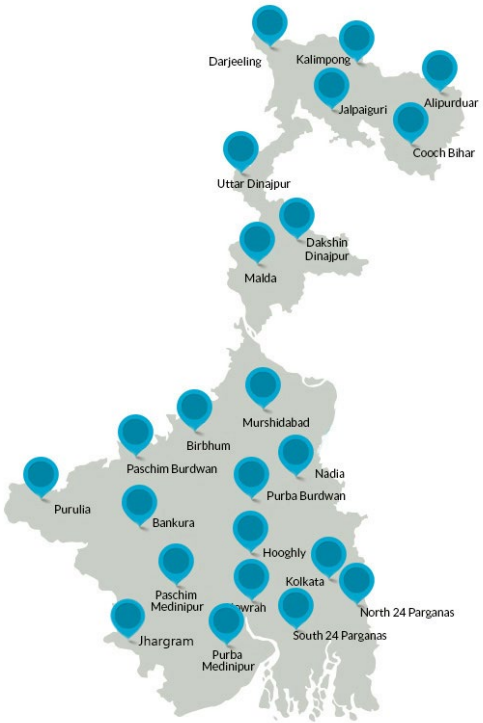

Figure 1. Location of Purulia District in the Map of West Bengal

Sources: https://wb.gov.in/government-district-and-localgovt.aspx

Figure 2. Map of the District of Purulia& its Administrative Blocks

Sources: http://purulia.gov.in

This research is based on Primary Data, *i.e.* data collected by the researcher directly based on field survey. Samples have been collected from a village named Baragora from the Purulia District in the State of West Bengal in India. From this village, only adult tribal people were

surveyed. The sample was drawn using the Convenience Sampling method. In this village, people were not comfortable interacting with an outsider coming from the metropolis of Kolkata. The families showed conservatism when their women were requested to appear to the researcher to answer the survey questions. Therefore, this study adopted convenience sampling rather than other sampling methods.

The village of Baragora is located in the Kashipur Block in Purulia District, near Kalidaha Anchal High School. According to the 2011 Population Census by Govt. of India, its population is 2,327. The nearest Rail Station is Metyal Sahar, 4 km West from Baragora.

From this village, 205 tribal people were surveyed.

The researcher conducted survey work with the help of a Local NGO named "Forum for Local Initiatives." Since 2006, this NGO has been working on several environmental protection projects such as afforestation and rainwater preservation with the help of villagers of Baragora. They have staged street plays as one of the media for creating awareness within the community. In the year 1988-90, the members of the "Forum for Local Initiatives" was associated with an environmental project, known as the "Indrabil Watershed Project" funded by "Counterpart Catholic Charities", an initiative of another NGO, the "Marshal Dahar Gaunta."

Researchers selected 205 respondents from various socio-economic backgrounds. Respondents were interviewed using a semi-structured interview schedule. Details on socio-demographic history were included, including such details as age, caste/tribe status, education, current place of residence, and average monthly family expenditure. These variables are thought to profoundly impact the level of eco-awareness of respondents that eventually affects their commitment to the environment. (Chatterjee 2008). In the course of this research several constraints arose, linguistic and terminological problems being the most important. The semi-structured protocols applied in the vernacular in face-to-face interviews also provided the respondents with the possibility of misunderstanding. Among the villagers, there has been a long standing misconception about the meaning of "environment". Overcoming this communication problem was a major methodological challenge, hence, qualitative interviewing in a face-to-face context was preferable to the questionnaire technique. Such qualitative interviews were frequently lengthy, and the rigor of quantitative research was lacking. Narrative approaches, as well as group discussions, were also sometimes employed.

For questions 1 & 2, the frequency distribution of the answers were investigated using table and diagram. For questions 3, 4, & 5, cross-tabulation of the two attributes were analyzed using tables and diagrams. Researchers also used χ^2-test for independence (see Annexure for a brief introduction to χ^2-test for independence). Lastly, for question 6, researchers investigated frequency distribution from the cross-tabulation of the three attributes using table and diagram.

All the tables and the graphs were prepared using MS Excel. The χ^2-tests were carried out using the Chi-square calculator available online for free at https://www.icalcu.com/stat/chisqtest.html.

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5.Results

5.1 Demographic Profile of the Respondents

Distribution of Respondents according to Gender

Analysis

Table 1above shows gender distribution of the respondents. The total no of participants were 205. There were 84 (41.0%) female and 121 (59.0%) male respondents. In this village, people were not sufficiently free to interact with an outsider from Kolkata. The families showed kind of conservatism when their women were requested to appear to the researcher for answering to the survey question as they were reluctant to permit female members of their household from talking to the researchers That is the reason behind the unequal number of male and female respondents in this study. Nevertheless, a good proportion of women respondents could be interviewed too eventually, as evident from Table 1.

Table 1. Frequency distribution of respondents according to gender

Gender	Frequency	Percent
Female	84	41
Male	121	59
Total	205	100

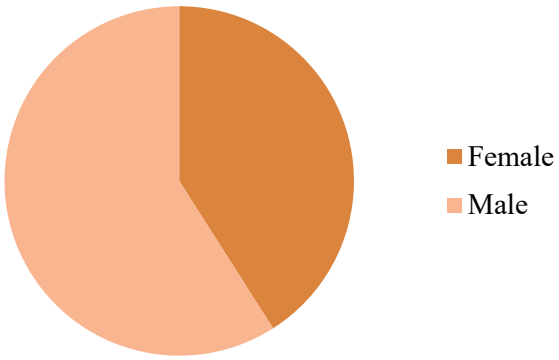

Figure 3. Pie Chart showing the distribution of respondents according to gender

5.2 Analysis of the Research Questions

In this section, the answers to the six key questions were sought one by one based on the methodology described earlier.

Nature of pre-existing awareness about eco-feminism:

Analysis

Table 2 represents the opinion of all respondents about the similarities between Violence against women (VAW) and violence against nature (natural environment) (VAN). Opinions of the respondents are sub-divided into three parts.

37 (18%) respondents out of 205 total respondents of this study show no concern about said topic.

47 (22.9%) respondents think there is some difference between the nature of violence on women and violence against the natural environment.

On the other hand, 121 (59%) respondents believe there is a similarity between the two kinds of violence in society, supporting the eco-feminist views.

It is remarkable that a marginalized rural people living in the lap of nature and sustaining their livelihoods on nature demonstrate such a high awareness of the core idea of eco-feminism. However, considering that 41% of the respondents either contradict the notion of eco-feminism or show no concern for the issue, there is still ample scope of work.

Table 2. Frequency distribution of awareness about VAW & VAN

Answers	Frequency	Percent
Don't know	37	18
Both are different kind of violence	47	22.9
Both are same kind of violence	121	59
Total	205	100

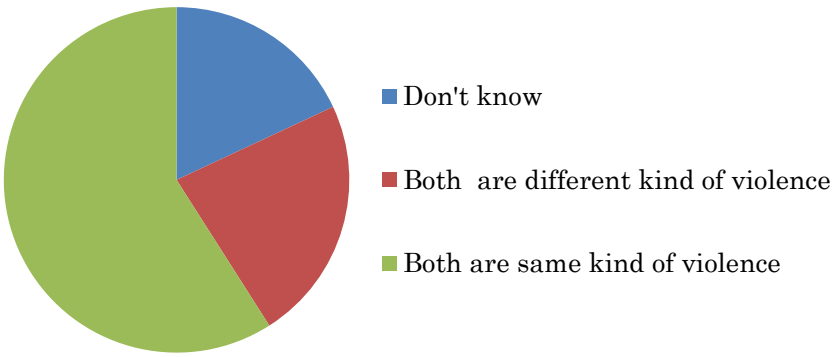

Figure 4. Pie Chart showing distribution of awareness about VAW & VAN

Choices of medium as the most powerful medium for spreading awareness:

Analysis

Table 3 represents the opinion of all respondents about the most powerful medium to resolve the problem of low level of awareness. Here the problem is 'Awareness about Eco-feminism'. The opinion of the respondents is sub-divided into six parts.

153 (74.6%) respondents believed that theatre is the main medium of creating awareness amongst the masses regarding the issue of Eco-feminism. The second-best medium was Dance which scored only 18 (8.8%) responses.

Assuming that the true effectiveness of a medium in creating awareness is accurately reflected in their opinion about the most powerful medium for creating awareness, this table confirms theatre as the best medium for creating awareness.

Table 3. Frequency distribution of opinion on most powerful medium

Medium	Frequency	Percent
Drama	153	74.6
Dance	18	8.8
Song	12	5.9
Cinema	15	7.3
Others	4	2
Mixed	3	1.5
Total	205	100

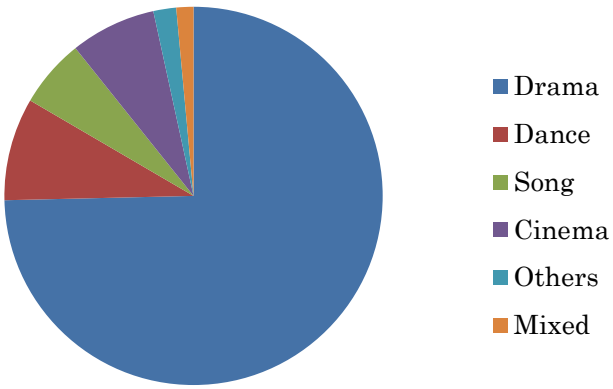

Figure 5. Pie Chart showing distribution of opinions on most powerful medium

The manner of varying awareness about eco-feminism across gender:

Analysis

Table 4 shows that a high number (52 of the 84 female respondents, 61.9% of all females) stated that VAN and VAW are the same kind of violence. This shows a slightly higher level of awareness when compared with the relatively low number (69 male respondents 57.0% of all males) of the 121 who opine that VAN and VAW are the same kind of violence.

The data also shows that 33 of the 121 male respondents (27.3% of all males) stated that VAN and VAW are not the same kinds of violence. This shows a low-level awareness compared with the relatively lower number (14 female respondents 16.7% of all females) of the 84 who opine that VAN And VAW are not the same kinds of violence.

The present study shows that female respondents are somewhat more conscious about the eco-feminism-related issues than their male counterparts. However, whether it is significantly higher or not will be tested later in this study using χ^2-test.

There was no prior study regarding the relationship between gender and awareness about eco-feminism. Some studies, Blocker and Eckberg (1997) have found a significant (albeit weak) correlation between gender and environmental concern,

Assuming that awareness about the environment is a proxy of awareness about eco-feminism, the findings of this study support such studies as Aydin & Cepri (2010), Arcury, Johnson, Milbrata, Mohai (1992), Davidson & Freuderburg (1996), Shahnawaz (1990), and Sundarajan & Rajashekhar (1993), Pradhan & Nagra (2010).

To check whether there is any significant interdependence between Gender and Awareness, a χ^2-test is carried out at 2 degrees of freedom and a 5 percent level of significance.

H_0: Gender & Awareness is independent (*i.e.*, gender does not influence the awareness)

H_1: Gender & Awareness is dependent (*i.e.*, gender influences the awareness)

The observed χ^2 is 3.5334. The result is not significant at a 5% level of significance. The *p*-value is .170899 (approx.), *i.e.*, the result will be significant above 17.0899% level of significance.

So, H_0 cannot be rejected.

It can be concluded that, in the scope of this study, the gender difference is not a significant cause of the difference in awareness about the relation between VAW & VAN. However, in social studies like this, one should not be too skeptical about a little high p-value. The p-value derived in this particular case suggests that there is almost 83 percent chance that H1 is true, i.e., gender influences the awareness about the relation between VAW and VAN. Coupled with the intuitive analysis of table 4, this suggests that women may be slightly more aware of the relation between VAW and VAN than men.

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Table 4. Frequency distribution of responses against gender

Gender (X)		Opinions on Similarities between VAN and VAW (Y)			Total
		Don't know	Both are different kind of violence	Both are same kind of violence	
Female	Frequency	18	14	52	84
	% within X	21.40	16.70	61.90	100.00
Male	Frequency	19	33	69	121
	% within X	15.70	27.30	57.00	100.00
Total	Frequency	37	47	121	205
	% within X	18.00	22.90	59.00	100.00

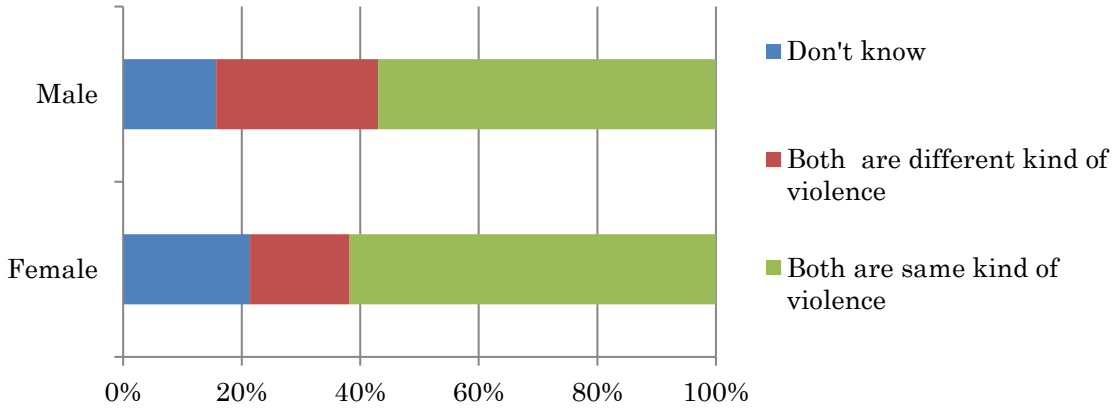

Figure 6. Bar Diagram showing the distribution of respondents according to responses against gender

The manner of varying opinions about the most powerful medium for spreading awareness over gender:

Analysis

Table 5 above shows that the maximum number of female respondents, *i.e.*, 68 (81%) out of 84 respondents, believe that theatre is the most popular medium for creating awareness. On the other hand 85 (70.2%) male respondents out of 121 believe that theatre is the best medium for creating awareness. Thus, although both male and female respondents favor theatre the most above all other media for creating awareness, female respondents appear to have a heavier bias towards theatre than their male counterparts.

Table 5. Frequency distribution of opinion on most powerful medium against gender

Gender (X)		Most powerful medium (Y)						Total
		Drama	Dance	Song	Cinema	Others	Mixed	
Female	Frequency	68	6	4	3	1	2	84
	% within X	81.00	7.10	4.80	3.60	1.20	2.40	100.00
Male	Frequency	85	12	8	12	3	1	121
	% within X	70.20	9.90	6.60	9.90	2.50	0.80	100.00
Total	Frequency	153	18	12	15	4	3	205
	% within X	74.60	8.80	5.90	7.30	2.00	1.50	100.00

To check whether there is any significant interdependence between Gender and the Choice of Medium, a χ^2-test is carried out at 5 degrees of freedom and 5 percent level of significance.

H_0: Gender & Opinions are independent (*i.e.*, gender does not influence the opinion)

H_1: Gender & Opinions are dependent (*i.e.,* gender influences the opinion)

The observed χ^2 is 5.4552. The result is not significant at a 5% level of significance. The *p*-value is .362804 (approx.), *i.e.,* the result will be significant above 36.2804% level of significance.

So, H_0 cannot be rejected.

It can be concluded that, in the scope of this study, the difference in gender is not a cause of the difference in opinion about which one is the most powerful medium for spreading awareness. As the p-value is too high, there rests no doubt about this conclusion.

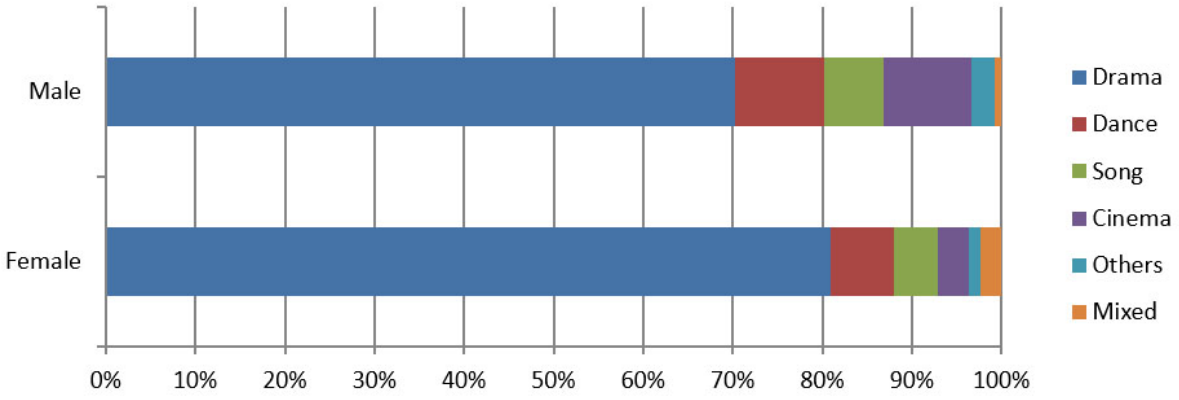

Figure 7. Bar Diagram showing distribution of respondents according to responses against gender

The nature of varying opinions about the most powerful medium for spreading awareness over different types of pre-existing awareness about eco-feminism:

Analysis

Table 6 below shows that out of the 121 respondents, who believe in the core idea of eco-feminism (by supporting that VAW & VAN are similar kinds of violence), 101 (83.5%) respondents believe that theatre is the most powerful medium for creating awareness. On the other hand, 51.1% of those respondents who do not believe in the core idea of eco-feminism (by saying that VAW & VAN are different kinds of violence) think that theatre is the best medium for creating awareness. 75.5% of the respondents who show confusion or declare their ignorance about eco-feminism's core idea supports that theatre is the most powerful medium for creating awareness. Another important thing to note from this table is that those who, without confusion, expressed their idea in contradiction to eco-feminism have significantly high support for Dance & Cinema as the most powerful medium.

Thus, it can be concluded that theatre is considered the most powerful medium for creating awareness by all people irrespective of their pre-existing awareness of eco-feminism's core idea.

To check whether there is any significant interdependence between Gender and the Choice of Medium, a χ^2-test is carried out at 10 degrees of freedom and 5 percent level of significance.

H_0: Awareness & Opinions are independent (*i.e.,* pre-existing awareness about eco-feminism does not influence the opinion about the most powerful medium or vice-versa)

H_1: Gender & Opinions are dependent (*i.e.,* pre-existing awareness about eco-feminism influences the opinion about the most powerful medium or vice-versa)

The observed χ^2 is 40.3151 (approx.). The result is highly significant at 5% level of significance. The p-value is 0.000015(approx.), *i.e.* the result is significant above 0.0015% level of significance.

So, H_0 cannot be accepted.

We can draw a conclusion that respondents having pre-existing awareness about eco-feminism prefer theatre as the most powerful medium for spreading awareness about eco-feminism over those who are confused and ignorant about the core ideas of eco-feminism. The confused/less-informed respondents also prefer theatre over other mediums but not as strong as the enlightened ones.

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Table 6. Frequency distribution of respondents according to their opinion on Similarity between VAN & VAW and most powerful medium for creating awareness

Similarity between VAN & VAW (X)		Medium (Y)						Total
		Drama	Dance	Song	Cinema	Others	Mixed	
Don't know	Frequency	28	4	3	2	0	0	37
	% within X	75.70	10.80	8.10	5.40	0.00	0.00	100.00
	% within Y	18.30	22.20	25.00	13.30	0.00	0.00	18.00
Both are different kind of violence	Frequency	24	11	0	8	3	1	47
	% within X	51.10	23.40	0.00	17.00	6.40	2.10	100.00
	% within Y	15.70	61.10	0.00	53.30	75.00	33.30	22.90
Both are same kind of violence	Frequency	101	3	9	5	1	2	121
	% within X	83.50	2.50	7.40	4.10	0.80	1.70	100.00
	% within Y	66.00	16.70	75.00	33.30	25.00	66.70	59.00
Total	Frequency	153	18	12	15	4	3	205
	% within X	74.60	8.80	5.90	7.30	2.00	1.50	100.00
	% within Y	100.00	100.00	100.00	100.00	100.00	100.00	100.00

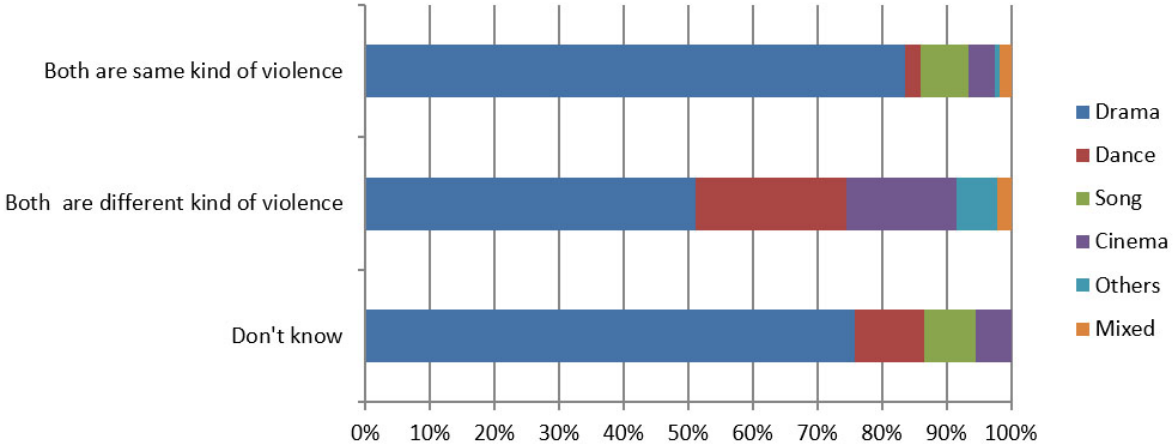

Figure 8. Stack Diagram showing distribution of respondents according to opinion on Similarity between VAN & VAW and most powerful medium for creating awareness

The manner of varying the opinions about the most powerful medium for spreading awareness over different types of pre-existing awareness about eco-feminism and gender:

Analysis

Table 7 shows that of all the females who show awareness about the core idea of eco-feminism, 86.5% consider theatre as the most powerful medium for creating awareness. On the contrary, 81.2% of all the males aware of the core idea of eco-feminism consider theatre as the most powerful medium for creating awareness. The gender difference among the respondents supporting the eco-feminist notion is not too prominent in selecting theatre as the most powerful medium for creating awareness.

Table 7. Distribution of respondents according to Gender, Opinion on Similarity between VAN & VAW and Opinion about the Most Powerful medium

Gender (X)	Similarity between VAN & VAW (Y)		Most Powerful Medium (Z)						Total
			Drama	Dance	Song	Cinema	Others	Mixed	
Female	Don't know	Frequency	14	2	1	1	0	0	18
		% within Y	77.80	11.10	5.60	5.60	0.00	0.00	100.00
		% within Z	20.60	33.30	25.00	33.30	0.00	0.00	21.40
	Both are different kind of violence	Frequency	9	3	0	1	1	0	14
		% within Y	64.30	21.40	0.00	7.10	7.10	0.00	100.00
		% within Z	13.20	50.00	0.00	33.30	100.00	0.00	16.70
	Both are same kind of violence	Frequency	45	1	3	1	0	2	52
		% within Y	86.50	1.90	5.80	1.90	0.00	3.80	100.00
		% within Z	66.20	16.70	75.00	33.30	0.00	100.00	61.90
	Total	Frequency	68	6	4	3	1	2	84
		% within Y	81.00	7.10	4.80	3.60	1.20	2.40	100.00
		% within Z	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Male	Don't know	Frequency	14	2	2	1	0	0	19
		% within Y	73.70	10.50	10.50	5.30	0.00	0.00	100.00
		% within Z	16.50	16.70	25.00	8.30	0.00	0.00	15.70
	Both are different kind of violence	Frequency	15	8	0	7	2	1	33
		% within Y	45.50	24.20	0.00	21.20	6.10	3.00	100.00
		% within Z	17.60	66.70	0.00	58.30	66.70	100.00	27.30
	Both are same kind of violence	Frequency	56	2	6	4	1	0	69
		% within Y	81.20	2.90	8.70	5.80	1.40	0.00	100.00
		% within Z	65.90	16.70	75.00	33.30	33.30	0.00	57.00
	Total	Frequency	85	12	8	12	3	1	121
		% within Y	70.20	9.90	6.60	9.90	2.50	0.80	100.00
		% within Z	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Total	Don't know	Frequency	28	4	3	2	0	0	37
		% within Y	75.70	10.80	8.10	5.40	0.00	0.00	100.00
		% within Z	18.30	22.20	25.00	13.30	0.00	0.00	18.00
	Both are different kind of violence	Frequency	24	11	0	8	3	1	47
		% within Y	51.10	23.40	0.00	17.00	6.40	2.10	100.00
		% within Z	15.70	61.10	0.00	53.30	75.00	33.30	22.90
	Both are same kind of violence	Frequency	101	3	9	5	1	2	121
		% within Y	83.50	2.50	7.40	4.10	0.80	1.70	100.00
		% within Z	66.00	16.70	75.00	33.30	25.00	66.70	59.00
	Total	Frequency	153	18	12	15	4	3	205
		% within Y	74.60	8.80	5.90	7.30	2.00	1.50	100.00
		% within Z	100.00	100.00	100.00	100.00	100.00	100.00	100.00

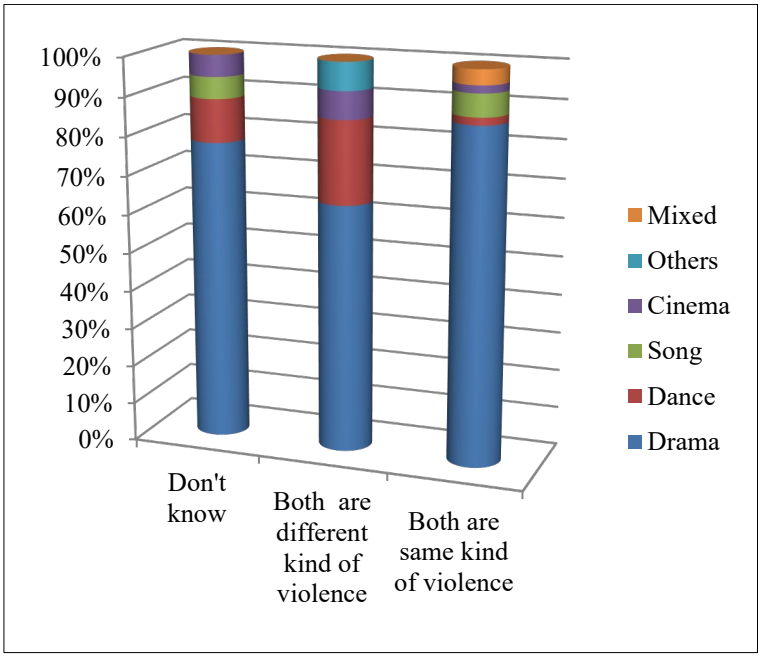

Figure 9. (A): 100% Stacked Cylinder Diagram showing the percentage distribution of female respondents according to Opinion on Similarity between VAN & VAW and Opinion about Most Powerful Medium

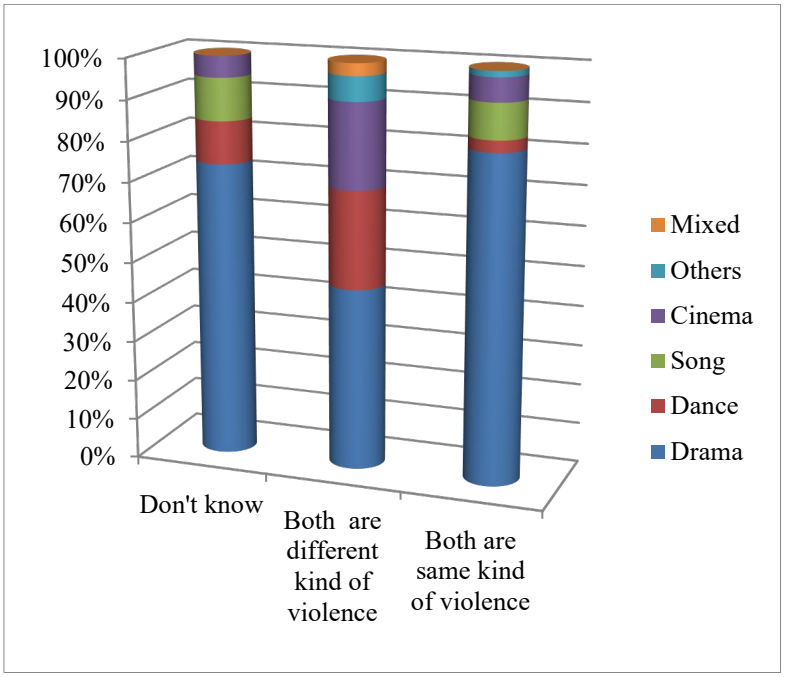

Figure 9. (B): Stacked Cylinder Diagram showing the percentage distribution of male respondents according to Opinion on Similarity between VAN & VAW and Opinion about Most Powerful Medium

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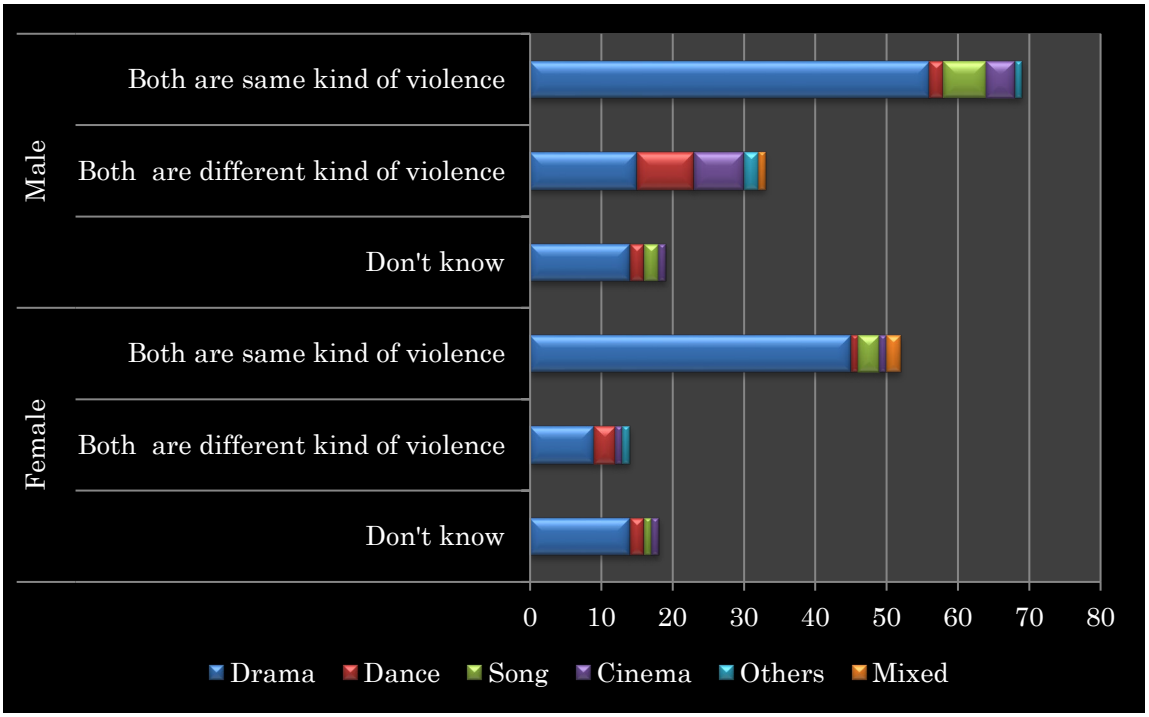

Figure 9. (C): Stacked Column Diagram showing the distribution of respondents according to gender, Opinion about the most powerful medium for creating awareness and Opinion about similarities between VAW & VAN

Among female respondents who showed confusion about the core idea of eco-feminism, 77.8% preferred theatre over other mediums for creating awareness. But, 73.3% of the male respondents having the same confusion preferred theatre over other mediums for creating awareness. Here again, the gender difference is not prominent in choosing theatre.

The idea of eco-feminism is contradicted by favoring the statement that VAW & VAN are different kinds of violence. The supporters of this contradictory statement should be the prime target (followed by the people who are confused) for spreading awareness about the core idea of eco-feminism. It is found from the table 7 above that 64.3% of all the female respondents contradicting eco-feminism prefer theatre as the most powerful medium for creating awareness, while 45.5% of their male counterpart shows preference towards theatre for the same purpose. While 21.4% of the females contradicting eco-feminism shows preference towards Dance as the most powerful medium for creating awareness and 7.1% favor Cinema, 24.2% of their male counterparts favored Dance and 21.2% favored Cinema. So, it can be concluded that although the respondents who contradict eco-feminism show clear favor for theatre over other mediums for creating awareness, Dance as a medium for the same purpose has somewhat significant preference for both the genders in this group and Cinema has significantly higher preference among the males than the females in the same group.

6. CONCLUSIONS

To address the threats to women arising from the present COVID-19 situation and threats to the environment that has emerged during 'unlock', this study investigated the use ofan eco-feminist approach through theatre.

Analyzing the impact of the COVID-19 pandemic on women and the environment, this study concludes that an eco-feminist approach is useful to combat the harmful consequences of the COVID-19 pandemic on woman. This has been a theoretical exercise.

Adoption of an eco-feminist approach means creation of awareness among masses about the core ideas of eco-feminism. To assess the scope of theatre to create awareness about eco-feminism's core ideas, we took a sample of tribal (Santhal) people from the village Baragora situated in the Purulia District in West Bengal, India. The Santhal people are historically marginalized, but they have a strong cultural heritage. Although these people have employed traditional theater culture, various organizations have used modern forms of theater to enhance reciprocal communication with them. Therefore, when they opine about the effectiveness of theatre in promoting awareness, it is not shaped by their traditional beliefs or notions.

The result suggests that awareness about eco-feminism is a slightly higher amongst females. Female respondents also favored theatre to create awareness more than their male counterparts. Still, in this case, gender is not a significant factor in preferring the best medium for the purpose. The study found that respondents having high eco-feminist awareness prefer theatre, compared to those who are either confused or ignorant about eco-feminism. In fact, the confused/less-informed respondents also favored theatre as the most powerful medium for spreading awareness but not as strong as those aware of eco-feminism's core idea. However, the relationship between the choice of medium and the pre-existing level of awareness is significant.

In this study, it has further been observed that in choosing the most powerful medium for creating awareness, females prefer theatre more than their male counterparts irrespective of their pre-existing conception about the core idea of eco-feminism. It has also been found that some respondents who contradict eco-feminist ideas show preference for Dance and Cinema as the most powerful medium for creating awareness whether they are male or female. Preference towards theatre is least among those males who contradict the core idea of eco-feminism.

Despite differences in choices as the most powerful medium for creating awareness, people in both gender and having whatever pre-existing perception about the core idea of eco-feminism prefer theatre clearly over other media for creating awareness. This implies that when theatre is used to create awareness on the core ideas of eco-feminism, the producing team will not need to consider whether the audience is male or female and whether they have any pre-existing conception about the core ideas of eco-feminism.

Therefore, this study prescribes that theatre should be taken as the medium for creating awareness about the core idea of eco-feminism, whatever be the gender of the target people

and whatever be their pre-conceived notion about the core idea of eco-feminism. So, the present disastrous situation arising out of the COVID-19 pandemic can be tackled by spreading awareness about eco-feminism by means of theatre.

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Original paper

Cultural Systems in Water Management for Disaster Risk Reduction: The Case of the Ladakh Region

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Abstract There has been an increase in hydrological disasters over the past few decades as a result of climate change. Also, there is a growing recognition of the need to integrate traditional knowledge into Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) policies and practices on a global scale. Traditionally, village folk have used observation-based, traditional methods to avoid high economic costs associated with sustainable management of their resources and livelihood. Due to ongoing climate change impacts and migrations, indigenous knowledge is gradually disappearing, and other modern systems have been unable to effectively replace it to the desirable extent. This paper investigates how the traditional knowledge and cultural systems of local communities living in the high-altitude cold desert region of the Ladakh region in India have contributed to their water management systems. In addition, the article discusses how haphazard changes in the contemporary environment are causing issues related to water scarcity and livelihood leading to the slow onset of disasters. Through non-participant observations during a two-month volunteering engagement and literature review, the present study attempts to track the changing realm and attitude of the Ladakhi community towards water conservation in light of climate change and depleting resources. A comparison was made between the government and non-government initiatives for the conservation and management of water resources. The results of this study suggest that traditional knowledge and cultural systems have a significant role in increasing community participation and awareness of climate change and disaster risk.

Keywords: Cultural System, Disaster Risk Reduction, Climate Change, Ladakh

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1. INTRODUCTION

The Hindukush Himalayas, popularly known as the 'third pole' because of their vast freshwater ice field, are experiencing increasing disasters, including flash flood, landslides, extreme water scarcity, wildfires, glacial lake outburst flow, and so on in recent decades (EM-DAT, 2014) (Sharma E., 2019). Studies have pointed out that natural calamities, including glacial retreat, melting of the ice, extreme rainfall, will aggravate with time due to climate change impacts and anthropogenic reasons (IPCC, 2012) (CRED, 2020). Previous studies warn that the growing number of natural disasters in the region will affect the lives and livelihood of the local communities, such as the risk of human loss, property damage, ecosystem disruption, and interruption of development projects in the coming days. The indirect consequences of these events will be observed as decreasing local resources and self-reliance with increasing external dependency during disasters (Dilshad, *et al*., 2019) (Ives, 1991) (Mishra, 2003). Extreme water scarcity is common in the region today, which is a sign of growing natural disasters in the area. In Ladakh, a part of the Hindukush Himalaya, existing limited water resources are depleting due to climate change, environmental degradation, and rapid socioeconomic changes (Mueller, 2020) (Nüsser, 2019). The conventional technology-driven, engineering-based solutions are found inadequate and ineffective for disaster risk reduction in the region. The Government and non-governmental organizations have introduced innovative disaster mitigation initiatives, yet only a few have meaningful impacts to tackle the increasing disaster risk (Mishra, 2003).

Arguably, these innovative, technology-driven projects failed because they overlooked the cultural aspects and undermined the indigenous knowledge and resources of the region (Dame, 2019). Because for many centuries, the indigenous people of this region have been living a safe and sustainable life by adapting to the extreme environmental and ecological conditions (Hodge, 1991). With experience and understanding of water as a resource, several indigenous mountain communities developed techniques to ensure its conservation and equitable distribution for agricultural consumption and daily activities (Kreutzmann, 2000) (Chettri, 2015). They co-operated among themselves and used indigenous knowledge and local resources to tackle the challenging climate conditions and water constraints (Srichandan, 2021). In different parts of India, we have seen earlier that the indigenous peoples, through their limited natural resources, effectively managed their disaster risks (Pasupuleti, 2013). In India, a few examples of traditional water harvesting in hill regions are the bamboo drip irrigation system of Meghalaya (Ryngnga, 2018), the Zabo system in Nagaland (Singh, 2012), and the Apatani in Arunachal Pradesh. The various water harvesting and distribution systems found in the mountainous region are specific to their regional conditions like climate, topography, and vegetation. However, all follow similar principles to direct, collect, store and conserve the surface run-off water using simple methods, materials, and social cooperation. This effective, sustainable water resource management has become viable because the local people integrated the disaster risk reduction initiatives with the culture (Pasupuleti, 2013) (Samaddar, 2014).

However, there has been limited understanding of how and to what extent the culture has empowered and enabled these local communities to manage and reduce water-related risks in the region effectively. There is also limited understanding of the form and nature of culture effective for disaster risk reduction, including water resource management (Srichandan, 2021) (Pasupuleti, 2013).

This paper focuses on the traditional water management systems of Ladakh that protected the ecological environment and the people from natural hazards and water scarcity despite the harsh geographic conditions. This study investigates how cultural systems and practices have enabled local communities to maintain water conservation systems effectively in Ladakh. For this, the authors have adopted mainly the secondary data collection methods, and the experiences and observations made by one of the authors in 2018 during her two-month internship with an NGO called Ladakh Ecological Development and Environmental Group (LEDeG) in Ladakh.

2. TRADITIONAL WATER MANAGEMENT SYSTEMS IN THE COLD DESERT REGION

2.1 The Humanised landscape of Ladakh and its water traditions

According to the Köppen climate classification, the Indian Mountain ranges fall within the humid subtropical climatic zone. Nevertheless, the region of Ladakh is an exception, geographically classified as the High-Altitude Cold Desert Region. Due to its unique location between the Greater Himalayas and Karakoram range (above 3000 meters), it receives low precipitation between 100 and 250 millimeters and has underdeveloped soil (Crook, 2001). Percolation of water is difficult due to the soil condition. As a result, groundwater in the region is scarce and limited (Labbal, 2000). Additionally, Ladakh experiences huge seasonal variations characterised by short dry summers and extremely cold and windy winters. The region becomes inaccessible during winters (Dame, 2019). The geographic location and climate challenges make this region susceptible to water scarcity and drought.

Humans establish settlements on a site that provides resources (like wood, water, soil, stone) for survival, settlement, and livelihood. In the past, indigenous communities followed several tangible and intangible systems that ensured resource sharing and utilisation without exploitation. Historically, Ladakhis treated water as a precious resource due to its limited availability. The availability and accessibility of water determined the location of settlement, density, building typologies, and building techniques (Labbal, 2000) (Ferrari, 2018) (Nüsser, 2019) (Hodge, 1991). It influenced many aspects of Ladakhi livelihood, lifestyle, and built environment. Water was utilised and managed through various systems and methods. The community's collective effort ensured its equitable distribution and usage. The religious beliefs and norms directed people's attitude to respect and maintain the sanctity of water sources.

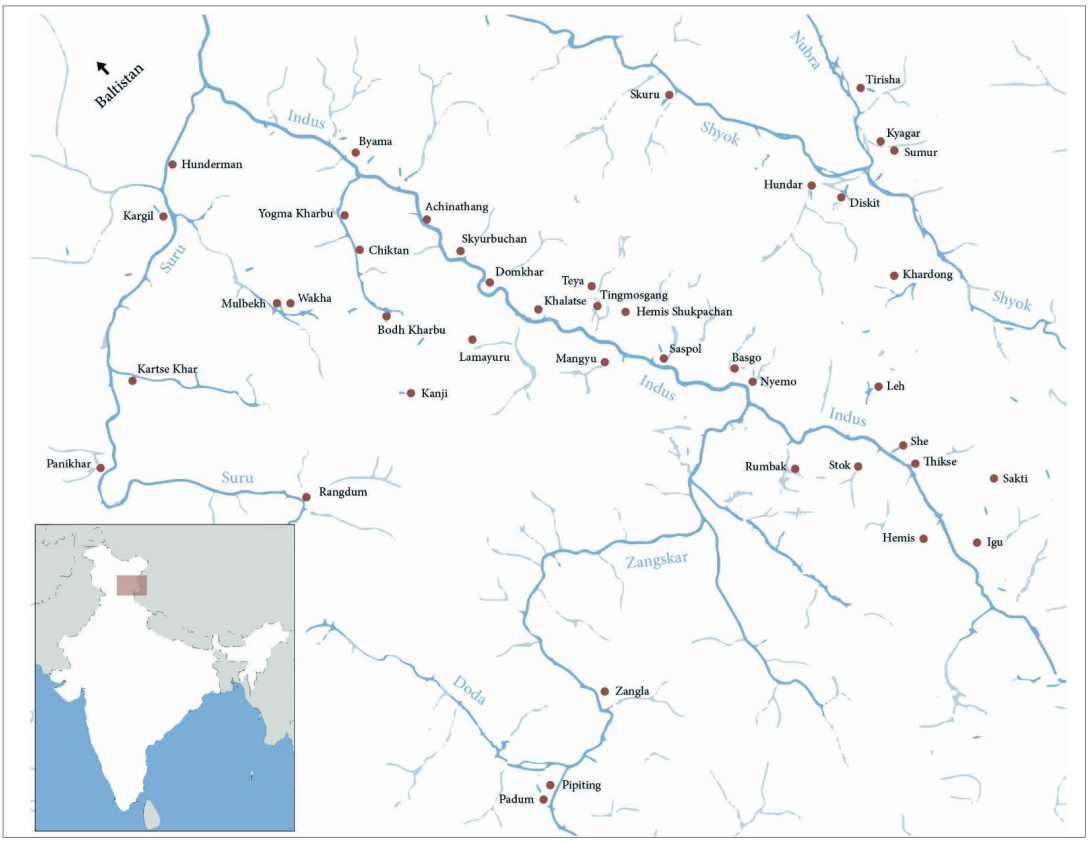

Figure 1. Settlements in Ladakh along the banks of the Indus River and tributaries. Source: (Ferrari, 2018)

Ladakh relies primarily on water from the Indus River and other glaciers that flow through its landscape. Rivers and their tributaries played a crucial role in site selection for settlement and agriculture Fig 1. The village and town settlements, agricultural fields, and willow-poplar trees create an oasis effect in the cold-desert region Fig 2. To sustain and survive within the harsh climate and limited recourses, the locals developed mutual trust and cooperation for water management required for agriculture, animal husbandry, and other purposes. In addition to the settlement location and livelihood, the choice of building materials, building form, and construction techniques helped them for sustainable water conservation and management.

In order to understand the influence and impact of the cultural system for effective water resource management in Ladakh, we developed a conceptual schema as depicted in Fig 3. Based on the framework, it shows that the traditional settlements and their built environments are a result of trial and error processes, based on locally available natural resources. The natural resources available in a region depend on the topography, climate, and vegetation, collectively called natural systems.

People engage with the natural resources through the cultural system (tangible and intangible systems) that comprises traditional technology, social systems, religious beliefs, and economy; as a whole, interconnected to the other. However, with the rapid changes in the environment, declining available natural resources, and socioeconomic factors, man-made systems no longer rely solely on natural systems. Increasing external assistance has reduced the community's self-reliant capacity. The cultural system that ensured resource management has suffered (Hodge, 1991) (Nüsser, 2016). In recent times, the increasing tourism and outmigration from villages to big cities have negatively impacted traditional water management and availability.

Figure 2. Ladakh as an Oasis.
(Photograph by Sweta Kandari, 2018)

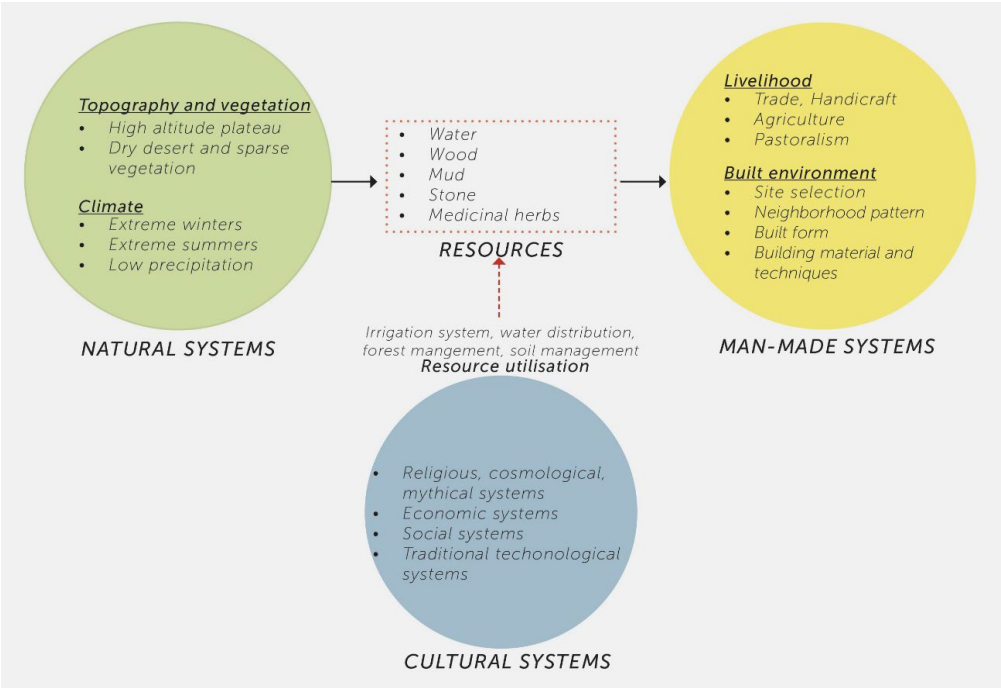

Figure 3. A prototype schema describing the natural, cultural and man-made system of Ladakh.

2.2 Transformation and risks

The region has witnessed tremendous changes rapidly in the past decade that has adversely impacted the water availability and environmental conditions of the region (Bhasin, 1999). This section briefly explains the increasing risks due to regional and global changes.

In the 9th century, the Ladakh dynasty was initially inhabited by nomads. They resided along the banks of the Indus River. Until the 1500s, the region witnessed magnificent construction of palaces and monasteries that were built by a series of kings. At the beginning of the 19th century, Ladakh came under the Dogra rule. In 1846, the region was integrated with the Indian state of Jammu and Kashmir. Finally, in 2019, Ladakh was given the status of Union territory.

The construction of the Leh road in 1966 and the construction of an airport in 1985 marked a turning point in Ladakh's transformation. This accessibility resulted in an increase of tourists from 500 in the 1990s to 205 thousand in 2017 (Kumar, 2019) . There were only 24 hotels in entire Ladakh in the 1980s. In the last four decades, the number of hotels increased to 670, with 60% located in Leh city (Khandekar, 2017) . Along with increasing tourist influx, the introduction of military forces contributed to new construction and expansion of built form in the region. The external influences and increase in the consumption of natural resources have resulted in rapid environmental, cultural, social, and economic changes and depleting natural resources (Bhasin, 1999) (Geneletti, 2009) .

Regional changes combined with the global climate and environmental changes have resulted in the retreat of the glacial belt. Cloud bursts have become frequent in the last decade, resulting in increasing flash floods and untimely rainfall (Ziegler, 2016) . Several studies claim that regional and global climate change may hit the region more frequently, creating more disaster risks in addition to the already existing ones (Nüsser, 2016). Melting of glaciers, increasing frequency of flash floods since 2005 (Masson, 2015), unusual spells of rain (Thayyen, 2013) led to water shortage in Ladakh. Severe water scarcity issues posed problems to the locals impacting their livelihood, lifestyle, and settlement (Keilmann-Gondhalekar, 2015).

Throughout history, the people of Ladakh had a complex relationship with water due to its scarcity. Local communities of Ladakh developed several social, technological, and religious systems for their management and conservation (Hodge, 1991). The next section describes how Ladakhis traditionally managed and conserved water through a network of tangible and intangible systems (Cultural Systems) (Fig 3) that helped them maintain a sustainable livelihood.

2.3 Traditional Technology and Methods

The traditional technological systems in this paper refer to the tangible aspects that the people of Ladakh incorporated for livelihood and settlement purposes. Agriculture was one of

the major occupations of Ladakh in 1971. To manage water for irrigation and agricultural purpose, the community channeled the water from the mainstream to the fields or settlement through canals made from boulders, branches, shrubs, stones, gravel, and naturally grown weeds. This traditional system of water distribution and irrigation is called Chorus or Churres. In this system, as shown in Fig 4, the first step is to divert the water from the mainstream by building a rough dam called Tokpo. The Mayur or the main channel (usually the first channel) from the Tokpo is directed towards the first water reservoir or pond called Zing. The water is further channeled to different fields through intermediate channels called the Yura and Nangyu or Nangyura and then into side channels and contour band channels called Yihu and Yang.

To implement the Churres system, water availability and its management played a significant role in the siting of settlements and agricultural fields (Clouse, 2017). The site chosen for settlement and agriculture was such that water could be diverted and directed from the stream through gravity without any complex mechanical equipment. Hence, the villages in Ladakh were always situated in the river valleys, as shown in (Fig 1). Houses were arranged in close clusters to provide more land for cultivation and easy water distribution (Ferrari, 2018). The buildings were positioned and oriented according to the natural slope that facilitated water drainage (Borah, 2015). Houses were built on a slightly higher ground than the agricultural fields for easy irrigation and to monitor the farms.

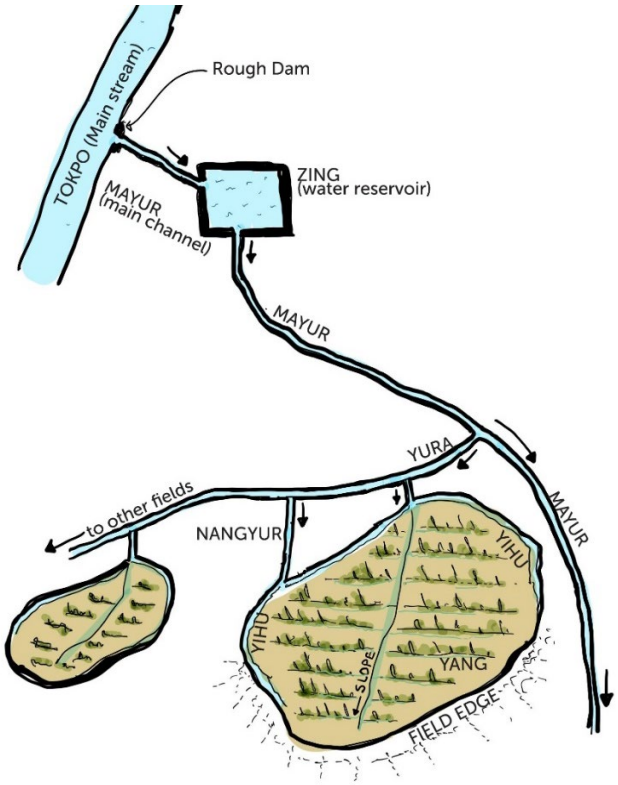

Figure 4. Chorus or Churres – Traditional water distribution and irrigation system in Ladakh. Adapted and modified from (Ives & Messerli, 1991)

From site selection for settlement to irrigation techniques, the people of Ladakh took extreme care to conserve water using simple methods and materials. In the built form, to conserve water, people in the region used dry toilets or composting latrines, locally called Dechot or Sanghot, as shown in Fig 5. Traditional houses had a composting toilet typically built inside the house. The dry toilet was typically built on the first floor with a hole in the slab. After using the toilet, a mixture of ash and mud was shoveled into the hole. The room below acted as a collection or decomposition room. It did not have any openings, and access to this room was from the exterior of the house. The absence of ventilation aided the decomposition of human excreta. The collection room was cleaned once or twice a year with the help of the community, and the human manure thus obtained was used as compost in agriculture fields (Mishra, 2018) (Hodge, 1991).

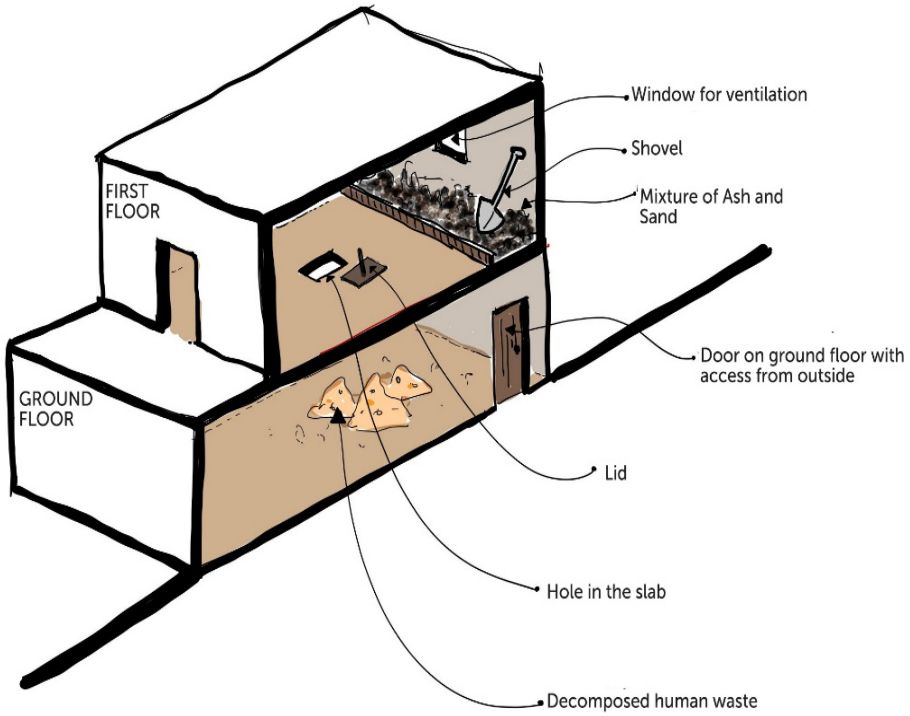

Figure 5. Dechot or Sanghot - Typical Section of Dry toilet.

Tourism has quickly replaced farming to provide sustenance, impacting the agricultural practices, traditional water management system, and water availability. There is a drastic shift in the occupation after the arrival of non-natives (the tourists and military personnel) in the region (Geneletti, 2009) (LAHDC, 2012). Also, the traditional house form is transforming in terms of built spaces and building materials.

Farmers have adopted modern crop production techniques like chemical fertilizers to meet the growing needs and changes while abandoning their traditional organic farming system. Water distribution and conservation methods have been altered to address the changes in the farming system. The Government constructed canals and reservoirs to address the water

shortage using non-local materials (like concrete) and techniques. Due to unfamiliarity with the construction material and technique of the new canals, the locals have started to depend on external help for repair and maintenance. Outsourcing the masons and materials has made the community dependent on external resources (Mankelow, 2003).

As agricultural activities have reduced due to increasing tourism-related activities, the need for a traditional water management system declined from 2005 onwards (Spindle, 2019) (Mishra, 2003). Water is no longer treated as a shared commodity. Today, water is extracted from the groundwater sources through borewells or mechanical pumps to meet the growing requirement of the locals and tourists. Water is also drawn from the Indus River using pumps and supplied through private water tankers (Mueller, 2020). Combined with climate change, this will only aggravate the existing pressure on the limited water availability. It will further impact the ecosystem of the mountain region and its community, making them vulnerable.

Table 1. Changes in the social systems and their impact on the livelihood and built environment.

	Traditional Methods since 16th century		Changes since 1966	
	Livelihood	Built environment	Livelihood	Built environment
Traditional Technological Systems	Organic agricultural practice through equitable water distribution system called *Churres* or *Chorus*	The site selection; building orientation, typology; construction material, techniques; construction of dry toilets responded to the water scarcity of the region	Introduction of alternative farming technique; abandonment of *Churres* in some towns; use of private borewell and mechanical pumping from Indus River	Introduction of flush toilets instead of dry toilets, bathroom; non-local materials used for construction; Change in building form and typology

Due to outward migration and the introduction of new construction technology, the local communities have refrained from adhering to the traditional knowledge and customs for site selection and building construction. Existing traditional residences are modified or rebuilt as homestays to keep up with the changing livelihood and economic opportunities. The building form and space allocation are modified to accommodate tourist demands and growing aspirations (Fig 6 and 7). Newly constructed residences have flush toilets instead of traditional dry toilets. In some cases, dry toilets are built as independent structures (Mueller, 2020). As per a Ladakh Ecological Development and Environmental Group (LEDeG) survey in 2019, an

average tourist consumes 75 liters of water a day compared to 21 liters of water used by locals. This change in traditional dry toilet systems adds water requirement pressure on the cold-desert region with scarce water. The lack of proper sewage has degraded the environment and water quality (Keilmann-Gondhalekar, 2015). In addition to this, the extremely low winter temperature freezes the water in pipes making the conventional toilets non-operational in winters.

The traditional technological water management system influenced the livelihood pattern and built environment (Table 1). As a part of the larger network of the cultural system, the traditional technological systems addressed the region's water scarcity and its extreme climatic condition. Abandonment of traditional technological systems and rapid transformations has led to an alarming water shortage in Ladakh.

2.4 Social systems

The functioning of the traditional irrigation system called Chorus or Churres depended heavily on the social system within the community and vice-versa. The objective of this system was to ensure the equitable distribution of water. The farms in the village were divided into groups or clusters, depending on the topography, area of land, soil type, and plantation. Each group was known as Bandabas or Bandobasti. The group or clusters of the villages came under one revenue officer jurisdiction, called Patwari. The revenue officer was in charge of resolving intra-group water conflicts and ensuring equal and fair water distribution across the village. However, before taking any water issue to the Patwari, the matter was resolved within the community (Angchok, 2006).

The responsibility of water distribution within the village was on the Chhurpon, derived from local words Chhu meaning water and Pon meaning Lord - translated as the 'Lord of Water'. The Chhurpon was elected annually by the community in every village. He was an experienced man with knowledge and expertise in the construction and functioning of the Chhures. On his selection, the Chhurpon and the community members signed a document called Kamgya. This agreement stated the obligations and duties of the Lord of the water. He was responsible for water management and its equitable distribution. He estimated the water requirements of the field by knowing the farm area and the type of crop cultivated. However, he did not do all of this alone. The community members assisted in the entire process of diverting, preserving water, and maintaining the system. The water channels and water tanks leading to the fields were built using natural materials with the help of villagers. After seasonal rains or winters, the community worked together to clear the debris and repair the canals. While supplying water to the fields, the collective system of Bandabas would enable the community members (along with the Chhurpon) to keep an eye on others and their water consumption to get a fair quantity of water for their fields. As a token of gratitude and in return for his services to the village, the villagers gave the Chhurpon a one-person load of the crop (ration required by one person). The

system of Chorus was successful only due to the community's collective efforts. They helped the Churrpon with the operation, maintenance, and monitoring of the entire system.

Some social systems also helped with the water distribution beyond the village boundaries. A mutual agreement was made between two villages for water storage and distribution if they were located along the same stream (upstream and downstream). The agreement helped maintain unity within the community and with the neighboring villages. The objective is to ensure equitable water distribution to both villages relying on the same water source. The neighbouring villages of Phey and Phyang are one such example. Another document made in the early 20th century called Riwaz-i-Abpasha, meaning 'the custom of irrigation,' outlined the water distribution rules between villages and the customs for sharing water(Dollfus, 2008).

Traditionally, due to the social nature of the Chhures system, any built form expansion or agricultural expansion required consent from the entire community. But, due to tourism-driven outward migration, the villages are becoming less occupied. As per the locals, the abandonment of consent from the community members for expansion or new construction and newly constructed canals under the government schemes has resulted in unregulated expansion. Tourism has led to the economic up-gradation of the people, enabling them to hire non-native (Bihari or Nepali) for agriculture and construction of new structures. The migrant workers are employed for comparatively cheaper rates and faster construction techniques as compared to the traditional masons (Schreiber, 2016) (Mishra, 2018). The hired laborers are unaware of the local customs, knowledge, and traditional techniques. The shift in the construction preferences has led the local masons and artisans to adapt to other livelihood opportunities causing a decline in traditional construction and material knowledge. People now depend on external assistance to repair or maintain the buildings, with a high risk of losing their identity.

Ever since the tourism and other service sectors became the main livelihood of the people instead of agriculture, the practice of Chhurpon and Chhures system began to disappear from Ladakh gradually. Today, the management and distribution of water are more private than communal Spindle (2019) points out from the notions of the community that the traditional systems such as Chhurpon have gradually begun to disappear in the region, indicating directly or indirectly the loss of mutual trust between the individuals and communities. When trust no longer sustains, traditions tend to dissapear. This then results in the beginning of institutionalization. Communities became dependent on the bore well systems, guided and further institutionalized by the local authority frameworks.

Table 2 demonstrates that transitioning into a singular family system from a non-multigenerational system, non-dependence among community members, and dependence on external sources for agriculture and construction have transformed the community. With these changes, the community has transformed from sustainable and self-dependent to dependent. The people of Ladakh are now majorly reliant on external assistance for their livelihood and construction of built form, further adding to their vulnerability (Dame, 2008) .

Table 2. Changes in the social systems and their impact on the livelihood and built environment

	Traditional Methods since 16th century		Changes since 1966	
	Livelihood	Built environment	Livelihood	Built environment
Social Systems	The Churres system brought the social concept of *Chhurpon- Lord of Water;* The tradition of maintaining the *Bandabas or Bandobasti for water management - a list that contains the groups of farmers residing in a particular village; Another social tradition of signing the Kamgya- a work contract between Chhurpon and community*	*Riwaz-i-abpasha;* Polyandry; communal house construction	Decreasing communal help and reliance on the community due to rural-urban migration; more individualistic approach, hiring non-native workers for agriculture	more reliance on external help (both material and labour) for house construction

2.5 Religious and belief systems

To understand sustainable water resources management, one has to look into another aspect of the complex cultural system, including religious, cosmological, and mythical beliefs. Water was acknowledged and given importance in the local folklore. Chuu- is the Ladakhi name for water. One such folklore described below emphasises the equitable distribution of water (Angchok, *et al*., 2008).

"chhuk-po nor-ri mi-gang, gya-tso chhu-yi mi-gang"
(Wealth does not satisfy a rich person; water does not satisfy the sea)

"chhu-zyig be-na gyal, mi-zyig dum-na gyal"
(Diverted water is safe, (and) people living together are safe)

"phu-a kang-ri chags-na, do-a gyam-tso khi"
(When glacier forms in phu (high altitude areas), the ocean is formed in the lower parts)

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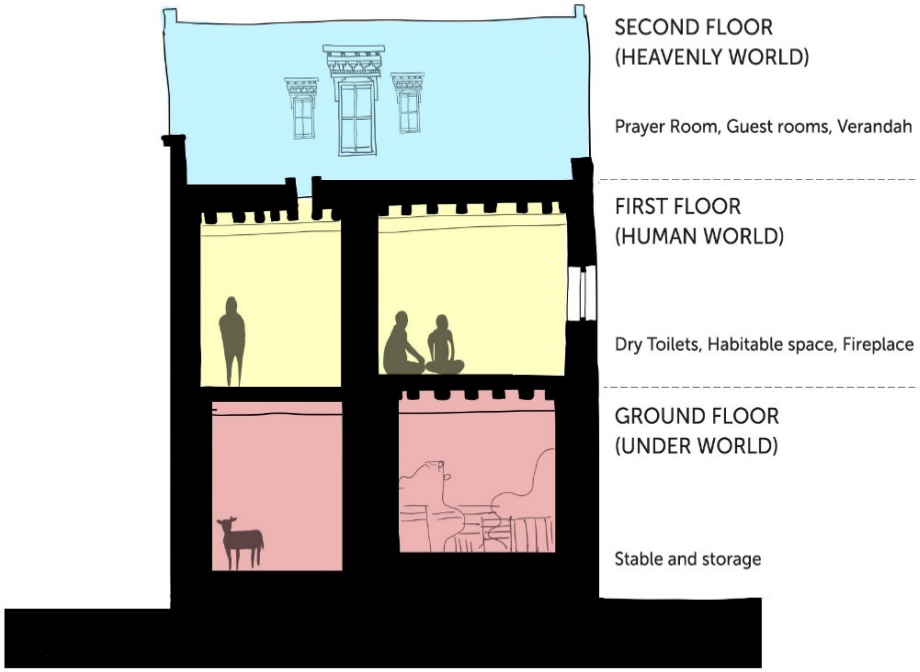

Figure 6. Typical Ladakhi house section showing the floor distribution as per cosmological and religious beliefs.

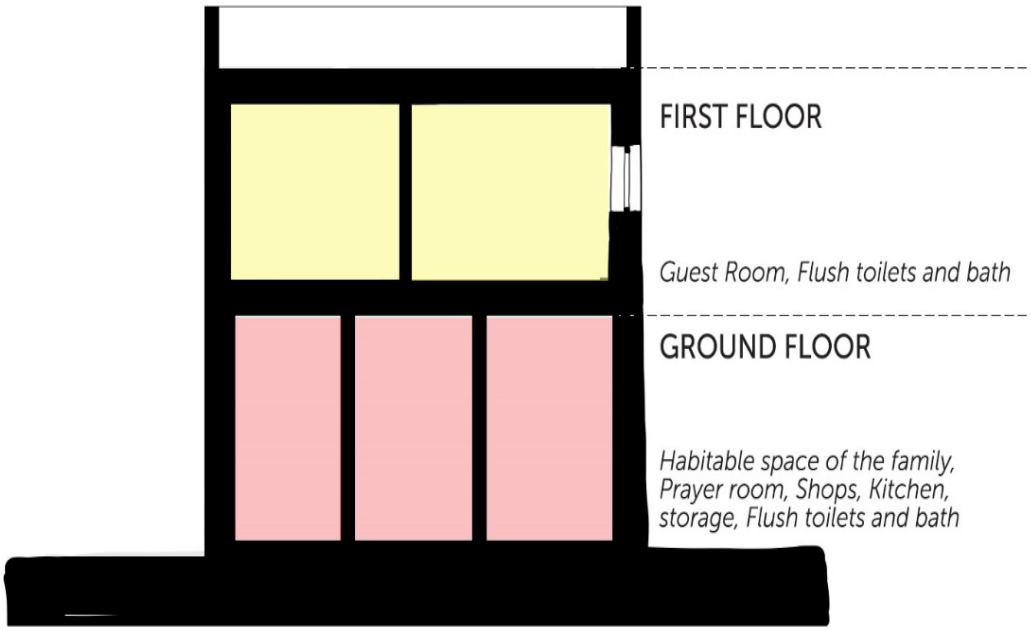

Figure 7. A changed typology of houses.

In his study, Angchok explains that the above folklore stresses the importance of social harmony and diversion of water through water channels like Mayur, Yura, Nagyur, etc. It ends

by indicating the importance of balance between climate and the natural process of the water cycle. When translated, the last line of the folklore is that water will be available for usage in lower altitudes only when the glaciers are timely formed in the high-altitude regions. With changing climate, one can observe the adverse effects of the receding glacial belt and untimely melting of glaciers in the region.

Traditional Buddhist communities strongly believed in the co-relation and co-existence of humans, spirits, and nature. They believed that humans' objectionable or disrespectful acts against nature or spirits resulted in unfavourable events. In one such belief, Lhu- a female deity associated with earth and water resides near water bodies like rivers, lakes, and natural springs beneath the earth's surface. In other beliefs, Lhu is also identified as the Nagasin, the Hindu Pantheon (Kaplanian, 2014). It is a popular belief that the spirit of Lhu provides good fortune to the villagers, along with the healthy production of crops and animals. To mark its presence, Lhu-bang is erected near water springs. It is a small rectangular structure with a base and conical or spherical top. The community members take special care to please the spirit by maintaining the sanctity and hygiene around Lhu-bang. It is believed that polluting the environment, chopping trees, polluting streams and water points offends her and can lead to misfortune (Angchok D. S., 2006). The religious, mythological, and spiritual beliefs directed the people to respect water as a resource and use it judiciously (Kaplanian, 2014) (Mann, 2002).

Table 3. Changes in the religious, cosmological, and other belief systems for water management in Ladakh and its effects on the livelihood and built environment.

	Traditional Methods since 16th century		Changes since 1966	
	Livelihood	Built environment	Livelihood	Built environment
Religious, cosmological, and mythical systems and belief systems	*Lhu*-bangs-religious structure, consultation to *Onpo* or *Lamas* for irrigation, sowing, harvest; festivals to celebrate sowing and harvest. These practices ensured that water was used as a common resource.	Site location, space allocation in the house based on belief in realms; folklore	Reduced consultations to *Onpo* or *Lamas*, comparatively less participation in the festivals	Less consideration of mythological realms or religious beliefs for new expansions and building typology

With growing water scarcity, change in economic pattern, outward migration, and the success of farming seasons with fertilisers, many traditional rituals and beliefs are abandoned

(Crook, 2001) (Dollfus, 2008) (Gagne, 2016). With the decreasing beliefs and increasing economic generation, locals try to meet the needs of the tourist while compensating for their rituals, practices, cosmological beliefs, and customs. This change in attitude is also reflected in the construction techniques and spaces in the built environment. Today, the spaces in the houses are designed solely on tourist requirements overlooking the region's water scarcity and geographic limitations. The construction of dry toilets to conserve water overlapped with the mythological belief in different realms (Fig 6). With changing requirements and aspirations, the building typology is altering rapidly (Fig 7). These changes overlook the traditional technological system of constructing dry toilets and the mythological belief of different realms within the house that supported water conservation (Table 3).

2.6 Economic systems

According to the conceptual framework (Fig 3) used to study the cultural system for water management in Ladakh, the last aspect has taken the most rapid transformation and seems to be the driving factor that now influences the cultural systems the most. This section explains how it has gone from being the least dominant to the most dominant factor influencing water resource management in the region.

Before the 1900s, the city of Leh in Ladakh acted as a nodal point due to its strategic location for trading in the Trans-Himalayan commercial route (Bureau, 2015). The earlier lifestyle of the Ladakhis was strongly influenced by Buddhist ideologies with negligible or no emphasis on financial aspects of life. They strongly believed in synergy between human spirits and nature. The community was founded on communal cooperation, ecological sustainability, and spiritual harmony (Hodge, 1991). In the past, the occupation of the Ladakhi population was agriculture, animal husbandry, and trading.

However, since Leh opened to tourism in the 1980s, there has been a drastic shift in the occupation. Many Ladakhis have abandoned agricultural practices and migrated towards the city for better opportunities in the tourism sector or government jobs (Clouse, 2017) (Patel, 2008) As a result of migration towards cities, villages in Leh lack a workforce during the sowing, farming, and harvesting period, coinciding with the tourist influx. The locals hire migrants and non-natives to meet manual labor needs for agricultural production. During summers, about one hundred thousand seasonal migrant workers reside in Leh (Spindle, 2019).

Today, receding glaciers (due to climate change) and their untimely melting overlaps with high tourist influx. Combined with the increase in water demand, Ladakh- a cold desert region, experiences extreme water shortage (Fig 8). The region experiences drought-like situations, making water unavailable during the sowing period. As the sustenance of the region was mainly on agriculture, water shortage affected the production of crops, making the community dependent on external resources. To meet the water scarcity for daily use and agricultural production, the Government introduced the Watershed Development Program and the Public

Distribution System, respectively. Rice and other non-native pulses-vegetables were introduced in this region under the Public distribution system (Mishra, 2003). Subsidies and handouts have significantly reduced and eroded the characteristics of self-sustenance and sustainability of these mountain communities (Dawa, 1999).

The chase towards economic upliftment opportunities has resulted in adverse effects, causing environmental degradation and impacting the soil, water, wildlife, vegetation, and people. (Borsdorf, 2015) . The self-sustaining cohesive cultural system of the community for water management has now become isolated, driven solely by the economy, and extremely reliant on external resources (Table 4).

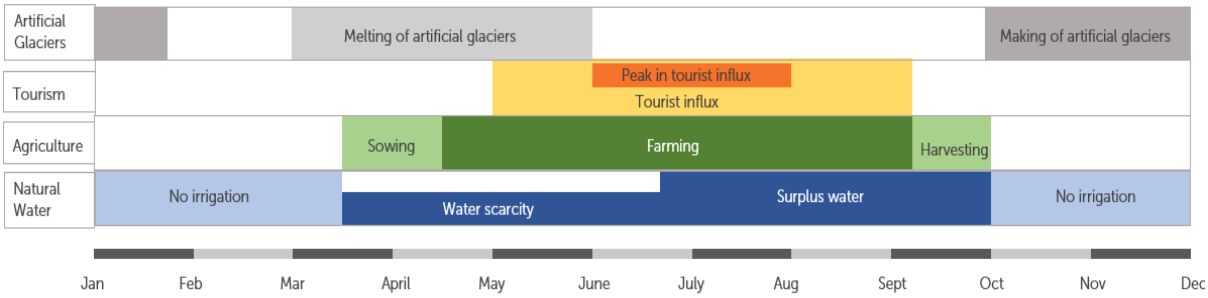

Figure 8. Yearly timeline showing the natural water available from the glacier for farming and its overlap with tourists visiting the region. Together, the increased water requirement results in water scarcity in the region.

Table 4. Understanding the Change in the economic systems for water management in Ladakh and its effects on the livelihood and built environment.

	Traditional Methods since 16th century		Changes since 1966	
	Livelihood	Built environment	Livelihood	Built environment
Economic systems	Agriculture; animal husbandry; trade- not driven by money but by social systems	Not money driven	Heavily influenced by tourism and military personnel	Heavily driven through monetary gains

2.7 Development Initiatives and Interventions

A decline of the traditional techniques and practices for water conservation and increased consumption has led to water shortages in the region. The Government and Non-Governmental Organizations (NGOs) took several initiatives to address the water shortage in the area and local requirements. While some of these initiatives consider the existing cultural systems, others overlook them. Initiatives that ignore the cultural systems are modified, discontinued,

or abandoned by the community. To address the rapid changes in the region, it is critical to understand and incorporate the existing cultural system for sustainable water resource management and project implementation.

The Indian Government has launched several state-driven centralised infrastructure development schemes in the region. In 2001, the Watershed Development Program funded by the state and central Government aimed to improve economic conditions by enhancing ownership and re-empowering the communities to be self-sustainable. However, Gutschow & Mankelow (2001) study provides several examples of unused and non-functional canals built under this project. They observed that extreme weather conditions cause rupturing of the cement lining and create racks in the concrete channels. In Zangla village, the community, unfamiliar with the new material and construction technique, attempted to repair the ruptured concrete using sods of the earth (Mankelow, 2003).

In 2013, the Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) was launched under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) mission for water distribution and sewage treatment. The UIDSSMT project planning documents describes the traditional water management system (Churres) as "provincial and contradictory to modernity" (Mueller, 2020). Though the program aimed at providing water to the locals, it was not very successful. It overlooked the local communities, their context, and characteristics, such as hydrology and geomorphology, socio-cultural or religious aspects. The project received a lack of public participation and caused spatial inequalities, leading to changes in the traditional land use pattern and haphazard expansion of the settlements (Dame, 2008) (Mueller, 2020).

NGOs play a significant role in the development of Ladakh. Since the 1970s, they have successfully channeled a substantial flow of international funds into the region (Dame, 2008). They have a long history of representing Ladakhi people, their practices, and traditions (Hodge, 1991). The NGOs play a pivotal role in organising and coordinating meetings with the community and the government agencies. They also raise funds, organise awareness campaigns, workshops and expeditions (Mueller, 2020), to put forth aspirations, ideas, concerns, issues, and initiatives of the Ladakhis.

To address the growing concern of water shortage and melting of receding glacial belts, two local engineers with the help of NGOs have taken the initiative to store water for agriculture and daily needs in the form of artificial glaciers and ice stupas. These initiatives became more successful than the top-down government initiatives because they integrated local resources and knowledge in the project and local communities in the decision-making process (Mueller, 2020).

Table 5. Analysis of Government and local initiatives for water management and conservation.

	Government Initiatives	Artificial glacier by Chewang Norphel	Ice stupa by Sonam Wangchuk
Implemented Since	2001 onwards; 2001- Watershed Development Program (WDP); 2013- UIDSSMT under JNNURM; 2019- Jal Jeevan Mission (JJM)	late 1980s onwards	2014 onwards
Construction Cost	Under the WDP-around four thousand $ per project; JJM mission-3.62 billion $	The construction cost is 4 thousand-1 million $ as compared to 2.5 million $ cement reservoirs; About 3.6 million $ is allotted per project fund through the WDP; however, only 860 thousand $ has been released in the last six years.	The pilot project costed 3 million $, but Wangchuk claims that the cost can be brought down to 500 thousand-1 million $; for 39.625 thousand gallons of water, the capital cost is 0.00032 $ per liter.
Technological system	UIDSSMT- State-driven centralised infrastructure scheme for formalised water distribution network and sewage system- theoretically aimed at re-empowering the community's irrigation system	Ten high-altitude artificial glaciers were built till 2009. Each provides about 6 million gallons of water; no machinery is required for its construction and operates entirely on gravitational force	Can be built anywhere as required, works based on gravitational force and properties of water, plastic hose pipes are required
Social system	not incorporated	Initially, the community took active participation, but over the years, it has reduced	community participation is through competitions, the locals are taught to build, repair and maintain on their own ice stupas
Religious, cosmological, and mythical systems and beliefs systems	not incorporated	not incorporated	The shape resembles Buddhist stupa in the region; tying of prayer flags due to association and religious belief
Economic systems	not incorporated	not incorporated	ice-café, and prospects of 'ice hotels' and 'ice climbing winter sports.'

Artificial glaciers were built at high altitudes, between 2400-3600m, in the late 1980s by a local engineer named Chewang Norphel (Vince, 2009). The large-continuous ice sheet about 300 m long is built by blocking, collecting, and freezing the water. To construct an artificial glacier, water is diverted from the mainstream and distributed along a gradually cascading

horizontal ground with the help of gravity. This method reduces sun exposure and prevents untimely melting of Ice. The artificial glaciers are built without using any machines and work on the principles of gravitational force. The frozen glacier starts melting in spring (April) during the sowing season. The water lasts for about 45 days until the high-altitude natural glaciers start melting (Norphel, 2017). The diversion of water from the mainstream, the use of simple technology without machines, and the active involvement of the community to divert, block and regulate water are the reason for the effectiveness of this initiative (Dar, 2017) (Vince, 2009). These characteristics relate to the traditional cultural (Churres) system for water management followed in the region.

Another conventional example for water conservation and distribution is ice cones, popularly known as Ice Stupas, built by Sonam Wangchuk. Unlike the glacier built by Chewang Norphel that requires a large horizontal space and high altitude, the ice stupas by Wangchuk can be built next to the village. The size of the stupa can be as per the requirement of the village. In this system, water is directed from a height with the help of gravity and released vertically upwards with pressure. This process is done at night to facilitate fast freezing (Maheshwary S, 2019). While maximising the volume of Ice, the stupas' conical shape helps the ice shadow itself and minimizes the exposed surface area to sunlight. As assessed in 2016, the water holding capacity of all Ice Stupas in the valley was about 27 million gallons per year.

The word 'stupa' comes from Buddhist shrines prevalent and predominant in the Buddhist region of Ladakh. Due to its visual resemblance to the stone and earth stupas in the region, people have a strong religious, spiritual, cultural association, and significance (Geneletti, 2009) (Killing Ladakh, 2018). Ice stupas aim to recharge the region's groundwater and provide water for agriculture and other purposes (Clouse, 2017) .

The construction of ice-stupas is solely by the local people and non-governmental participants. The NGO's play a significant part by providing either personal funding or sponsorships. So far, the Government's involvement is limited only to consenting the area the construction of ice stupas (Kumar, 2019). Over the last few years, the ice stupas have scaled up in the region. An annual ice stupa-making competition is being organized across Leh to spread this knowledge and encourage local participation. The villagers are first taught to build ice stupas and then encouraged to participate in a competition that challenges them to build the biggest stupa in the region within a stipulated time. During the winter of 2019-20, 26 ice stupas were constructed across the valley (Pandit, 2020). In addition to their contribution to the technological, social, religious, and spiritual system. The ice stupas can also contribute to the economic system of the locals (Nayar, 2019) (Safi, 2017) by creating hospitality opportunities like 'ice restaurants or café', 'ice hotels' or for adventure sport like 'ice climbing' (ET, 2019) (Kumar, 2019). Ice stupas have demonstrated the importance of religious and cultural association with sustainable and inclusive water resource governance.

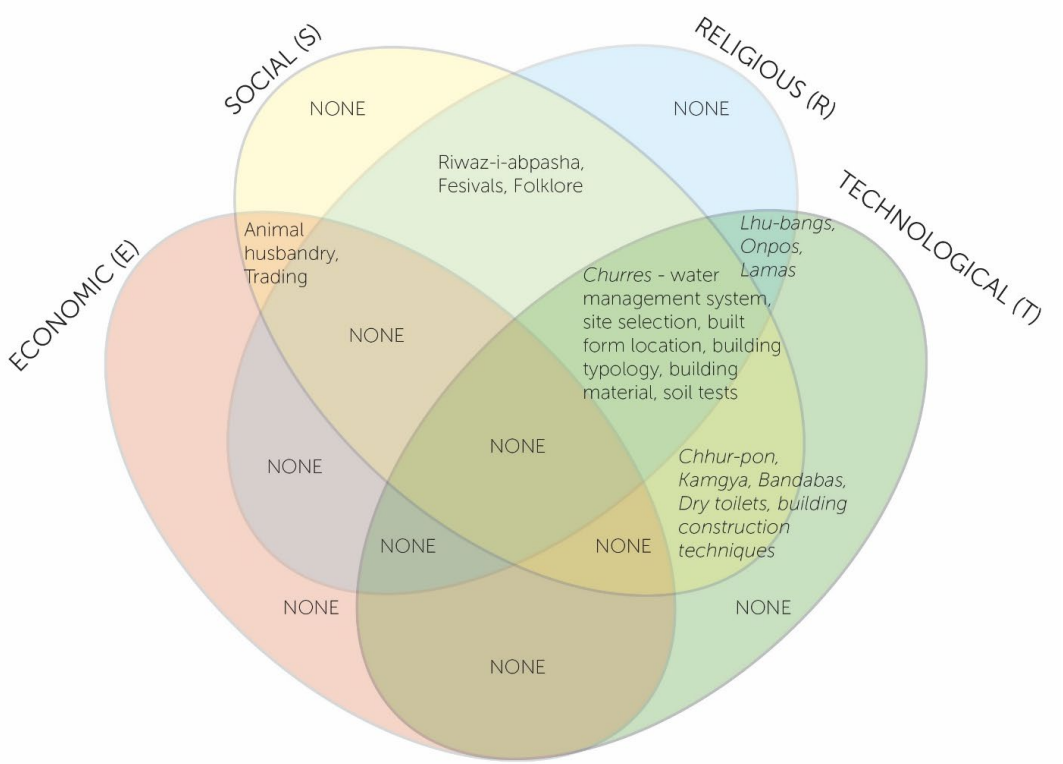

Figure 9. The overlaps between the economic, social, religious, and technological aspects that collectively shaped the traditional system for water management in Ladakh region.

3. DISCUSSION

Water plays a fundamental role in the daily life of Ladakhis and is embedded in their culture and identity (Mueller, 2020) . In the past, it was considered sacred, and the community guarded it against exploitation and pollution (Schreiber, 2016). A well-maintained irrigation system was viewed as a symbol of the self-reliance of the village and its households (Mankelow, 2003) (Crook, 1994). Through social participation and monitoring, regulation of common resources gave a sense of association, ownership, and responsibility that collectively formed the village solidarity. The traditional cultural systems ensured optimum and equitable water utilisation by everyone in the community and neighbouring village. According to Hodge, the Ladhaki community was established on the principles of communal cooperation, ecological sustainability, and spiritual harmony. The rituals and ceremonies were not limited to religious and social practices but informed the nature-human interaction, aiding harmonious co-existence (Hodge, 1991).

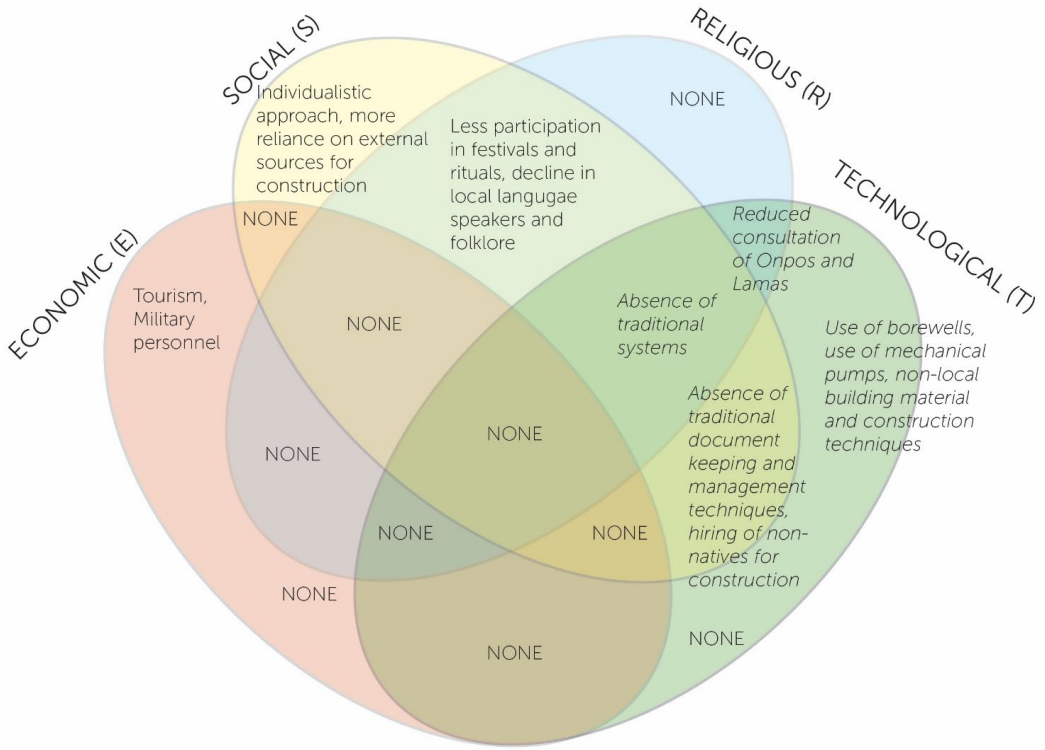

Figure 10. Changes in the traditional systems of the region that impact the water management and conservation.

We conceptualized the cultural system as the integration of technological (T), social (S), religious (R), and economic (E) sub-systems in order to systematically analyze the importance of culture for effective and sustainable water resource management in the Ladakh region. The Venn diagram in Fig 9 demonstrates the cultural system in the Ladakhi traditional water management method. The traditional cultural system was not solely driven by the economy (E). The only aspect that the economy influenced was the occupation of animal husbandry and trading. The systems for water conservation and management were dependent on the relationship between various social (S)-religious (R) and technological (T) sub-systems. The figure helps us understand that the systems are not isolated but interlinked.

The Venn diagram in Fig 10 explains regional changes induced by tourism have adversely impacted the cultural systems that ensured water conservation. In contrast to the traditional system that did not give much importance to the economy, today's cultural system is primarily driven by the economy. Due to outward migration, there is a decline in the social system of the villages. The systems of Churres, Chhurpon, Bandabas, cleaning of dry toilets have collapsed in villages. The recent changes mainly focus on economic upgradation and do not address the network within the cultural system. New constructions, agricultural practices, and development programs often overlook the existing cultural systems. Due to their correlation, as explained in Fig 11, any change in one system creates an unavoidable impact on the other.

In addition to the global changes, the regional changes have added pressure to the existing water scarcity of the region. The changing social relations and economy have resulted in a draught-like situation, low food production, water scarcity for agriculture, and daily needs.

The government initiatives are unsuccessful as they focus mainly on the technological and engineering aspects. John Crook expresses his concern on the implementation of 'so-called development programs' in Ladakh, stating that it "would weaken and the old system of local linkages through inter-familial goodwill would break apart" (Crook, 1994). Another study claims that the governmental approach of formal construction of water management increases the dependency of self-reliant communities on the Government (Dame, 2019). Implementing unfamiliar technology makes the communities dependent on external support and help. In many instances, the initiatives are abandoned, dilapidated, or unused (Gutschow, 2001) . After its completion, such projects do not empower the people to maintain and operate them. The government-initiated Watershed Development Program demonstrated the failure of an authority-driven centralised structure for formalized water distribution solely focused on technological and economic aspects (Mankelow, 2003) (Mueller, 2020). Studies in other parts of the world also reported that government-driven water resource management programs are often unsustainable as these projects ignore the local communities' meaningful engagement and self-reliance (Samaddar S, 2019) (Samaddar S., 2021). On the contrary, ice stupas are more successful as they solve water shortages and involve the community in its construction. The ice stupas incorporate a strategy of construction and management by the community members (Kumar, 2019). In addition to its contribution to the technological, social, religious, and spiritual system, the ice stupas also contribute to the economic system (Nayar, 2019) (Safi, 2017).

This study helps to analyze the relationship between the cultural system, changes, and development interventions. It demonstrates that adaptation of cultural systems (that focuses interlinking the traditional technological-ecological knowledge, social and religious systems) with modern technology can revive and enhance the community's resilience while addressing the depleting resources, natural hazards, risks, and social vulnerability.

4. CONCLUSIONS

This study deals with the increasing water-related risks in the ecologically fragile Ladakh region of India, and the significance of culturally viable alternatives. Unlike conventional studies focusing solely on the technical and engineering aspects of water resource management, this study intended to explore the role of cultural systems and practices to enable these risk preventive interventions to be sustainable and effective. With experience and knowledge, the mountain communities have developed several tangible and intangible methods that defines their cultural systems. These traditional systems respond to the geographic and climatic constrais of particular region.

The study findings show that though several governmental and non-governmental initiatives have been introduced recently to deal with scarcity issues, the projects that received success are the ones that effectively integrated socio-cultural values, beliefs, and practices in the risk management process. The study of artificial glaciers and ice stupas exemplifies that a development initiative has higher chances of success when it identifies, acknowledges, and includes traditional systems and the community. The inclusion of a cultural system makes the community resilient while boosting its economy and livelihood.

The traditional water resource management practices also demonstrated that financial gains and opportunities did not solely drive such initiatives. The traditional system paid adequate attention to the cultural well-being of the community while dealing with water-related risks. The systems for water conservation and management were dependent on the inter-relationship and interconnection between various social (S)-religious (R) and technological (T) sub-systems of the system. However, in contrast to the traditional system that did not give much importance to the economy, today's cultural system is primarily driven by the economy. Due to outward migration, there is a decline in the social system of the villages. The social systems of Churres, Chhurpon, Bandabas, cleaning of dry toilets have collapsed in villages. The recent changes mainly focus on economic up-gradation and do not address the network within the cultural system. New constructions, agricultural practices, and development programs often overlook the existing cultural systems. Due to their correlation, any change in one system creates an unavoidable impact on the other. The regional changes induced by tourism have adversely impacted the cultural systems which were responsible for sustainable water conservation.

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Investigating Public Perceptions Concerning the Acceptability and Effectiveness of Nudges for Disaster Risk Reduction Efforts in Japan

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Abstract In Japan, local governments have attempted to prepare citizens for and protect them from potential natural disasters by organizing activities such as evacuation drills and enacting rules and regulations such as building standards. A complementary approach to disaster risk reduction (DRR) efforts is to use "nudges." In this paper, we investigate nudges as a means to improve current DRR efforts. Through a survey, we analyze the views of Japanese people regarding the acceptability of nudges and their effectiveness in influencing people's behavior. We conclude that the most favorable nudges in terms of effectiveness and acceptability are those used in an emergency scenario (when a disaster is imminent) that also convey useful information.

Keywords: Behavioral Economics, Nudge, Disaster Risk Reduction

1. INTRODUCTION

Before starting this article, it is important for us to define "nudge." In the context of behavioral economics, a nudge is any mechanism implemented to influence people's decisions without introducing mandatory actions or restricting choices and without making major changes to economic incentives (Thaler and Sunstein 2008). Some of the most well-known nudges are the use of default options (people tend to abide by defaults because of psychological inertia), changing the order of objects (such as food in a cafeteria), and disclosing population statistics (people tend to follow what the majority of people in their society are doing). There

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are many examples of how beneficial nudges have been in helping people in a wide range of areas, including saving money for the future (Thaler and Benartzi 2004), paying taxes (Kettle *et al*. 2016), and protecting the environment (*e.g*., the "Don't Mess With Texas" campaign explained in Nagatsu [2015]). Another example that can be considered a nudge is that of "agency assignment" ; for example, a study from McGlone *et al*. (2013) concluded that people's threat perception of human papillomavirus (HPV) was higher when assigning agency to HPV (*e.g*., "HPV preys on millions of people") than when assigning agency to people (*e.g*., "Millions of people contract HPV").

Conceptually, nudges differ from persuasion or some methods in the risk communication field in that they are not an appeal to people's reasoning or logical thinking, instead, nudges influence people's behavior by triggering shallow cognitive processes (Saghai, 2013). Also, nudges are not limited to verbal communication, they can be delivered through changes in visual design, by use of colored lights, sounds, introduction of visual illusions, etc. Modifying messages to obtain a predictable result is only one of many ways to apply nudges; Of course, there are intersections between nudge theory and risk communication studies, when, for example, risk communication studies involve transforming messages in order to trigger shallow cognitive processes then those changes in the messages can be considered nudges. The same intersections also exist when it comes to nudges and techniques of persuasion.

Despite finding only a few examples of nudges specifically in DRR research through our review of the literature, examples of nudge research can be found in the field of disaster risk communication, including work from Ohtake, Sakata, and Matsuo (2020). By using messages that express social norms and communicate the potential for loss if evacuating late in a disaster, they showed that more people could be nudged to evacuate early compared with those who received only evacuation advisory messages.

One problem in researching nudges in DRR is that some theories can be tested only during the occurrence of an actual disaster (and would require a camera recording people's reactions). On that matter, Fujimi and Fujimura (2020) used virtual reality (VR) to test the effects of leading evacuees and using a trapezoidal river design (both of which are nudges that appeal to human herd-behavior instinct and visual cues) to encourage people to evacuate from a flood, concluding that the groups that received the nudges evacuated earlier than groups that did not.

Figure 1. Red sea level warning sign in Okinawa, Japan (taken by author)

It is important to note that nudges also happen naturally and help people to prepare and save their lives. One such example is "lead evacuators." Research by Katada (2016) on the 2011 Great East Japan Earthquake provides evidence that if some people evacuate at the earliest sign of an incoming tsunami, this act will

influence other people to evacuate as well. Given how lead evacuators can predictably influence other people's decision to evacuate, the concept of "lead evacuators" can be considered a nudge even though the term "nudge" was never used by Katada (2016) to describe the concept. Sometimes nudges are also coupled with other approaches, for example, making tsunami signs that are green, yellow, or red can provide an intuitive notion that some places are safer (green) than others (see Ongkrutraksa, 2015), possibly encouraging people to act faster or to memorize where they should go in the event of a disaster (see Figure 1). Nudges can also help people understand DRR information better (through simplification) and allow the information to have a greater impact on people through the method and timing of information disclosure.

Nevertheless, as we will see later in this article, not all nudges are considered acceptable by the majority of respondents who answered our questionnaire survey. On top of that, sometimes private companies or governments will use nudges in a way that does not align with people's best interests. For example, a company trying to sell magazines might offer a 3-month free trial to attract clients, but to cancel the subscription, people have to take actions such as calling a customer service agent or submitting a form. Because of inertia, many people will let the subscription continue after the first 3 months and continue paying for a product they do not actually want. In behavioral economics, taking advantage of people's flaws to steer them to do things that are not in their best interest is known as "sludges" (Thaler 2018).

In DRR, the goal is for the largest number of people to survive a natural disaster, so it is easy to see that any method used to steer people into harm's way would be a sludge. But the question is how do we know when a nudge is actually a sludge? What if nudges that the government intended to help people actually lead them to harm? Unfortunately, this is a difficult question, but it is not unique to nudges—the same question can be asked about efforts in education and law enforcement. The best we as researchers can do is to either study past real-world examples or to test nudges in as realistic a scenario as possible.

Our goal with this paper was to create a classification of nudges in the field of DRR, to understand their acceptability and the limits on their effectiveness, and to consider directions for future work. This research shows that there are differences regarding the acceptability of nudges by Japanese people, therefore they should not all be banned from practice in Japan and at the same time they should not all be utilized since some nudges might be unacceptable for the majority of the population. We hope this study will help guide decision makers in Japan in order to improve their DRR methods and that nudges will be used as a complement to educational methods. Moreover, we hope the results of our survey can be used by scientists in order to make comparisons with surveys done on nudges in different fields or applied in different societies in order to better understand the nuances of nudge acceptability. Finally, we hope our classification of nudge, judge and oblige (NJO) presented in section 2 can be used in future comparative studies between different methods of DRR.

In the first part of this paper, we present a classification of nudges and compare these nudges with other DRR approaches. In the second part, we present a questionnaire survey intended to help us understand Japanese people's opinions about nudges in terms of acceptability and effectiveness in comparison with other DRR methods. Finally, in the third part, we present our conclusions and outline our future work.

2. CLASSIFYING NUDGES USED IN DRR

To clarify and compare different methods of changing people's behavior in DRR and shape this study, the authors defined the three following concepts: "nudge," "judge," and "oblige" (hereinafter referred to collectively as "NJOs"). A nudge is as defined previously in this paper: a method to influence people in a predictable way, that preserves freedom of choice, that is easy and cheap to avoid, and that does not significantly change the economic incentives (Thaler and Sunstein, 2008). Judges are methods that involve educating or informing people and appeal to their logic, reasoning, memory, and knowledge. Examples of judges are education provided in schools explaining how disasters happen and what the signs of imminent disasters are; this includes textbooks about natural disasters and the like. Obliges are methods that involve restricting freedom of choice and are usually achieved through legislation and law enforcement. Oblige methods appeal to people's desire to avoid punishment or sanctions as well as their desire to do the right thing for society. For example, laws about how houses have to be constructed to withstand disasters are obliges. Please see Table 1 for a quick summary of nudges, judges, and obliges.

As seen in Table 1, judges are applied through education (*e.g.*, in schools, via the media, at events), obliges are applied through legislation and law enforcement, and nudges are applied through what is called "choice architecture." Choice architecture is a term coined by Thaler and Sunstein (2008) and refers to the practice of influencing people's choices by organizing the environment or context in which people make decisions. For example, a government official that prepares a pamphlet to be distributed in their town with the aim of influencing people to prepare an evacuation bag is a "choice architect." Many features of the pamphlet, including the images, words, and choice of information to be shared, can contribute to people's decision to prepare an evacuation bag; in the worst case, they simply ignore the pamphlet's message and do not prepare an evacuation bag.

In his book Thinking, Fast and Slow (2011), Daniel Kahneman presents the theory that humans have two systems of thinking: one that is automatic, fast, and unconscious, and another that is slow, logical, and conscious. Thaler and Sunstein also refer to these two systems of thinking as the "automatic system" and the "reflective system." Considering the two different systems of thinking, we classified NJOs according to which system of thinking they appeal to (see the second row of Table 1). Accordingly, it follows that if there is a behavior change, nudges encourage mostly unconscious behavior changes, whereas judges mostly encourage

conscious behavior changes. This is because people generally do not realize they are being nudged, and thus the change is not conscious. At the same time, judges work through education and depend on people's conscious, logical thinking and memory in order to have an effect. Obliges work because people consciously follow rules and regulations; however, the behavior change is often forced and therefore might not continue in the long term if the rules and regulations are ever changed or rescinded.

Another nuance of the differences between NJOs is what kind of liberty they preserve. We classified NJOs based on Hayman's (1992) classical conception of liberty. Therefore, nudges protect people's negative liberty because no obstacles, barriers, or constraints are introduced when a nudge is used. In other words, with nudges, people can choose whether or not to do a certain thing. In contrast, judges protect people's positive liberty, giving them the power to act according to their own reason and free will. Finally, obliges protect people's civil liberties because people have liberty as long as they act within the boundaries of human laws.

Table 1. Table summarizing the differences between nudges, judges, and obliges

	Nudge	**Judge**	**Oblige**
Applied through:	Choice architecture	Education	Legislation and law enforcement
Works due to:	People's automatic system of thinking	People's reflective system of thinking	People's reflective system of thinking
Encourages:	Unconscious behavior changes	Conscious behavior changes	Forced, conscious behavior changes
Protects liberty:	Negative Liberty	Positive Liberty	Civil liberty
Examples:	Sirens, colored signs,emergency items' placement and availability in stores, message simplification, signaling default evacuation routes, *etc*.	Learning hazard maps, attending classes, reading textbooks, *etc*.	Building codes, compliance laws, driving restrictions, evacuation orders, *etc*.
Dark side:	Sludges	Incomplete education, misinformation	Despotism

It is important to note that sometimes a government approach to DRR might apply multiple NJO concepts at the same time. For example, using flashing lights to show the path to an evacuation shelter both transmits information (which is considered a judge) and appeals to people's tendency to follow a default route (which is considered a nudge). In reality, most choice architects' attempts will directly or indirectly result in some type of nudge even if they

are not intended or considered as such. A simple example is the arrangement of food in a school cafeteria line. Even if a school has not thought about nudging people's food choices, they will inevitably do so by how they arrange the food (Bucher *et al*. 2016). Simply put, it is impossible to avoid nudging in some cases.

Considering various methods already defined and studied in the field of health and risk communication, we could think about how these methods would be classified in terms of NJO. For example, the concept of invitational rhetoric as defined by Foss and Griffin(1995) constitutes an invitation to the audience to enter the rhetor's world and to see it as the rhetor does. As invitational rhetoric requires the use of a reflective system of thinking, it is closely related to the judge concept. On the other hand, the concept of "positive affect" used in health and risk messaging, intents to induce individuals' positive feelings such as happiness. According to Guan and Mohatan(2017), people who feel good when exposed to a health message tend to have more favorable attitudes towards the message. Because of the change in individual's attitudes as a consequence of "positive affect" messaging and the fact that positive affect appeals to a feeling (rather than logical thinking) makes it possible to categorize the "positive affect" strategy as a nudge. Simplification of forms and information presented to individuals is considered as a nudge by Thaler and Sustein (2008), as it makes it more likely that people will answer forms (see John and Blume, 2018 for an example of simplification nudge). It is therefore possible to see how another concept in the risk communication field, called "exemplification theory" could be considered a nudge, as the presence of an example makes an information easier to be remembered (Spence and Westerman, 2017). In fact, examples being remembered easily can become a problem if individuals apply it as anchoring bias.

Finally, in Table 1, we present what we believe to be the "dark side" of NJO: NJO methods can be used in unethical ways. We consider methods that focus on welfare, autonomy, dignity, and self-government to be ethical applications. As pointed out by Sunstein (2016), some methods focus more on one value than another and sometimes there are conflicts among the values. For example, a method that increases welfare might simultaneously undermine autonomy. Well-planned nudges (not sludges) are ethical in the sense that they increase welfare when they influence people to make better decisions. Sunstein also pointed out that the best nudges are those that also protect autonomy, dignity, and self-government. For example, disclosing the nutritional information of foods in a cafeteria can nudge users to select healthier options. This increases welfare while also promoting autonomy because it provides education to people about the nutrition of the foods.

In summary, the "dark side" of nudges would be the aforementioned sludges. For judges, the "dark side" would be any type of education that is incomplete or contains incorrect information that purposefully (or not) leads people to draw the wrong logical conclusions, which in the context of DRR might lead them to endanger themselves. As for the "dark side" of obliges, the closest term would be "despotism," which in colloquial terms would be understood as "an oppressive exercise of power."

3. ONLINE QUESTIONNAIRE SURVEY

There are many possible arguments against using nudges instead of rules or for simply doing nothing to change outcomes. Some of those arguments might come from the nature of certain nudges that might be more accurately described as "manipulation" and are considered by some to be unethical given that they affect people's dignity (Sunstein 2016). But as seen in the previous section, in the same way that laws are not inherently unethical, nudges are also not inherently unethical. To grasp which nudges are considered acceptable and unacceptable in Japan, we created a questionnaire survey which was administered in January 2021 by an online survey company who sent the survey to their nationwide customers. We also wanted to use the survey to understand people's expectations of which nudges might or might not be effective in influencing people to prepare for natural disasters.

There are several reasons why we chose to conduct this survey in Japan. First, people in Japan are aware of natural disasters because many different types of natural disasters occur in Japan (e.g., landslides, earthquakes, tsunamis, volcanic eruptions, snow storms, typhoons) and most people are at risk of being affected by at least one of these disasters in their lifetime. In addition, most people in Japan are familiar with the concepts of early warnings, evacuation areas, and evacuation drills. Therefore, it should be simple for them to answer survey questions about these matters. Second, in a previous questionnaire survey about nudges that was conducted across multiple countries by Sunstein and Reisch (2019), Japan was found to be an outlier, having one of the lowest approval rates for many different types of nudges, including placement of food in a cafeteria and placing food warnings on packages, and we hoped to better understand why this is the case through our own survey. The English version of the full survey is presented in Appendix A.

3.1 Method

The survey was divided into four parts. The first part comprised basic demographics questions about age, gender, and prefecture of residence. For the second and third parts, we asked respondents about many different NJOs; some of them actually exist in Japan, whereas others were invented for the sake of the survey. The second part asked the respondents how acceptable they thought the various NJO methods were, and the third part asked how effective they thought each NJO method would be in changing people's behavior. Finally, the fourth part of the survey had an open-ended question asking the respondents to share their own ideas for methods that might be used to help people prepare for a disaster.

To organize the second and third parts of the survey, we separated the NJOs of common themes into questions; henceforth, each NJO method will be referred to as a "question item." For example, if the goal of the NJO is to influence people to prepare an evacuation bag, the NJOs (question items) were placed under a question about evacuation bags. In each question,

five options were presented in a Likert-scale format for respondents to rank each NJO question item, as in the example question shown in Figure 2. To reduce the risk of our questionnaire unfairly nudging people's answers, we also randomized the order in which the question items appeared to the respondents (see Koppell and Steen 2004 as an example of how ordering can affect results).

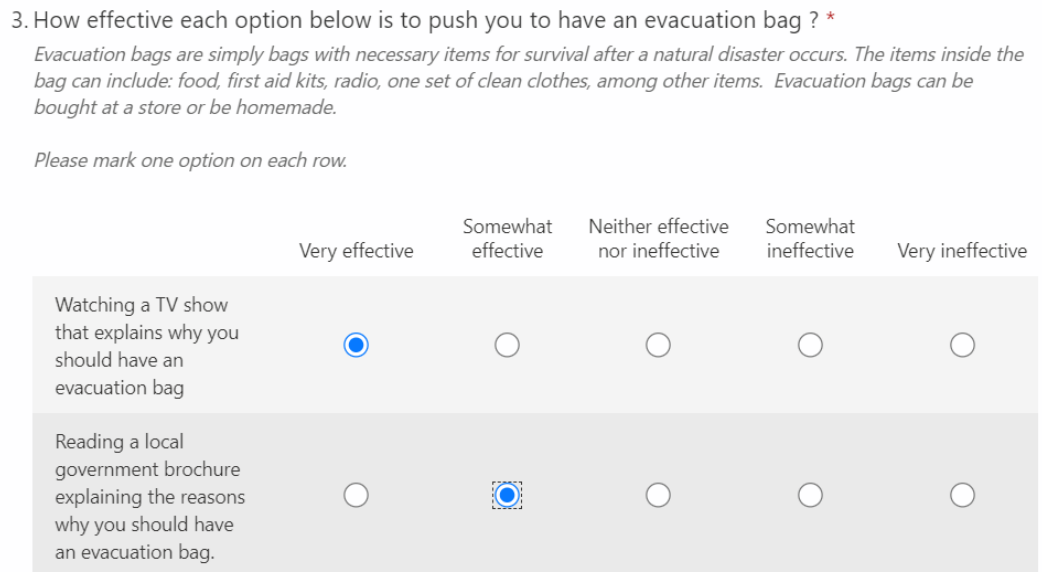

Figure 2. Example survey question showing the format of the questions.

In Japan, local governments promote activities that encourage people to make preparations and take action in the event of a disaster. Each survey question was designed to focus on the following actions and activities: visiting evacuation areas or evacuation towers ahead of a disaster; preparing an evacuation bag in advance; evacuating early; checking the evacuation route map; securing the furniture in one's home; and participating in evacuation drills. As for the question items, we designed them so that at least one nudge, judge, and oblige were represented under each question.

To create a variety of NJO question items, we considered different methods of delivery. The oblige question items can include laws, rules, or the revocation of privileges. The judge question items varied in terms of the type of media considered, including pamphlets, television, or text messages. The largest number of question items involved nudges because they are the focus of our research and we wanted to compare various nudge approaches. A wide range of delivery methods were used for the nudge question items, including using objects to attract interest, adding interesting designs to objects, using celebrities to deliver messages, and using sounds or lights to attract people's attention, showing a default path, and so on.

The full list of questions and question items pertaining to the second and third parts of the survey and their reference numbers are presented in Appendix B The reference numbers in Appendix B will be used to discuss the results in the next section.

3.2 Limitations

Questionnaire surveys on nudges can yield important results about what people consider to be acceptable and unacceptable in terms of nudges. For example, Hagman *et al*. (2015) conducted a survey and concluded that people with a more individualistic worldview are less likely to perceive nudges as acceptable, while those who are more prone to analytical thinking are less likely to perceive nudges as an intrusion on their freedom of choice.

Yet, because nudges often succeed without people realizing they have been nudged, and because there is often no indication that something is being used as a nudge, most people cannot effectively judge how effective a nudge might be in influencing their behavior in real life. Therefore, in the short term, surveys can be an important tool for measuring acceptability perception, but scientists and policymakers cannot use a questionnaire survey to determine the effectiveness of nudges. Sunstein *et al*. (2019) also pointed out this limitation in their study of nudges that involved a survey.

Another limitation is that the general public may not be aware of nudges or how they work, and it can also be difficult to explain some nudges in the limited space available in a questionnaire survey form. Also, many of the nudges presented in our survey had never been used before (in contrast with the judges used); therefore, people were likely not so familiar with them and this might have led to biased answers. Nevertheless, we hope that in the future, scientists testing nudges will be able to compare real-world tests of nudges with our survey results.

3.3 Results

A total of 800 people answered the survey. In terms of demographics, 50% were men and 50% were women, which is close to the gender distribution in Japan in 2019, which was 48.6% male and 51.4% female. The respondents ranged in age from 19 to 88 years, and about 33% were over the age of 60 years (in 2019 about 34.4% of people in Japan were over the age of 60 years). The areas of residence varied, but the largest number of respondents were from Tokyo (123), Kanagawa (77), and Osaka (75), which were the three most populated prefectures in Japan in 2019. The numbers mentioned in this paragraph are from the Statistics Bureau of Japan (2021). Even though our survey was conducted in 2021, the demographics can be reasonably expected to be basically the same as in 2019.

3.3.1 Opinions about acceptability

Respondents' answers regarding the acceptability of each NJO method are shown in Figure 3.

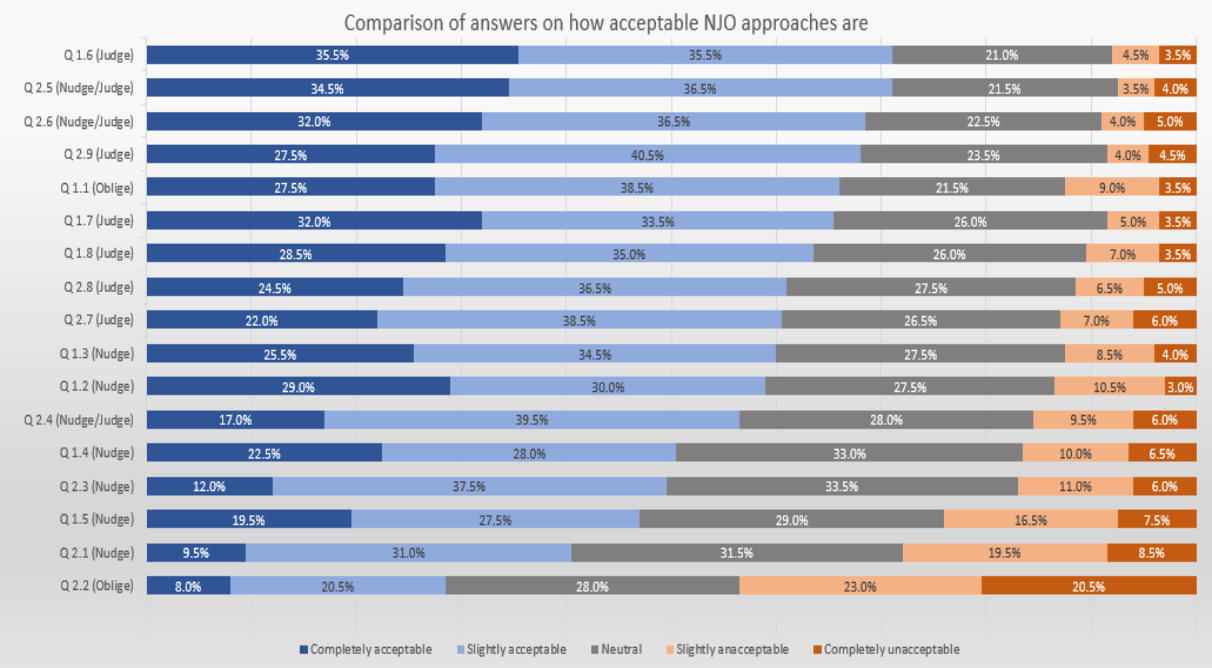

Figure 3. Results of respondents' opinions of NJO methods regarding how acceptable they are. "Q1" indicates that the method was presented in Question 1, "Q2" indicates that the method was presented in Question 2, and so on. As mentioned before, some methods cannot be purely described as only a nudge or only a judge, so some methods are classified as nudge/judge.

Regarding the acceptability of each NJO method, more than 50% of the respondents found all of the judge methods slightly or completely acceptable. As for the oblige methods, opinions varied, with about 68% of respondents answering that the oblige method in Q1.1 was slightly or completely acceptable, while about 56% of respondents said the oblige method in Q2.2 was slightly or completely unacceptable. As for the nudge methods, there was a tendency for nudges that also work as information sharing (loud sirens, flashing lights that lead to an evacuation area, large clocks showing the estimated time of the tsunami's arrival) to be considered very acceptable, while others were considered more acceptable than unacceptable, but not by a big margin. Only one nudge method was considered more unacceptable than acceptable, namely, Q2.1, which involved using TV to show the grief of family members who had lost loved ones in a disaster.

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After comparing the results by the percentages of answers, we also performed an exploratory factor analysis to see which NJOs would be grouped together based on the answer patterns. Even though our data were not numerical, because we had ordinal data, it was still possible to use factor analysis. Our ordinal data ranged from 1 to 5, with 1 indicating completely acceptable and 5 indicating completely unacceptable. The extraction was by correlation matrix based on an eigenvalue greater than 1, a maximum number of iterations for convergence of 25, and suppressed coefficients smaller than 0.4. We obtained three factors, and the grouping of methods by factor are shown in Table 2

Table 2. Factor analysis results of the NJOs presented in acceptability questions

Factor 1: Information sharing and seeking	
Q2.9	Judge
Q2.5	nudge/judge
Q2.6	nudge/judge
Q2.7	judge
Q2.8	judge
Q1.6	judge
Q1.7	judge
Q1.8	judge
Q2.4	nudge/judge
Q1.1	oblige
Factor 2: Entertainment Nudges	
Q 1.4	nudge
Q 1.5	nudge
Q 1.2	nudge
Q 1.3	nudge
Factor 3: Controvertial NO	
Q 2.2	oblige
Q 2.1	nudge
Q 2.3	nudge

We expected that the groups would be composed of two different methods, but this is not the result that we obtained. As seen in Table 2, nudges paired with judges and judges only were grouped together under the first factor as along with one oblige method (Q1.1). All NJOs in this factor were also those considered most acceptable compared with other NJOs, and they are all related to either sharing some relevant information or requiring people to do something to obtain information (such as in Q1.1) therefore this factor was labeled "Information sharing or seeking." Under the second factor, we found four nudges (Q1.2, Q1.3, Q1.4, Q1.5) which were not considered as acceptable as those in the first factor, but the "acceptable" answers outweighed the "unacceptable answers" and a large portion of answers were "neutral"; Nudges in factor 2 were also always related to fun, relaxation, or entertainment. therefore, we named this factor " Entertainment nudges."

Finally, the third factor included two nudges and one oblige method (Q2.1, Q2.2, Q2.3), and these three NJOs were also the ones considered least acceptable by respondents.

We expected that Q2.1 would be considered more unacceptable because it appeals to people's fear or sadness. We also expected that the oblige in Q2.2 would be considered very unacceptable because it involves punishing people who do not comply by revoking their privileges of staying in a shelter. Although, Q2.1 and Q2.2 were not surprises, the nudge in Q2.3 (talking about assigning leading evacuation roles) was. One reason why Q2.3 might have been considered somewhat unacceptable is that in this method, the government asks people to collaborate on evacuation efforts (instead of other more passive approaches where evacuees do not have an active role except for evacuating themselves whenever they see fit). However, we

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can see from Figure 3 that the nudge in Q2.3 still received more answers in the "acceptable/slightly acceptable" category than not, and so we decided to name this factor "Controversial NO" (for nudge and oblige).

3.3.2 Opinions about effectiveness

As for the results about how effective each method of NJO was, judges were generally seen as quite effective, whereas oblige options followed the same trend as before; that is, some were seen as very effective while others were seen as very ineffective. Nudge options varied as well, with nudges appealing to emotions such as "fear" and "sadness" and those appealing to people having "fun" or following what a celebrity does on TV were seen as less effective than nudges that improve awareness and are coupled with information about disaster prevention. Figure 4 shows the results of the top 5 best-rated nudges according to effectiveness and Figure 5 shows the results of the top 5 worst-rated nudges according to effectiveness.

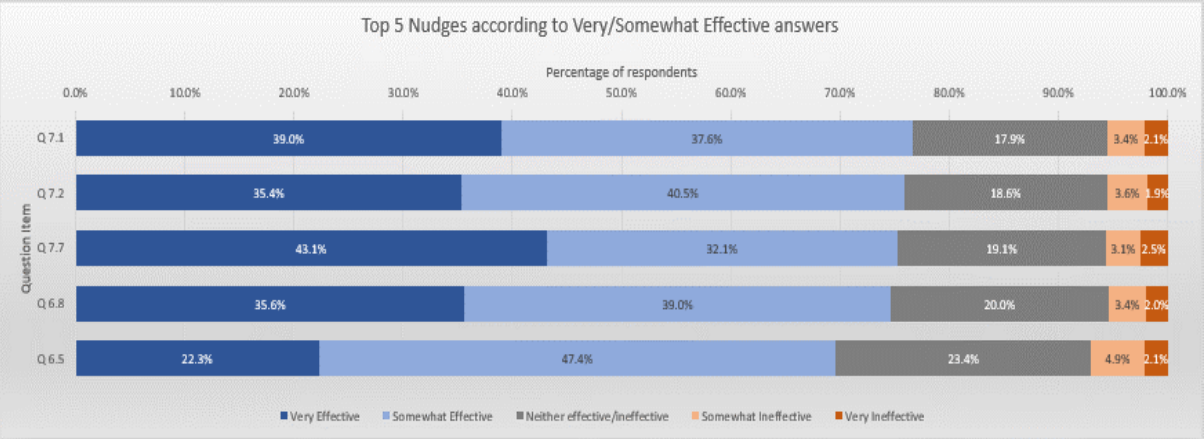

Figure 4. Top 5 most-effective nudges according to respondents' answers

It is interesting to note that although the majority of respondents agreed that the judge options were very effective, there was a large number of neutral answers for many of the least effective nudges; Q4.6, Q6.6, Q4.3, and Q5.3 received more "neutral" answers than both "somewhat/very effective" and "somewhat/very ineffective" answers. This shows that many people were undecided about the efficacy of nudges, which is only natural given that nudging is a somewhat recent concept that is not taught in schools and is rarely talked about in the media.

As can be seen from Q5.3 in Figure 5, most respondents did not think that playing a game featuring an evacuation route map was an effective method for motivating people to check their evacuation map ("very ineffective," "ineffective," and "neither effective/ineffective" accounted for 63% of the responses to Q5.3). Despite this discouraging result related to game-based nudges, we have decided to test as a future work what people's real-life reactions to a

game involving nudges would be. We want to compare the results obtained from testing the game with the results of the present survey because, as discussed before, questionnaire surveys are not a reliable way of testing the effectiveness of nudges.

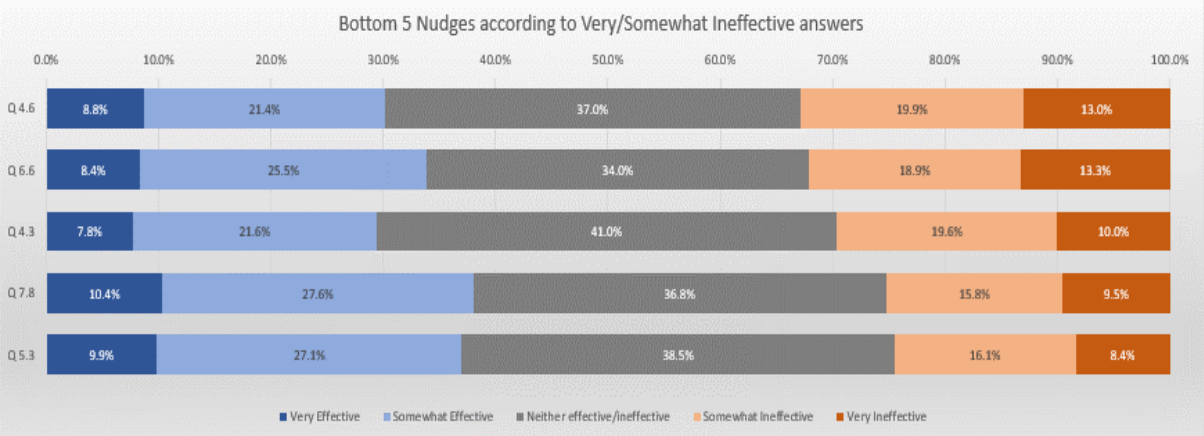

Figure 5. Top 5 least-effective nudges according to respondents' answers

3.3.3 Open-ended question results

The final item of the questionnaire was a non-mandatory open-ended question, which read as follows: "If you have any suggestion of things that can push people to prepare for a natural disaster or evacuate their houses, feel free to comment below." Of the 800 respondents, 190 (about 24%) shared their thoughts.

After reviewing the responses, we were able to classify them into 29 topics, although 11 answers could not be classified because they were too vague. Table 3 shows the top 10 most-mentioned topics. Because some comments touched on more than one topic, they were classified according to multiple themes, and thus the number of classifications (234) exceeded the number of answers (190).

Regarding what could be considered as nudges, 12 comments mentioned that it would be good for disaster victims to share their experiences. Listening to survivors sharing their experiences can give us real lessons, but they can also influence us to take action to reduce risks. In addition, eight people expressed a desire for more straightforward and easier-to-understand information, which can be considered a nudge. A particularly notable result was that eight people mentioned wanting more realistic disaster simulations (some mentioned using virtual reality and others mentioned conducting more realistic disaster drills). The following comment (translated from Japanese) from a respondent explains why it is important for people to participate in simulations.

"Earthquakes and big typhoons have happened but people say 'it is not a problem!' They don't care much about disasters. If people have never experienced a disaster, their caution

can be zero. Visiting some facilities and having them experience an earthquake and typhoon would be effective for helping people to quickly understand."

Table 3. Top 10 most-mentioned topics by respondents

Answer Topic	Total answers
Get free benefits, more affordable prices, wider availability of emergency goods	19
Restrict freedom and/or apply punishment	18
Evacuation drills (for school children or everyone)	18
Information could be shared on TV	17
Use of neighborhood associations, local community activities	17
Each person has their own responsibility to prepare and remain vigilant	12
The local government is responsible for distributing information	12
Disaster victims could share their experiences to increase people's awareness	12
Information could be shared via pamphlets	9
Information could be shared via non-specified media	9

Seventeen respondents mentioned that they would like to strengthen ties with neighborhood associations or participate in community activities. This is a very good method not only for preparing for a disaster but also for increasing community resilience. Neighborhood associations can have an impact by providing nudges because people can learn what others in their community are doing to reduce risks, and as a result, they may be influenced to do the same. The following is a comment from a respondent about this topic.

"In the event of a disaster, I think it's best to cooperate with people in the neighborhood, so I think that regular calls and disaster prevention drills by the neighborhood association are essential."

As for judges, many people mentioned sharing disaster prevention information and hazard information through the media, with TV being the most mentioned type of media (17 mentions), followed by pamphlets (9), the Internet (8), SNS(7), and radio (4). In addition, six people mentioned that schools should teach DRR, and three people mentioned that they would like to learn about the history of local disasters.

As for responses pertaining to oblige methods, 18 people mentioned ideas involving restricting freedoms through laws or applying punishment for people who do not follow guidelines. The idea behind many of these comments is that people will not act or they will think it is not important to prepare unless it is mandatory to do so, as illustrated by the following comment.

"I myself have been the victim of various disasters, but I regretted that it took so much time to take action, even though I prepared to evacuate based on what I saw on TV. But, I don't think I'll work so hard to prepare in advance until the disaster is happening, and I don't think most people will do it unless it's mandatory."

The most important takeaway from the results of the open-ended question is that each person has different needs and different opinions about which methods will most likely contribute to saving lives in the event of a natural disaster. On the upside, nudges, judges, and obliges are not mutually exclusive, and a multitude of them can be applied in different situations and circumstances. For example, a town can conduct mandatory evacuation drills (oblige) while simultaneously educating people through pamphlets (judge) and requiring shops to place emergency goods near the entrance to influence people to buy them (nudge).

4. DISCUSSION AND CONCLUSION

Although nudges often occur naturally, they can also be used as an intentional method by governing bodies and organizations to help people understand important DRR information, attend drills, and act in their own self-interest to protect their lives when a natural disaster occurs. This can be seen in past DRR research where, even though the term "nudge" was not used, nudges were shown to be involved.

Moreover, the application of nudges requires a nuanced approach because not all nudges will be accepted by people in the same way. For example, it is apparent from the present survey that a nudge involving showing the grief of families who have lost loved ones in a disaster was not viewed as acceptable by a significant number of people (36.2% of respondents). It is also important to bear in mind that when testing nudges, be it in the form of surveys, simulations, or real-life situations, the results concerning effectiveness and acceptability will vary according to culture. Because our research was done in Japan, our results are a reflection of Japanese culture. One solution to increase acceptance is to make transparent the goals that the government or decision-maker is trying to reach by using nudges and which nudges they are using. Of course, the same nuance and consideration should be applied in other behavior-changing approaches, including those that limit freedom of choice (obliges) and those that involve education (judges).

As for the effectiveness of nudges compared with other methods, nudges that are used in emergency situations (*e.g.*, the use of sirens when a disaster is known to be imminent and people need to evacuate) and also help to deliver information are viewed to be as effective as judges. However, some nudges that appeal to people's desire for fun or relaxation are not so effective, according to the survey respondents. This might be due to the fact these nudges are novel and may not have an obvious connection to DRR unless a lengthy explanation is provided. Also, as previously mentioned, questionnaire surveys are not the best way to grasp the

effectiveness of nudges because many biases might be at play when people answer. Another point to consider is that nudges work somewhat unconsciously. For example, people might not realize that DRR-related goods have been placed at the entrance of a shop in order to influence shoppers to buy them. This is why real-world testing is preferred, and if that is not possible in the DRR field, then it is important to perform as realistic a test as possible, such as by using virtual reality.

The open-ended question of our survey also shed light on many points. First, people have a clear belief about the effectiveness of a wide variety of DRR methods. Many mentioned obliges, but many also mentioned judges and nudges. Second, the large number of responses to the open-ended question and great length of some of them shows that people want to engage on this topic. Some people even used the survey as a way to express their worries and feelings as well as share problems with their city's preparedness (*e.g.*, the lack of evacuation towers in coastal towns).

There is still a lot of room for studies involving nudge approaches in the field of DRR. From the results of the present survey and literature review, it is our opinion that nudges should be used to complement current DRR methods rather than replace them because a variety of approaches based on education or law enforcement have already been shown to be effective in previous studies. Decision-makers should avoid using nudges deemed to be manipulation or sludges, and schools should teach about nudges so that the general public will be able to watch out for them. Private companies are already using sludges to help their bottom line. Therefore, giving people the tools to understand how these soft methods work to influence decision-making should empower them in many other areas of life.

5. FUTURE WORK: NUDGE EXPERIMENTATION

In this part, we discuss our reasons for creating the game Kuroshio no Himitsu ("The Secret of Kuroshio" in English). In short, the game aims to nudge people to visit tsunami evacuation sites while enjoying sightseeing spots in Kuroshio, a town in Kochi Prefecture, and to familiarize themselves with cultural, historical, and disaster-related information.

According to the survey results, judges are the top category in terms of effectiveness and acceptability, followed by nudges that also convey information (the "nudges/judges" approach). Nudges that appeal to people's desire for fun, including those in Q1.2, Q1.4, and Q1.5 (see section 3.2.1), were more often viewed as "somewhat/completely acceptable" (57.6%, 42.3%, 39.2%, respectively) than as "somewhat/completely unacceptable" (13.2%, 19%, 24.3%). Even though the number of people who found these nudges acceptable exceeded the number of people who found them unacceptable, there were still many neutral answers (29.3%, 38.8%, 36.6% respectively).

Nevertheless, given the limited ability of questionnaire surveys to evaluate of effectiveness of nudges, we decided to attempt a real-world test of a nudge. Because the best nudges in terms of acceptability seem to be those that also convey information (i.e., nudges paired with judges), we decided to test a nudge that appeals to people's desire for fun while also conveying DRR-related information. The result was Kuroshio no Himitsu.

There are quite a few reasons why we decided to specifically use a game to test the nudge concept. First, as mentioned before, our research did not show good results for game-based nudges, and thus a real-world test is needed to verify the true effectiveness. Second, because this research was conducted during the COVID-19 pandemic, we could not test a nudge approach involving large groups of volunteers gathered in the same place at the same time. Third, we wanted to minimize biases caused by the presence of the researchers while the volunteers tested the nudge approach. A mobile game that can be downloaded independently and played individually avoids the risks presented by the COVID-19 pandemic and enables volunteers to respond to an online survey about the game without the researchers being present. Finally, previous research on a digital game for disaster-prevention learning by Huang *et al*. (2013) showed that playing the game increased both the players' willingness to learn and their satisfaction, demonstrating the potential for games that are paired with education.

Next, we had to decide the purpose of the game, that is, what we want to nudge people to do. In Japan, many coastal towns are at risk of inundation by tsunamis, and after an earthquake occurs, people usually have very little time to evacuate. Therefore, to evacuate quickly, it is important for people (both local residents and visitors) to be aware of the evacuation areas around town as well as how to get to them. Thinking about this issue, we developed a smartphone game with the aim of nudging people to physically visit evacuation areas during normal times when there is no imminent disaster. The target area for the game is Kuroshio, which was chosen because of its proximity to the Nankai Trough, which is expected to be the site of a massive earthquake and tsunami in the future (Garrett *et al*. 2016). Kuroshio has a small population of around 10,000 people, according to the most recent national census (Statistics Bureau of Japan, 2020), but the town receives many tourists from all over Japan, who come for the surfing, sightseeing, and local cuisine (most famously, bonito fish dishes, known as katsuo in Japanese). Tourists are especially vulnerable to tsunamis because they are less likely to be familiar with the town's evacuation areas and routes and may not be aware of the region's history of disasters.

The game uses the player's GPS coordinates to localize them on the map and then shows them points of interest (Figure 6). If the player wants to advance in the game, they have to walk to the points of interest shown on the map. When the player arrives at a point of interest, they have to scan a QR code that has been placed there. In total, 20 points of interest have been added to the game. These points include evacuation areas and towers in addition to important places for the local community such as beaches, parks, museums, and local businesses.

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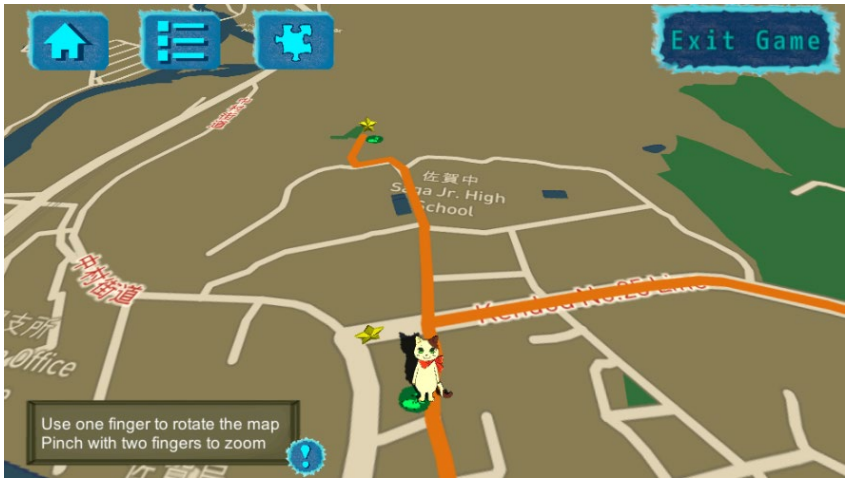

Figure 6. Screenshot of the game Kuroshio no Himitsu showing, a map with the player's GPS location (the cat) and the points of interest (stars).

There are a few ways players are nudged to visit all the locations (to keep them from quitting the game before checking in at all 20 places). First, the game has characters and a story, and the end of the story is revealed only when the game has been finished. Second, each time a player visits a new location they receive a few pieces of a jigsaw puzzle, which they can put together to complete a picture. Third, as shown in Figure 6, there is an orange path that shows a suggested "default route," which is intended to simplify the player's decision about which streets to use.

The game helps players learn in two ways. First, by physically walking around the town, they can memorize the landscape more effectively than by simply reading a map, according to a study by Presson and Hazelrigg (1984). Of course, in this game, players also look at the map on their phone, so they can benefit from seeing both the map and the actual places as they walk around town. Second, the characters in the game sometimes talk about past disasters that happened in the town, as well as share a few facts about the evacuation towers and the pine tree forest (which has been conserved between the ocean and the town with the aim of lessening the impact of a tsunami).

As for testing the game, we plan to test Kuroshio no Himitsu with volunteers. The game will not be advertised as a game for disaster risk reduction or learning purposes. There are two ways the game's effects will be tested. First, the players will be asked within the game itself to complete an online questionnaire. Second, we will record on the game's server which players visit which locations in order to obtain concrete data.

In the future, it would also be interesting to know how this type of game would perform in different towns and to compare the results among them. Other forms of nudges should also be tested in the same town in order to adequately compare different methods. The researchers hope that the game Kuroshio no Himitsu can set a good example of the use of such nudges in future studies.

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Technical Note

Evacuating Vulnerable People During a Tsunami Disaster in Japan: A Simulation Using Wheelchairs

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Abstract Safe, rapid evacuation during natural disasters is particularly challenging for people who are vulnerable and/or need assistance. This study evaluated the feasibility of an evacuation route from a residential area to a designated destination for wheelchair-bound people and their caregivers. Thirteen individuals participated in an evacuation simulation in which they pushed wheelchairs carrying individuals from a start point to a designated destination along a specified route. The simulation was implemented on September 9, 2018, between 9:00 AM and noon. The weather was recorded hourly. Individuals in the wheelchairs were weighted to equal the average weight for Japanese men aged ≥65 years. The route comprised three sections: two were within the predicted tsunami inundation zone and one was on higher ground. The gradients, distances, and altitudes of the three sections were determined using official documentation. Participants were videotaped as they traversed the route, and their speeds and times recorded as the wheelchairs crossed from one section to the next. Immediately upon reaching the destination, participants completed a questionnaire assessing the physical effects of the activity. The route was 280.6 m long with a total vertical increase of 13.9 m. Mean total transit time was 3 min 25 s, and the mean time taken to evacuate the predicted tsunami inundation zone (at 210.2 m) was 2 min 15 s. All participants' speeds were slowest in the third section, which had the steepest gradient (11.14%). Ten participants reported moderate difficulty, difficulty pushing, and sweating. Nine participants reported shortness of breath. The results support use of the evacuation destination during a predicted earthquake tsunami ≥8 m high at landfall.

Keywords: tsunami evacuation, vulnerable people, wheelchair

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1. INTRODUCTION

It is important that residents who need assistance and their caregivers are immediately evacuated when a tsunami is imminent. To effectively accomplish this, disaster prevention organizations need to know the best ways to evacuate vulnerable people and how rapidly this could be achieved. A previous study on vulnerabilities in cyclone evacuation discussed the role of poverty and resultant lack of knowledge and awareness in evacuation (Haque E., and Blair D. 1992). However, excepting our own work, there is no research focusing on the physical vulnerability of people with disabilities and older people in evacuations. Previous studies have measured the transportation speed of vulnerable people under controlled conditions on an experimental course (Ohtsu et al. 2020) and using four types of transportation equipment in drills in urban areas (Ohtsu and Hokugo 2019). Some studies have measured transit speeds along evacuation routes within a tsunami evacuation tower (Tanaka et al. 2019), and the amount of time taken to walk an evacuation route during an evacuation drill (Nihei and Hashimoto 2013, and Muraishi 2014). However, the effect of gradient on evacuation time has not been studied. Evacuation drills have been conducted in Kainan City, Japan, in which community disaster prevention organizations and/or units have assembled and subsequently walked to evacuation destinations. However, such drills have not always considered individual circumstances, including mobility and speed. To support fire departments in assisting residents, it is important to be able to predict residents' mobility by determining how fast wheelchairs can transport people.

One way to prepare for a tsunami or similar natural disaster is to practice before the event moving groups of people to designated safe shelters at higher altitude locations. However, this approach has not been implemented in all the relevant coastal municipalities, and evacuation during an event with no previous practice is risky. Plans and drills are essential disaster prevention activities that facilitate effective evacuations and maximize protection from harm during a disaster. To develop plans and drills, it is important to determine how much time it takes to evacuate all residents in a particular area.

To address this knowledge gap, this study conducted a hands-on simulation experiment of the evacuation speed of people in wheelchairs. The simulation was conducted in Kainan City, Wakayama Prefecture, Japan, which is within the estimated tsunami inundation zone in the event of a great Nankai Trough earthquake. Over the last few decades, research has been conducted on predicted tsunamis caused by undersea earthquakes near the coast of Japan. This research has enabled the estimation of tsunami heights in coastal areas and tsunami arrival times from the earthquake epicenter. Estimated tsunami arrival times are recorded and publicly available via hazard maps published by local governments. People are required to evacuate to an altitude higher than the estimated tsunami height within the tsunami arrival time. The aim of the present study was to examine the evacuation time of the target population to determine if this requirement is achievable, and whether the target population is at risk. The estimated tsunami inundation area as specified by the Kainan City hazard map is shown in Fig. 1. The Ministry of Land, Infrastructure, Transport and Tourism has predicted that a great Nankai

Trough earthquake would have a magnitude of 9.1, a maximum tsunami height of 8 m, and that the time between the earthquake and a 1 m tsunami landfall would be 43 min in Shimotsu, Kainan City. The maximum expected inundation depth of the study area inundation zone shown in Fig. 1 ranges from 2 to 5 m and 5 to 10 m (as shown in Fig. 2), with most of the evacuation route subject to substantial inundation (*i.e.*, inundation of up to three building stories). A tsunami occurs following earthquake tremors in the ocean trench. Generally, to the place closer to the trench tsunami reaches earlier, whereas to the place further away from the trench tsunami takes longer time to reach. This study was conducted in a small part of the area of expected tsunami damage. The aim of the simulation was to clarify the evacuation speed and amount of time needed to evacuate wheelchair-bound people from the inundation zone to a public park designated as the evacuation destination for vulnerable people (in wheelchairs) and their supporters. This study is unique because it evaluated the route designated for community disaster prevention organizations during a disaster; therefore, the findings contribute toward a better understanding of the effectiveness of the current tsunami evacuation plans. The simulation used wheelchairs for transit because the effect of traffic congestion on automobile transit is unpredictable; therefore, cars are not reliable evacuation modes to study in simulations. Some vulnerable people may be moved on stretchers without back supports or wheels; however, this method requires supporters to bear the weight of the vulnerable people. Stretchers are not a feasible option in aging rural areas because supporters are likely to be older adults assisting other older adults over relatively long distances. In these contexts, wheelchairs are the most practical way to evacuate vulnerable people.

2. MATERIALS AND METHODS

The simulation was conducted in the Shimotsu area of Kainan City, Wakayama Prefecture, Japan, on September 9, 2018. Fig. 1 shows the evacuation route and Table 1 describes the topography of the route's three sections. The route began within the predicted tsunami inundation zone of a great Nankai Trough earthquake. The route ended at the entrance to Minato Fureai Park, which is outside and higher than the inundation zone. The Kainan City Tsunami Evacuation Plan designated this park, which is on high ground, as an emergency evacuation destination (Kainan City 2017). The route covered 280.6 m and was divided into three sections for the simulation. Section 1 had a mild gradient (0.09%), and Sections 2 and 3 had relatively steep gradients. Sections 1 and 2 were within and Section 3 was outside the predicted tsunami inundation zone. The difference in altitude between the route's start and endpoints was 13.9 m. This route was selected as an evacuation route for the simulation because it is wide and has a low density of old wooden buildings, and old brick walls; thus, the possibility of route blockage is low.

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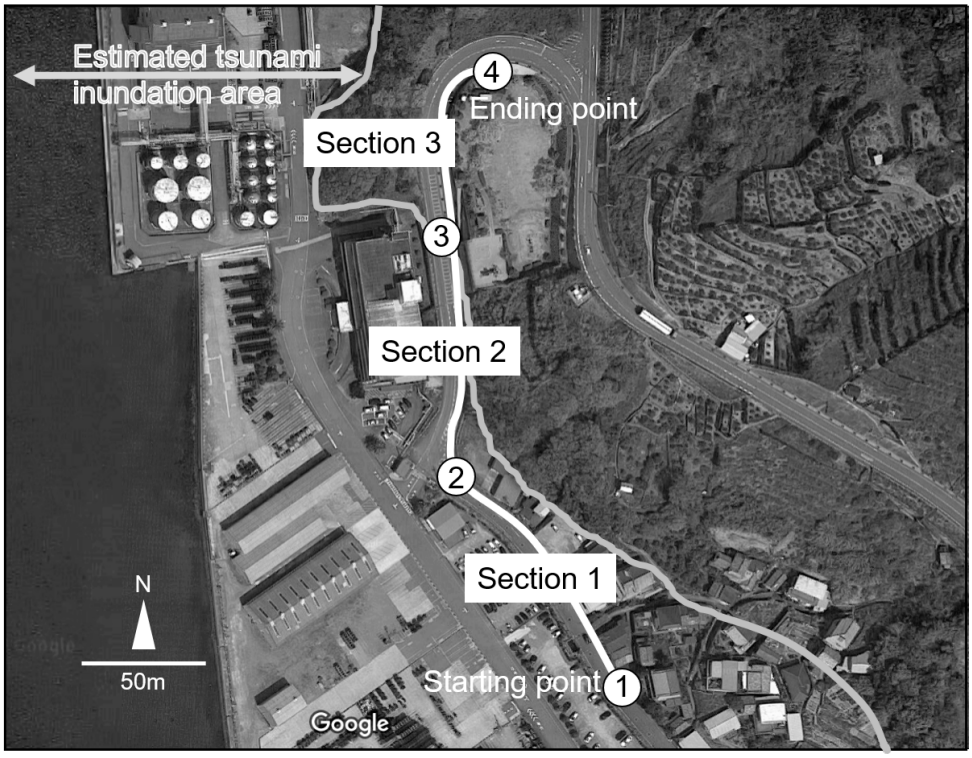

Figure 1. Evacuation Route. Numbers in circles represent the points at which the time was recorded. Source: Google Earth (accessed on October 20, 2018)

Fig. 2 shows the hazard map of the study area and the maximum inundation depth of the inundation area in Kainan City.

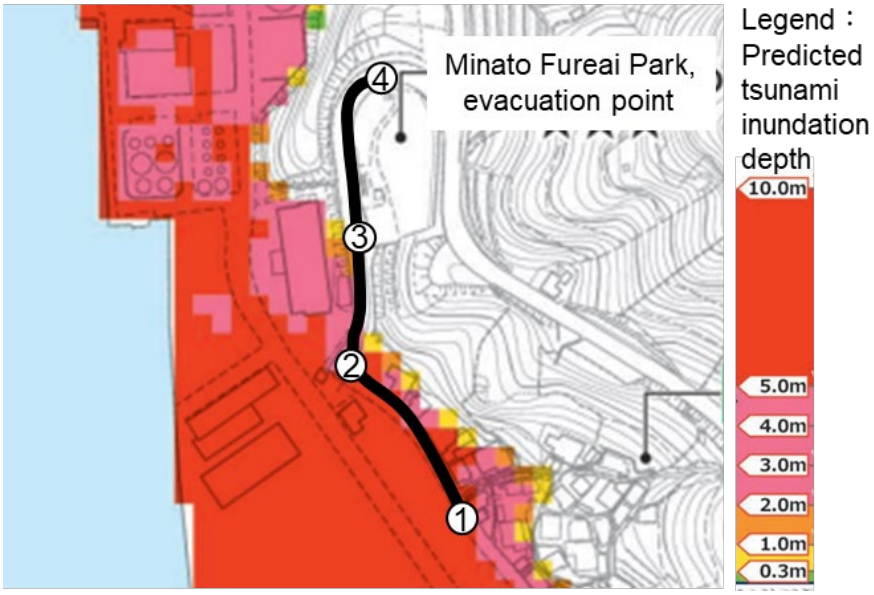

Figure 2. Hazard Map of Shimotsu Area, Kainan City. Magnified image of the area of interest shown in Fig. 1. Source: Kainan City (accessed on December 4, 2021)

Table 1. Topographical Information and Evacuation Route Length by Section.

	Section			Total
	1	2	3	
Average gradient (percentage)	0.09	6.00	11.14	4.96
Length (meters)	110.0	100.0	70.0	
Altitude (meters)	0.1	6.0	7.8	13.9
Transit distance (meters)	110.0	100.2	70.4	280.6

The evacuation destination used in this simulation is listed in the Kainan City Regional Disaster Prevention Plan (Kainan City 2017). The city government has designated 98 evacuation sites, of which No. 62 is Minato Fureai Park. The route designed for this study is a "horizontal evacuation" route to higher ground, rather than a "vertical evacuation" route to a higher floor of a building. Although this area contains a high-rise building, it is in a factory that is surrounded by wire mesh and so is not an easily accessible evacuation point. Therefore, evacuation to higher ground is the only option in this area. The evacuation route extends from the residential area to the destination and has a maximum gradient of 11.14%, which allows for transit by wheelchair. The streets along the route are wide enough to allow people moving at a normal speed to pass slower moving individuals and wheelchairs. The altitude of the destination is 16 m, which is twice the predicted maximum height of a tsunami in Kainan City in the event of a great Nankai Trough earthquake (Kainan City 2017). Roads leading to higher ground from the destination have been constructed; these could be used as routes for secondary evacuations to higher ground if the tsunami wave height is greater than expected or if evacuees need to be moved to shelters. Minato Fureai Park is large enough to be used as a central base for disaster prevention activities, and contains facilities for storing materials and equipment used by community disaster prevention organizations.

Modes of transit

Two types of wheelchairs were used for the simulation: Wheelchair A (W-A) and Wheelchair B (W-B). W-A is slightly lighter than W-B (17.0 kg and 17.9 kg, respectively), and differs slightly in size to W-B (85 cm versus 88 cm high, 68 cm versus 62 cm wide, and 110 cm versus 104 cm deep, respectively).

Simulation procedure

Participants

There were 26 participants in this study. Participants were university students, staff, and teachers who were recruited by the authors. All participants took part voluntarily. Thirteen participants (men and women aged 23–56 years) were assigned to push the wheelchairs.

Thirteen different participants were pushed in the wheelchairs. The body weight of each wheelchair-bound individual was supplemented to equal 62.04 kg, which is the average weight for Japanese men aged ≥65 years (Bureau of Statistics of the Ministry of Internal Affairs and Communications 2011).

Procedure

First, the 13 participants assigned to push the wheelchairs were given the following instructions: "Today, we are conducting a simulation about moving vulnerable people. You need to pretend that you are evacuating from a tsunami inundation zone with a vulnerable person in a wheelchair. You must push the wheelchair with the person sitting in it from the designated starting point to the designated endpoint at the park. You must put the safety of the vulnerable person first while pushing the wheelchair along the evacuation route as quickly as possible." Researchers accompanied each participant as she or he pushed the wheelchair along the route and videotaped the process from beginning to end. The video content was used to determine participants' evacuation time, which was used to calculate evacuation speed. The time at which the rear wheel of the wheelchair passed over each of the four designated points (see Fig. 1) was recorded. Point 1 was the starting point and Point 4 was the end of the route. Points 1 and 2 were inside the inundation zone, Point 4 was outside the zone, and Point 3 was the transitional point. Fig. 2 shows a researcher filming a participant pushing a wheelchair during the simulation. The study comprised the simulation (*i.e.*, the activity of pushing the wheelchair) followed by a questionnaire (Fig. 4).

Figure 3. Photograph of the Simulation in Progress (Section 2 on the Route). Source: *Author*, September 9, 2018

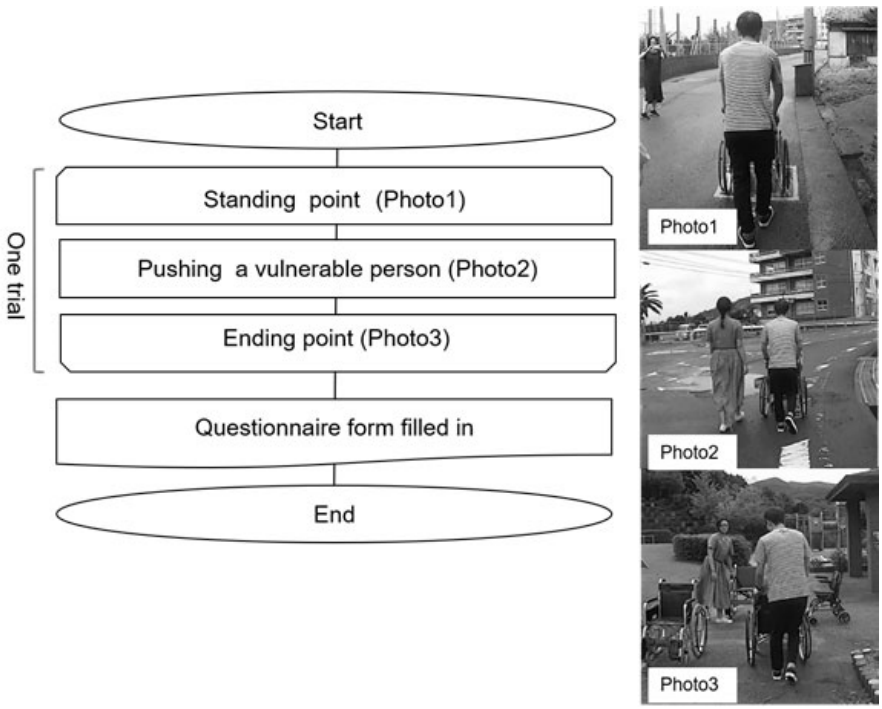

Figure 4. Study Procedure. 1 Source: *Author*, September 9, 2018

3. RESULTS

Weather conditions

The weather conditions between 9:00 AM and noon on September 9, 2018, are shown in Table 3. It was cloudy (with 15.0 km visibility), the temperature range was 26.1−28.0℃, and there was no precipitation (Japan Meteorological Agency 2019). Participants started the simulation sequentially rather than at the same time; therefore, each participant had a different start time.

Table 3. Weather Conditions on the Route During the Simulation.

Time	Air pressure (hPa)		Dew point (C)	Steam pressure (hPa)	Humidity (percent)	Wind velocity	Wind direction
	Land	Sea					
9:00	1011.0	1013.1	23.9	29.6	85	4.3	S
10:00	1011.2	1013.3	23.8	29.4	87	2.1	E-NE
11:00	1011.1	1013.2	22.6	27.4	73	4.7	S
Noon	1010.7	1012.8	22.9	28.0	74	5.6	S-SW
September average*	1010.7	1012.8	24.9	21.8	69	3.5	E-NE

*Average value of the weather in September in Wakayama City for 30 years from 1991 to 2020 (Japan Meteorological Agency, 2021).

Transit speed and time

All 13 wheelchair-pushing participants completed the route without pausing and there was no interference from moving bicycles or pedestrians. For all participants, transit speed was the slowest in Section 3, which had the steepest gradient on the route. The slowest speed in Section 1 (1.43 m/s) was shown by a 26-year-old male participant. A 56-year-old female participant had the slowest speed in Section 2 (1.28 m/s). The slowest speed in Section 3 was 0.88 m/s, which was shared by a male participant aged 26 years and a female participant aged 29 years. The longest transit time from beginning to end (Point 1 to Point 4) was 3 min 54 s, and the shortest transit time was 3 min 10 s. The maximum time it took to reach and pass Point 3 (which was the point at which the route left the predicted tsunami inundation zone) was 2 min 35 s, and the slowest time to that point was 1 min 56 s. Table 4 shows the transit speeds and times of each participant.

Table 4. Transit Speeds and Times of the 13 Participants.

Subject	Age	Gender	Transit speed (m/s)				Transit time (hh:mm:ss)
			Section				
			1	2	3	Total	
1	20s	Male	1.43	1.62	1.14	1.40	0:03:21
2	30s	Male	1.96	1.52	1.01	1.46	0:03:12
3	50s	Female	1.45	1.28	0.88	1.20	0:03:54
4	20s	Female	1.80	1.67	0.93	1.43	0:03:16
5	20s	Male	1.53	1.67	1.19	1.47	0:03:11
6	20s	Male	1.45	1.47	1.01	1.31	0:03:34
7	20s	Female	1.53	1.52	0.90	1.30	0:03:36
8	20s	Male	1.72	1.54	1.10	1.45	0:03:13
9	50s	Female	1.57	1.39	0.94	1.29	0:03:37
10	50s	Male	1.57	1.54	1.08	1.40	0:03:20
11	20s	Female	1.62	1.52	0.88	1.31	0:03:34
12	50s	Female	1.55	1.67	1.19	1.48	0:03:10
13	40s	Female	1.64	1.57	0.99	1.39	0:03:22
Max	-	-	1.96	1.67	1.19	1.48	0:03:54
Min	-	-	1.43	1.28	0.88	1.20	0:03:10
Average	-	-	1.60	1.54	1.02	1.38	0:03:25
Standard deviation	-	-	0.15	0.11	0.11	0.08	

Relationship of transit speed to gradient and altitude

Changes in speed throughout the route

Fig. 5 shows the relationship between transit speed and gradient by section. This relationship seemed to be associated with gradient. Speed was slower in Section 3, where the gradient was steepest. It is reasonable to assume that speed decreased over time owing to participants becoming tired and the increase in the gradient of each section along the route.

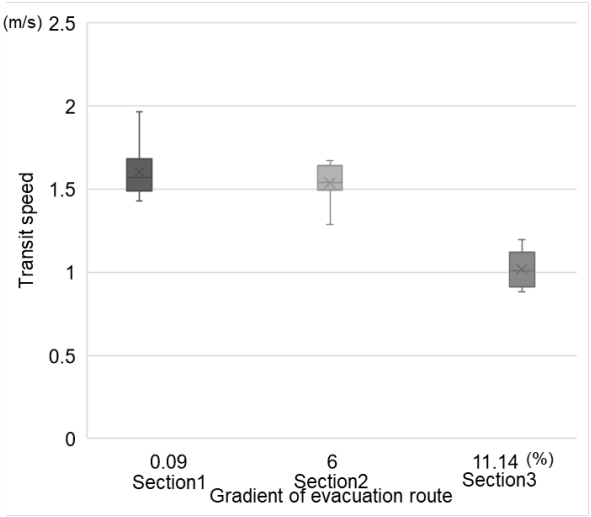

Figure 5. Relationship Between Transit Speed and Gradient.

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Relationship between time and altitude

The amount of time it took to reach and pass Point 3, where the route left the predicted tsunami inundation zone, was the total transit time from the beginning of the route to the end of Section 2. The longest time it took to cross Point 3 was 2 min 35 s, and the shortest time it took to cross Point 3 was 1 min 56 s (average = 2 min 15 s). At Point 3, the altitude was 8 m, which is the predicted maximum tsunami height. Fig. 6 shows the relationship between time spent and altitude for each participant and the point at which each participant crossed Point 3.

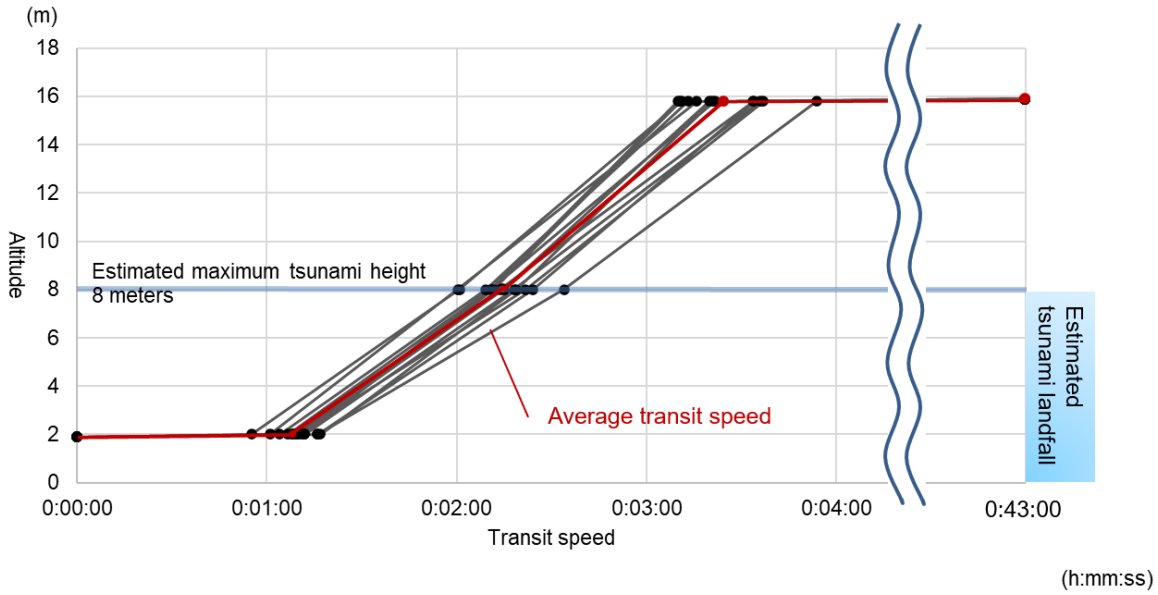

Figure 6. Relationship Between Time and Altitude Along the Route by Participant.

Questionnaire results

At the end of the route, participants completed a questionnaire to assess their previous experiences, how difficult they found the activity, the extent of physical difficulty, and their physical responses to the activity. The responses to the questions about previous experience with wheelchairs, evacuation drills, and evacuation simulations and experiments had no clear relevance to transit speeds and times.

Participants' difficulties with the activity are shown in Figs. 8–10. Ten of the 13 participants indicated that pushing the wheelchairs was the most difficult part (Fig. 7). Ten of the 13 participants stated that it was "rather difficult" to perform the activity, which was the response option indicating the second-highest level of difficulty, although two participants indicated that it was "easy" and one chose the "usual" difficulty option (Fig. 8). Participants reported some muscle pain in the arm (n = 1) and lower back (n = 1), one said that they had experienced "backache" (n = 1), and 10 reported sufficient exertion to be "sweating." Nine subjects experienced shortness of breath (Fig. 9).

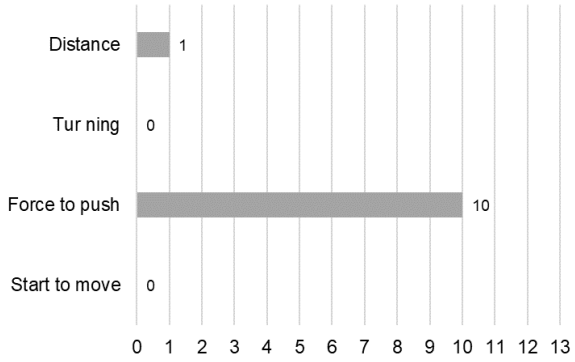

Figure 7. Aspects of the Difficulty of the Activity.

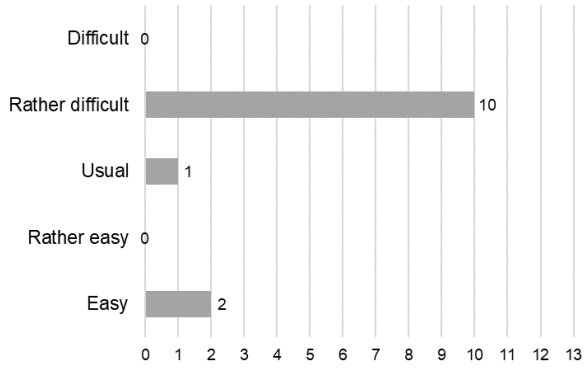

Figure 8. Extent of Physical Difficulty of the Activity.

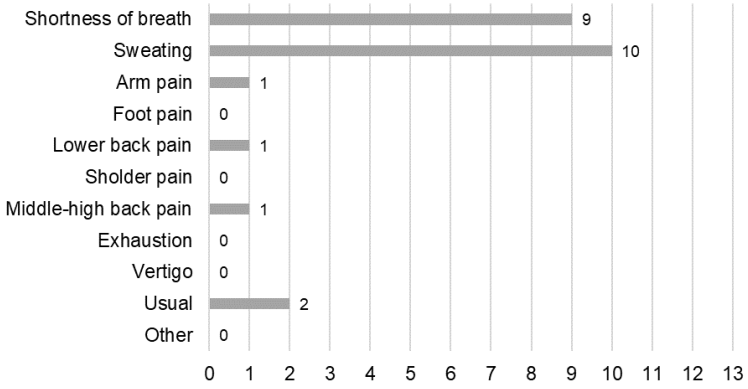

Figure 9. Effects on the Body of the Physical Activity (Multiple Responses Allowed).

4. DISCUSSION

There may be differences between the results obtained in this simulation and performance in a real disaster owing to differences in evacuation preparation time and doubts or indecision before starting to evacuate.

The average age of the participants differs from the average age of residents of this area. Therefore, these results may not fully reflect the transport speed and evacuee experiences on the day of a disaster. However, these findings are meaningful because this was a hands-on velocity experiment conducted along a real evacuation route, rather than a computer simulation. Therefore, the results could be used as realistic data for larger-scale computer-based evacuations. Future studies could further refine these data by asking residents to participate in an evacuation drill.

5. CONCLUSION

This study evaluated the feasibility of an evacuation route from a residential area to a designated destination for vulnerable people and caregivers. We conducted an experiment in Kainan City, Wakayama Prefecture, to simulate the evacuation of vulnerable people to the Minato Fureai Park. The key findings of this study are as follows.

The longest transit time was 3 min 54 s, the shortest transit time was 3 min 10 s, and the average was 3 min 25 s. The longest transit time to reach and pass Point 3 (as shown in Fig. 1), where the route left the predicted tsunami inundation zone, was 2 min 35 s, the shortest transit time was 1 min 56 s, and the average time was 2 min 15 s. Regarding the relationship between transit speed and gradient, speeds were slowest in Section 3, which had the steepest gradient. These results may be helpful in designing evacuation support plans to ensure the safety and wellbeing of residents in this and other areas at risk of tsunami damage. However, a limitation of the simulation was the small number of participants. Unlike previous simulations conducted in buildings or outdoors at private locations, this simulation used the streets that residents use daily. Therefore, the simulation had some spatial and temporal limitations. Future studies should carefully measure speed and other aspects of evacuee activity to reduce tsunami casualties.

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Journal of Integrated Disaster Risk Management

Perspective

Researching Integrated Disaster Risk Management from an Interpretive/Critical Perspective

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Abstract This essay describes what an interpretive/critical perspective on integrated disaster risk management entails and highlights related research contributions in the field. These contributions offer researchers examples of interdisciplinary, international, multi-methodological, and cross-cultural research in an array of disaster contexts that reflect the philosophical and normative commitments of interpretive/critical scholarship. The essay describes the author's experiences in applying an interpretive/critical perspective in researching the U.S. Wireless Emergency Alerts (WEA) system, and it explores the value (and risks) that such a perspective holds for policy intervention, institutional practice, and one's own professional development.

Keywords: Interpretivism, critical theory, integrated disaster risk management, mobile technology, public alert and warning

1. RESEARCHING INTEGRATED DISASTER RISK MANAGEMENT FROM AN INTERPRETIVE/CRITICAL PERSPECTIVE

Drawing from natural sciences, engineering, economics, ecology, and social sciences, integrated disaster risk management considers various natural, technological, and institutional drivers of disaster risk, as well as possible mitigation options including policy, structural, response management, and risk transfer (Wouter Botzen *et al.*, 2019). Much of this work focuses on developing innovative approaches to risk assessment, cost-benefit analysis of risk management options, and ways of optimizing financial, material, technological, and human

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resources within and across disaster phases: mitigation, preparedness, response, and recovery. A random scan of recent titles in this journal suggests the scope of related research: "Towards Optimal Architectures for Hazard Monitoring Based on Sensor Networks and Crowdsensing" (Georges, 2020), "Assessment of Social Vulnerability in the Evacuation Process from Mount Merapi: Focusing on People's Behavior and Mutual Assistance" (Chasanah & Sakakibara, 2020), and "Distributed Ledger Technology for an Improved Index-Based Insurance in Agriculture" (Sushchenko & Schwarze, 2020), just to name a few.

This type of research is immensely valuable for practitioners and scholars. Yet, consistent with the bulk of disaster risk research, these studies, along with most of the articles in this journal, rely upon an "objectivist" ontology. As Chipangura *et al.* (2016) state, an objectivist ontology tends to treat disaster risk as an "objective, deductive, nomothetic, quantitative, explanatory and universal" phenomenon (p. 264). This ontological commitment uniquely distinguishes objectivist from interpretive/critical research. Interpretive/critical researchers view social reality as being embedded within and impossible to disassociate from its historical, material, and cultural setting. As a result, interpretive/critical researchers tend to avoid hypothesis testing and instead aim to interpret social reality via in-depth exploration of people's sensemaking processes. This essay introduces an interpretive/critical perspective to disaster risk researchers who may be unfamiliar with its philosophical commitments and objects of study.

The inspiration for this essay is twofold. First, the article, "Theoretical Contributions of Interpretive and Critical Research in Health Communication," written by Heather Zoller and Kimberly Kline, appeared in the *Annals of the International Communication Association* in 2008. In this essay, I mimic the Zoller and Kline (2008) article in exposing readers to the value (and risks) of an interpretive/critical perspective. Second, this essay coincides with the August 2021 publication of *Critical Disaster Studies*, edited by Jacob A. C. Remes and Andy Horowitz. That landmark volume introduces readers to a radical idea:

> Unlike most existing approaches to disaster, critical disaster studies begins with the idea that disasters are not objective facts, but rather are interpretive fictions—and they shape the way people see the world. By questioning the concept of disaster itself, critical disaster studies reveals the stakes of defining people or places as vulnerable, resilient, or at risk.

This essay likewise argues that many of the concepts deployed within integrated disaster risk management research—*i.e.*, disaster, vulnerability, resilience, risk, and so on—are made meaningful within and through power-laden struggles over language. My hope is that by sharing some of my personal experiences as an interpretive/critical researcher, I might compel some readers to explore what value an interpretive/critical perspective might bring to their research endeavors.

My own work within the integrated disaster risk management area focuses on the moment that lies just between preparedness and response. Specifically, I am among a handful of

researchers who study *mobile* public alert and warning (Bean, 2019; Bean *et al.*, 2015; Bopp *et al.*, 2021; Cain *et al.*, 2021; Cao et al, 2021; Casteel & Downing, 2016; Doermann *et al.*, 2020; Kim *et al.*, 2019; Kuligowski & Doermann, 2018; Lambropoulos *et al.*, 2021; Ling & Oppegaard, 2021; Lui *et al.*, 2017; Nakayachi *et al.*, 2019; National Academies of Sciences, Engineering, and Medicine, 2018; Riel, 2019; Sutton & Kuligowski, 2019; Sutton *et al.*, 2018; Wood *et al.*, 2018; Yoder-Bontrager *et al.*, 2017). Mobile public alert and warning encompasses the technologies, infrastructures, policies, practices, personnel, cognitions, behaviors, and outcomes associated with alert and warning messages delivered through mobile devices (Bean, 2019). I was fortunate to be introduced to this research area by Dr. Dennis S. Mileti when I joined him for a U.S. Department of Homeland Security-funded study of warning system integration in the United States (Bean & Mileti, 2010). Dr. Mileti was regarded as one of the world's foremost disaster sociologists and a—if not *the*—principal expert on public alert and warning. Tragically, Dr. Mileti died from complications from COVID-19 in 2021, but his legacy endures.

Even though I was trained in rhetorical and critical-cultural research traditions during my doctoral studies in communication, I have only recently begun to apply an interpretive/critical perspective in my mobile public alert and warning investigations (Bean, 2019; Bean & Hasinoff, 2022; Bean & Madden, 2019). My collaborations with Dr. Mileti and colleagues from 2009 to 2016 instead focused on conducting qualitative research of mobile public alert and warning messages in ways that aligned with an objectivist ontology and Dr. Mileti's sociological Hear-Confirm-Understand-Decide-Respond model of public warning (for an overview and critique of this model, see Sellnow & Seeger, 2013). My doctoral dissertation advisor was Dr. Bryan C. Taylor, co-author of the oft-cited *Qualitative Communication Research Methods* (Lindlof & Taylor, 2002), so I felt prepared to address the qualitative research dimensions of the multi-methodological investigation that Dr. Mileti was leading. However, my training under Dr. Taylor emphasized rhetorical and critical-cultural communication research, and I was always slightly uncomfortable about some of the objectivist, linear, and mechanistic assumptions that the Hear-Confirm-Understand-Decide-Respond model made about the nature of communication (see Sellnow & Seeger, 2013). I did not often discuss these assumptions with Dr. Mileti, although he seemed intrigued about the diversity of communication theory: One time I visited his home in Rancho Mirage, California for a research meeting, and Dr. Mileti delighted in showing me a copy of his first academic publication, which happened to appear in a communication journal. "Who knew I was a communication scholar?" he jibed.

It was in 2017, after being invited by Dr. Keri K. Stephens to the "Crisis & New Media Conference" at the University of Texas, that I returned to my rhetorical and critical-cultural roots to explore some of the questions that I had ignored during my collaborations with Dr. Mileti. Those explorations culminated in the 2019 volume, *Mobile Technology and the Transformation of Public Alert and Warning* (Praeger Security International). Although he would not have referred to himself as an interpretive/critical scholar, in engaging "milling"

behavior in response to warning messages (*e.g.*, Wood *et al.*, 2018), Dr. Mileti was similarly concerned with the messy dynamics of human communication and meaning making.

With this background in mind, in the remainder of this essay, I expand upon Chipangura *et al.*'s (2016) discussion of social constructivism in disaster risk research. Specifically, drawing from Zoller and Kline (2008), I first describe the commitments of an interpretive/critical perspective. I then highlight recent integrated disaster risk management research that draws upon that perspective. I subsequently discuss the value and risks of the application of that perspective in my own work and conclude with a call for researchers to consider an interpretive/critical perspective in their work.

2. WHAT IS AN INTERPRETIVE/CRITICAL PERSPECTIVE?

Similar to its constituent disciplines, integrated disaster risk management research typically entails objectivist or "post-positivist" analysis of economic or cognitive-behavioral variables. Positivism "is based on the belief that there is an objective reality and that knowledge exists as something that can be observed and measured" (Chipangura *et al.*, 2016, p. 263). *Post*-positivism eschews the (19th century) positivist idea that the researcher and research object (including people) can be completely independent of each other; it instead seeks to avoid hidden biases that subtly taint research preferences and interpretations through improved methodological rigor, triangulation, and error reduction. However, post-positivism maintains an assumption that "the world as it is" can be approximated. Also known as the "correspondence theory" of meaning, this assumption holds that "words" uncomplicatedly denote "things" in the world (Ott & Domenico, 2015). Take for example the three articles mentioned in the introduction of this essay: Georges (2020) developed mathematical models to address the optimal sensor placement problem. Chasanah and Sakakib (2020) developed an index of people's behavior, mutual assistance, and social vulnerability for pedestrian evacuation. Walking speed and risk perception were the main variables, and mutual assistance was found to be effective in reducing evacuation times for vulnerable people in their case study. Sushchenko and Schwarze (2020) compared features of yield-based insurance and index-based insurance for agriculture to show that an application of distributed ledger technology could solve compensation payment problems and facilitate the development of innovative insurance mechanisms. These post-positivist studies were selected at random, and they offer valuable contributions, but they are typical of the type found in journals that publish integrated disaster risk management research. In these studies, subjective meaning is viewed as transparent or unimportant, *i.e.*, as a neutral link intervening between initiating material factors and the human behaviors those factors are alleged to produce (Blumer, 1969).

By contrast, an interpretivist/critical perspective is drawn from developments in Continental Philosophy that occurred in the second half of the twentieth century. Touchstones within this tradition include the French historian and philosopher Michele Foucault's (2007) investigations

of how knowledge, discourse, and power reciprocally shape social truths across time. Claude Lévi-Strauss's (2008) development of structural anthropology explained why and how humans are unaware of the workings of the social structures that shape their daily life. Julia Kristeva (1984) examined how "poetic language" challenged correspondence conceptions of meaning in which words merely denoted things or thoughts. These developments greatly contributed to the understanding of the human experience, the relationship between humans, language, and nature, and the arc of social development. These perspectives share a concern for the "intersubjectivity" of language and understanding, that is, the idea that the production and reproduction of knowledge (including self-knowledge) arises from subjective experience shared among people through the exchange of symbols (*i.e.*, language). In the late twentieth century, scholars from across the humanities and social sciences began applying approaches derived from hermeneutics, structuralism, post-structuralism, deconstruction, feminism, psychoanalytic theory, and critical theory in their work. Critical "turns" or variants of anthropology, communication, psychology, and sociology began to emerge to investigate the role of discourse, culture, and power in interpreting social phenomena and shaping disciplinary knowledge.

An interpretive/critical perspective maintains different ontological and epistemological assumptions than a post-positivist perspective. Ontology refers to the nature of phenomena and epistemology refers to how we can study or come to know that nature. Theories, research goals, and practical orientations vary due to different ontological and epistemological assumptions. An interpretive/critical perspective maintains the basic ontological assumption that our perceptions of ourselves and reality are constituted through the meanings that we attach to them. These meanings are historically and culturally constructed through social, power-laden interactions. An interpretive/critical perspective therefore emphasizes meaning's "subjective character, its relational quality, its contextual nature, its non-linguistic dimensions, its embodied tenor, and its indirect referentiality" (Ott & Domenico, 2015, p. 253). Every human being is born into a set of historical, material, social, and symbolic conditions that they did not choose but which they must confront in making sense of themselves, others, and the physical and social phenomena they experience.

Epistemologically, earthquakes, tsunamis, volcanic eruptions, and other natural phenomena are "non-discursive," but their meanings and implications, like the concepts of "integrated," "disaster," "risk," and "management," are not pregiven and must be constructed and reconstructed intersubjectively. From this perspective, meaning "does not exist prior to utterances; meaning depends upon and emerges within specific language use" (Ott & Domenico, 2015, p. 245). In other words, what an earthquake "meant" to someone living 500 years ago is not the same as what it means to someone living today due to historical, cultural, and linguistic differences (Steinberg, 2006). Importantly, meaning cannot be separated from processes of disaster risk policy formulation and implementation (Chipangura *et al.*, 2016). Thus, an interpretive/critical perspective focuses squarely on the process of meaning-making. As Zoller and Kline (2008) state:

> This perspective seeks to provide in-depth understanding of lived experience or a unique, well-argued and defended interpretation of a discourse to impart some insight into the multiple ways in which communication fosters particular meanings. Interpretive/critical scholars do not necessarily attend to (in)accuracy or rightness/wrongness of messages as measured against some objective reality. Rather, they engage in the double hermeneutic … of interpreting others' interpretations, remembering that the phenomena we study in the social sciences are socially constructed. (p. 93)

This perspective nevertheless acknowledges that the meanings humans give to earthquakes, tsunamis, volcanic eruptions, and other natural phenomena are not infinite. Mark Johnson (2013) argued that meaning "arises from the felt qualities of events and situations generated by active and moving bodies … [it] emerges out of (or originates with) pre-conscious sensorimotor experiences that precede and, subsequently, structure perception and other higher cognitive processes such as intellectual feelings and reflective thinking" (quoted in Ott & Domenico, 2015, p. 239). Johnson's perspective helps account for the similarity of meanings and practices observed across cultures and time periods in relation to earthquakes, tsunamis, volcanic eruptions, and so on (Garnier, 2019).

The "critical" element in the interpretive/critical perspective relates to the ethical and political position one takes vis-à-vis the double hermeneutic and constructed interpretations. The objective of critical research is not necessarily to defend a scientific consensus or create a new one but rather to provoke "dissensus," *i.e.*, to foster the (sometimes uncomfortable) recognition of the ways that certain people's interests are privileged over other people's interests in the struggle to control meaning (Deetz, 1992). While interpretivism and critical theory both assume socially constructed realities, interpretivism is generally more focused on describing and understanding those realities, while critical theory explicitly seeks to challenge dominant meanings and social orders. A critical perspective emphasizes issues of power, control, inequality, and difference that may be ignored in mainstream disaster risk management research.

The criteria for judging the worth of scholarship differs between a post-positivist and interpretive/critical perspective. Post-positivist studies tend to aim for predictive validity, reliability, and generalizability. An interpretive/critical perspective, by contrast, tends to emphasize the usefulness and depth of insight of a researcher's interpretation through the transparency, comprehensiveness, and quality of the analysis. Evidence within an interpretive/critical study is usually of two types: (a) evidence of a systematic and rigorous analytical process, and (b) evidence of the basis of results and knowledge claims (Greckhamer & Cilesiz, 2014). The usefulness of the research for both those under study (*i.e.*, in helping to transform inequitable policy and practice) and other discourse communities (*i.e.*, scholars, practitioners, policymakers, *etc*.) is also a measure of quality. How well a study connects local knowledge to the larger sociocultural context is critical.

It is important to note that post-positivist and interpretive/critical studies do not necessarily require different methods, although quantitative approaches are typical of the former and qualitative approaches are typical of the latter. Zoller and Kline (2008) observe, however, that "the approach to analyzing and understanding data, not the strategy for collecting data, distinguishes between post-positivist and interpretive/critical research" (p. 95). It is also important to underscore that both generalizability and local specificity can be equally desirable research objectives. Context-dependent findings can generate hypotheses that lead to broad validation and generalization, while generalized findings can, alternately, spur investigations of local, situated knowledge and the diversity of meanings. Post-positivist and interpretive/critical perspectives need not be set in opposition to each other.

That said, an interpretive/critical perspective enables the donning of a particular kind of scholarly identity, one contrasted with alternate ontological and epistemological commitments (*e.g.*, objectivism, post-positivism, experimentalism, *etc*.). That identity emphasizes the "reflexive study of symbolically-mediated, intersubjective meanings, as they arise experientially" for researchers through their "immediate encounters" with the members of the groups they study (Taylor *et al.*, 2021, p. 5). One's confrontation with that scholarly identity invites reconsideration of the "deep, interconnected questions of *what we do*, *how we do it*, and *who we are*" (p. 2, emphasis in original). Engagement with issues of struggle, trauma, judgement, and advocacy are permitted and encouraged, and avowals of detached, neutral, and de-politicized social-scientific inquiry are viewed with suspicion (Mumby, 1997).

Despite the insights that an interpretive/critical perspective might yield, intellectual communities tend to see some ontological and epistemological perspectives as more legitimate than others based on that community's values and purposes. There is professional risk in using a research perspective that one's peer group does not find legitimate. For some researchers, disaster risk management is a topic *exclusively* associated with physical and material phenomena that can be objectively assessed, wherein "disaster risk can be viewed as the real, quantifiable product of nature's impact on society; independent from the social constructions of a society" (Chipangura *et al.*, 2016, p. 265). In this regard, integrated disaster risk management research that explicitly applies the philosophical commitments of interpretivism is somewhat rare. Google Scholar reveals just 152 results when using the search terms "disaster risk management" and "interpretivism." Research that draws upon critical theory appears slightly more prevalent, with Google Scholar revealing 250 results when using the search terms "disaster risk management" and "critical theory." There are, of course, plenty examples of research that generally reflect (some of) the commitments of an interpretive/critical perspective without overtly naming it (*e.g.*, Figueroa, 2013; also see Yamori, 2020). Nevertheless, interpretive/critical research is merely a drop in the bucket of integrated disaster risk management research more broadly, which sees 2,300 Google Scholar results using the search term "integrated disaster risk management" and 55,000 results when the word "integrated" is removed.

This section discussed some of the main features of an interpretive/critical perspective.

The next section highlights how those features have been applied in recent integrated disaster risk management research.

3. EXAMPLES OF INTEGRATED DISASTER RISK MANAGEMENT RESEARCH USING AN INTERPRETIVE/CRITICAL PERSPECTIVE

The examples discussed in this section illustrate how researchers have applied an interpretive/critical perspective in disaster risk management studies. This section is not intended as a comprehensive review of scholarship, which is beyond the scope of this essay. In reviewing disaster risk research that uses a social constructivist perspective, Chipangura *et al.* (2016) already identified and synthesized many interpretive/critical studies. This section therefore concentrates on a handful of post-2015 examples that explicitly invoke an interpretive/critical perspective, as well as the overarching position that:

> … disaster risk is not only primarily the outcome of geophysical processes, but can be seen as created in social, economic and political systems, including the product of failed development. Disaster risk is therefore more a function of vulnerability than natural hazards. (Chipangura et al., 2016, p. 268)

For example, Ginige *et al.* (2016) used an interpretive perspective to examine how to "mainstream" women into disaster reduction practices in the built environment in Sri Lanka (where women accounted for 80 percent of the deaths from the 2004 Indian Ocean earthquake and tsunami). By "mainstreaming," the researchers referred to the process of assessing the implications of any planned disaster reduction action for different gender groups, "It is a strategy for making the concerns and experiences of women as well as men an integral part of the design, implementation, monitoring and evaluation of policies and programmes at all levels to ensure that women and men benefit equally" (p. 612). To do this, the researchers explicitly applied their commitment to the "constructionism ontology and interpretivism epistemology" (p. 612), adopting a case study approach, in-depth interviews, and thematic analysis. Consistent with an interpretive perspective, the researchers acknowledged the contingency of their conclusions and recommendations, "Mainstreaming women into DRR [disaster risk reduction] in the built environment is not a universally standard practice that can be designed to implement in any country or place disregarding the contextual variables such as social, economic, cultural and political factors" (p. 616). Illustrating a critical edge in their analysis, the researchers mined interview data to identify regulatory loopholes that hindered the proper implementation of the gender mainstreaming process. They quoted one of their participants, who warned, "that 'documentation ensuring peoples' voices are heard can be easily manipulated," which suggested that "the process of mainstreaming women could be limited only to a paper exercise" (p. 622). Another participant warned of "people in the local community trying to manipulate DRR knowledge and needs to achieve their personal intentions" (p. 622). In this way, the

Ginige *et al.* study represents the critical perspective's focus on power and control over language/text.

The Ginige *et al.* (2016) study underscores the theme of holding disaster risk management stakeholders accountable for the participatory practices they claim to support. Too often, institutions sustain their power by using the rhetoric and form of community participation yet empty that participation of its substantive content (Doxtader, 1995). For example, in "External Stakeholders' Attitudes Towards and Engagement with Local Knowledge in Disaster Risk Reduction: Are We Only Paying Lip Service?" Trogrlić *et al.* (2021) demonstrated that "appreciation" of the importance of local knowledge of disaster risk reduction is widespread within the field, but its inclusion in actual practice remains limited (p. 1). Explicitly citing an interpretivist epistemology and using a case study research design, the authors interviewed external stakeholders involved with community-based flood risk management in Malawi to understand the meanings and uses of "local knowledge." They found "the strong dichotomy between local and scientific knowledge persists and it has led to the further marginalisation of [local knowledge]" (p. 1).

From a post-positivist perspective, the idea that disaster risk management experts should give "equal weight, recognition and importance to [local knowledge]" (Trogrlić *et al.*, 2021, p. 1) is puzzling. From the traditional perspective, the limits of "local knowledge" actually serve to justify the necessity of disaster risk managers as providers of superior expertise in the first place (Ponce de Leon, 2021). At its worst, disaster risk management research risks stigmatizing local knowledge (read: culture) as a morass of primitive structures and processes contributing to irrational decision-making. An interpretive/critical perspective reconsiders this non-expert/expert relationship, focusing instead on bi-directional exchange through the collaborative construction of disaster risk information suited to local needs (*e.g.*, Takenouchi *et al.*, 2017). In contrast to a top-down approach, the collaborative paradigm emphasizes that effective disaster risk management practices are collaboratively constructed by collectively transforming a large amount of highly specialized risk information into a format that addresses local needs and the empowerment of local actors (Mărgărint *et al.*, 2021; Takenouchi *et al.*, 2018).

Recent examples of interpretive/critical studies that advance local actor empowerment include Chipangura *et al.* (2017) and Ponce de Leon (2021). Chipangura *et al.* (2017) critically explored societal perceptions of disaster risk problems in Zimbabwe in order to give them meaning and render them manageable. The researchers found that similar to the case in other non-Western countries, Zimbabwe's disaster risk management system is dominated by the "hazard frame," with rival frames such as "vulnerability" and "theistic" being silenced (p. 317). The researchers' interpretive/critical analysis concluded:

> … disaster risk problems should not be viewed as unitary and state-centred, but rather as diverse and multi-dimensional. This realisation is crucial in understanding that the locus of disaster risk problem is not to be found primarily in governmental agencies;

> rather, it is to be found in the communities where risk is generated and experienced. (p. 323)

In "The Purok System of San Francisco, Camotes: A Communication Perspective of Community-Based Haiyan Response," Ponce de Leon (2021) similarly argued that the community-based disaster risk management (CBDRM)-based *purok* system used in the Philippines is superior to the top-down approach to disaster risk management imposed by national authorities. However, Ponce de Leon's analysis did not simply valorize local knowledge: it acknowledged that the *purok* system has at times not worked well because communities have lacked trust in their local government leaders. Ponce de Leon stated that despite the promise of empowerment, "the *purok* system is largely top down in its transfer of knowledge: citizens feel that the *purok* system forces them to volunteer, obey, and cooperate on penalty of not being helped in the future" (p. 3). Ponce de Leon's critical analysis demonstrates how the move from top-down to horizontal and collaborative approaches is not immune to the influence of power. As Fuentealba *et al.* (2020) state:

> Although the literature asserts that DRR—like all policy interventions—is a political process, there is still a need to expand this knowledge in terms of how DRR governance evolves over time and how and when policy implementation produces certain effects on the ground. (p. 245)

An interpretive/critical perspective does not shy away from the power-laden dynamics of disaster risk management, *i.e.*, its institutional and disciplinary politics. The next section further engages these themes.

4. APPLYING AN INTERPRETIVE/CRITICAL PERSPECTIVE IN MOBILE PUBLIC ALERT AND WARNING RESEARCH

In this section, I discuss how I have applied an interpretive/critical perspective in my research concerning mobile public alert and warning, and I describe the value (and risks) that such a perspective holds for policy intervention, institutional practice, and researchers' professional development. As the studies reviewed above indicate, there is no singular approach to applying an interpretive/critical perspective, and within my own research, I have drawn upon grounded theory, rhetorical analysis, cultural studies, and ideology critique in analyzing and interpreting mobile public alert and warning phenomena.

For example, before experts can "optimize" mobile alert and warning messages (National Academies, 2018), they must understand how diverse groups of people make sense of and respond to their content. During my collaborations with Dr. Mileti, I used a grounded approach (Strauss & Corbin, 1997) to identify and analyze themes that emerged from focus groups I conducted with community members in Denver, Colorado. I discussed with these community members mock WEA messages for different types of hazards. While the themes that emerged

were viewed through an objectivist lens and associated with Dr. Mileti's Hear-Confirm-Understand-Decide-Respond model of public warning (Bean *et al.*, 2014), the experience was nevertheless eye-opening in helping me see how race, class, and gender intersected people's interpretations and responses (social categories were not the focus of the project, however). For example, a few of the Black participants in the focus groups commented that messages emanating from the Denver Police Department would not be trusted, while nearly every White participant voiced high levels of trust in those messages (Bean *et al.*, 2014). The project did not test mock messages in Spanish, thereby further entrenching what de Onís *et al.* (2020) have called emergency management's "English monolingualism." When asking participants about the messages' instruction to shelter in a basement, some participants intimated that they had no basement, revealing the message writer's middle-class assumptions about the typical domicile (Bean *et al.*, 2014). Several women in the focus groups stressed their responsibilities as mothers: They would seek to protect their children before all else, even in ways that could seem irrational.

In this case, an interpretive/critical perspective was valuable for surfacing differences in what constitutes an "appropriate" response to mobile alert and warning messages. The perspective usefully accounts for the diverse experiences of research participants. While I did not conduct contextualized investigation of alert and warning response based on social identity categories, I gained an awareness of how "non-rational" ways of responding to warning messages are construed based upon a particular set of values and assumptions. In subsequent studies, I have taken to heart the lessons learned from this experience, striving to ensure that research designs better account for participants' demographic, linguistic, and cultural diversity. Public alert and warning officials must likewise account for their community members' diverse experiences despite what generalized (post-positivist) social science research findings may reveal.

Another area where an interpretive/critical perspective has been valuable is in understanding how technological choices shape mobile public alert and warning policies and practices. Traditional risk communication studies typically correlate alert and warning message elements with public responses (*e.g.*, Sutton *et al.*, 2018). While such studies are extremely valuable, knowledge, discourse, and power embedded within institutional settings shape technological choices in the first place. In my study of the origin and design of the WEA system (Bean, 2019), I used an interpretive/critical perspective and a rhetorical approach to analyze how certain stakeholders framed the "problem" that the WEA system was supposed to address. These stakeholders defined the problem in terms of the need for a "bell ringer," *i.e.*, a mobile device-based alert that would compel recipients to check other sources of media (*e.g.*, television or radio) for further information. Other stakeholders, however, believed that the "bell ringer" framing discounted the powerful role that mobile devices could play in helping message recipients immediately obtain additional and confirming information. These stakeholders instead sought to shape the WEA system in ways that facilitated rapid information acquisition via messages that included hyperlinks and phone numbers. Several years after the initial design of the WEA system had been approved (without permitting embedded hyperlinks and phone

numbers), the U.S. Federal Communications Commission (FCC) reversed course, claiming that wireless service providers had provided no evidence that such inclusions would degrade their networks, as had been asserted during the WEA system design phase (see Bean, 2019).

In this case, we can observe how certain stakeholders sought to control discourse in ways that produced outcomes congruent with their material (read: financial) interests. It took 12 years for the design of the WEA system to change, illustrating how the struggle to control meaning can produce lasting consequences for disaster risk management technologies and those who must use them. Integrated disaster risk management researchers would do well to scrutinize how certain assumptions, policies, and processes are constructed as "normal," "natural," or "self-evident" within institutional settings. A critical perspective might emphasize, for example: a) how historical/social processes construct the authority, legitimacy, and standard operating procedures of disaster risk managers (*e.g.*, de Onís *et al.*, 2020); b) how disaster risk management discourses work to suppress or elide conflict among competing groups (Bean, 2019); c) how techno-rationality prohibits indigenous or alternative reasoning and decision-making processes (*e.g.*, Ponce de Leon, 2021); and d) how instrumental rationality and technocratic authority compel consent from stakeholders (*e.g.*, Shaw *et al.*, 2021). A critical perspective calls for the undistorted representation of the full variety of stakeholder voices in processes of disaster risk management decision-making (Deetz, 1992).

Lastly, an interpretive/critical perspective has been valuable in investigating the role of institutional ideology and identity vis-à-vis WEA system policies and practices. Specifically, I have critiqued the WEA system's "Presidential Alert" message class, demonstrating how it perpetuates ideological assumptions about the necessity of presidential control during a national emergency (Bean, 2019). The design of the WEA system is shot through with the Cold War-era assumption that instantaneous presidential communication is not only desirable but the principal reason to have a national alert and warning system in the first place (Siegel, 2011). The problem with this assumption is that many Americans do not share institutional members' belief that the President of the United States should be always able to (under all conditions) send a message to them. For example, the FCC acknowledges that a Presidential Alert could interrupt the last goodbyes exchanged between loved ones during a cataclysmic disaster (such as a nuclear attack). The occupational identities and ideological commitments of those in control of the WEA system have naturalized presidential authority and control as institutionalized "common sense." The Presidential Alert moniker reinforces a technocratic, "closed world" ideology (Edwards, 1996).

In 2021, following a 2018 false alert WEA message of a nuclear missile attack on Hawaii, the FCC cited comments based on my interpretive/critical research (Bean, 2019) in a rulemaking that renamed the Presidential Alert message class as "National Alert" to avoid undesirable political associations that could hamper public protective action compliance (Federal Communications Commission, 2021). In this case, an interpretive/critical perspective helps us see how policy making is marked by complex interactions among rhetoric, ideology, and identity. An interpretive/critical perspective reveals the "gaps, compulsions, excesses,

contradictions, absurdities, and repressions of hegemonic ideology" (Taylor, 2010, p. 7). Indeed, even Dr. Mileti once mocked the peculiar deference paid to the WEA system's Presidential Alert message class:

> No words out of a president's mouth after a nuclear attack are going to calm anybody. If we just had ten nuclear bombs take out Chicago, New York City, Washington, D.C., Los Angeles, Seattle, Houston, Dallas, *etc*., do you think it's going to be possible to calm anxious nerves? It's insanity. (Every Little Thing, 2017, 20: 48)

These examples point to the value of an interpretive/critical perspective, but there is professional risk involved in challenging dominant perspectives. Let me be blunt: Interpretive/critical researchers risk being excluded from institutional funding opportunities that privilege mainstream approaches. Institutional elites may shun one's work, denying interpretive/critical researchers both access to inside arenas of decision-making and the ability to participate in related initiatives, working groups, or conferences. Disciplinary colleagues may deem one's work "renegade" and avoid collaborations. Similar to the challenges faced by "activist" researchers (Frey & Carragee, 2007), those who deploy an interpretive/critical perspective in their work may confront a more difficult career path. The payoff for using an interpretive/critical perspective, however, is considerable: intellectual sanction to (a) investigate processes of meaning construction, (b) explore knowledge of disaster risk management practices and everyday experiences, (c) theorize the politics of identity construction and its relationship to social power in disaster risk management, and (d) amplify marginalized voices (Zoller & Kline, 2008). For me, the benefits have so far been worth the risks, but every researcher must calculate for themselves the potential tradeoffs.

5. CONCLUSION

Interpretive/critical research has made major contributions in disaster-related fields including health communication, sociology, psychology, and others. Work directly within the integrated disaster risk management arena cited herein is promising, and we can expect more to follow in the future. Organizations such as New York University's Initiative for Critical Disaster Studies signal that disaster risk reduction, disaster medicine, public health, emergency management, and various engineering fields are ripe of the application of an interpretive/critical perspective. Indeed, the IDRiM Society's charter states that its main objective is to "promote knowledge sharing, interdisciplinary research and development on integrated disaster risk management contributing to the implementation of success models for efficient and equitable disaster risk management options" (2021). The IDRiM Society's acknowledgment of "equity" is laudable. An interpretive/critical perspective likewise emphasizes that research should aim to cultivate marginalized voices, to support people who are most at risk, and to contribute to efforts to build more just, equitable, and safe communities.

Finally, this reflection essay is itself a construction and interpretation. It works to define disciplinary boundaries and shape meaning. It aims to challenge certain disciplinary norms but may also reify others. It represents one researcher's attempt to make sense of his life's experiences and to impart something of value to readers. It asks readers to critically assess whose voices are being heard and whose interests are being served in disaster-related research and to reflect upon how the pursuit of (post-positivist) theory development intersects the lived experience of those who must confront the onset or aftermath of a disaster, as well as those who study such groups. Ideally, this essay might serve as a resource to either shake up taken-for-granted assumptions about the nature and role of research or bolster one's resolve in choosing an interpretive/critical perspective. Interpretive/critical research may not always be well received by colleagues and stakeholders who may have more to gain by ignoring the substance of its ethical and political implications. Asking questions about power, control, interests, and equity can spur discomfort, suspicion, or resentment. But it can also inspire, critique, and cajole—and those outcomes are at the heart of the scientific enterprise as much as any other.

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Original paper

Evacuation Preparation Scenarios of Households during Early and Emergency Evacuation: A Case Study of Cyclone Bulbul in Southwestern Coastal Bangladesh

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Abstract Bangladesh is one of the most disaster-prone countries worldwide. Every year, the country sees a small- or large-scale disaster, with past disaster history showing that cyclones have been a major phenomenon. Cyclone Bulbul made landfall on the southwestern coast of Bangladesh on November 10, 2019, with an average storm surge height of 1.0 to 1.5 meters—resulting in the inundation of low-lying areas in 14 coastal districts. This study conducted a questionnaire survey of 413 households in Gabura, a union under Shyamnagar Upazila of Satkhira District, from mid-February to mid-March 2020 to investigate respondents' evacuation experience during Cyclone Bulbul. The questionnaire survey comprised both qualitative and quantitative approaches that analyzed disaster preparedness level, successful evacuation scenarios, and early evacuation decisions and their implementation in Gabura Union during Cyclone Bulbul. The survey results revealed that approximately 55% of the respondents evacuated during Cyclone Bulbul. Among them, 47% made early evacuation decisions, but an analysis of their evacuation starting time revealed that only 35.5% of them evacuated early before Cyclone Bulbul made landfall. Moreover, this research highlighted the importance of having adequate preparation time before starting evacuation, with most of the household respondents stating that they needed 2 hours in preparation time before starting evacuation. However, the preparation time varied between 1 and 6 h depending on the evacuation stage, the type of preparation activities, and the presence of vulnerable members in the house. Both categories of respondents, that is, those who made early evacuation decisions and those who followed through, cited evacuation companions, the presence of sick members

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in the house, distance from home to shelter, evacuation travel time, and socio-economic characteristics as common influential factors. Respondents in the emergency evacuation category identified previous disaster experience, the presence of sick members in the house, and socio-economic aspects as the factors that they considered while making evacuation decisions during Cyclone Bulbul. This analysis of factors influencing early evacuation decisions, early evacuation, and emergency evacuation helped shed light on people's perceptions about disasters, which can guide authorities in taking policy actions to improve early evacuation possibility and issuing early evacuation orders to ensure safe and successful evacuation during cyclones or other disasters in the future.

Keywords: Cyclone Bulbul, Evacuation Preparation Time, Primary Stage of Cyclone, Early Evacuation Decision, Early Evacuation

1. INTRODUCTION

Evacuation plays a vital role in reducing disaster damage. This study mainly focused on the early evacuation scenario and the possibility of early evacuation during future disasters, especially cyclone disasters. For the analysis, the study chose three wards in Gabura Union of Shyamnagar Upazila (sub-district) of Satkhira District, one of the worst-hit communities during Cyclone Bulbul, which struck the southwestern coast of Bangladesh on November 10, 2019.

Early evacuation decisions define whether households decide to evacuate before they receive the official evacuation order. Early evacuation decision means that after hearing the first warning signal, respondents decide their possible evacuation before they receive the official evacuation order—10 h before the predicted landfall of the cyclone. Similarly, if in actual cases, households make their evacuation before they receive official evacuation orders from a responsible authority, this is distinguished as early evacuation. There is no official early evacuation order from the perspective of Bangladesh during cyclones. This research examined the possibility of early evacuation based on the current official evacuation order. Evacuation during a disaster facilitates successful and safe evacuation, which is important for reducing physical damage. The Bangladesh Meteorological Department issued a cyclone warning at four stages: the first stage is the cyclone alert stage, 36 h before the predicted landfall; the second stage is the cyclone warning stage, 24 h before the predicted landfall; the third stage is the cyclone disaster stage, 18 h before the predicted landfall; and the last stage is the cyclone great-danger stage, 10 h before the predicted landfall (Parvin *et al.* 2019). These four stages of warning signals are the current organizational framework for the Bangladesh Government Disaster Management Ministry to disseminate the warning and evacuation orders during cyclones. The official evacuation order is given at the cyclone great-danger stage, 10 h before the predicted landfall. This research investigated the details of early evacuation decisions and

early evacuation and the associated influential factors that affect the safe and successful evacuation.

Although the complexities and rules of early evacuation are different for different disasters, researchers agree that early evacuation is important to mitigate damage during tsunami disasters (Yun and Hamada 2012). However, that study focused only on the starting time of evacuation during a tsunami disaster, rather than determining the early evacuation time. An effective evacuation plan and timely evacuation are very important for safe evacuation—reducing casualties and property damage. Kruger *et al.* (2019) confirmed that successful evacuation involves various components, such as governmental and non-governmental organizations' participation, disaster response capabilities, sources of information, and aspects related to communication sources. Bangladesh is recognized as one of the most disaster-prone countries worldwide, as it frequently experiences cyclones and other disasters. Therefore, many people are vulnerable, both physically and economically, leading their lives in danger. The coastal zones are low-lying areas situated on the deltas and floodplains of the three major rivers. Cyclones formed during the monsoon season from June to September are usually associated with storm surges. Because of such storm surges, high tides make the coastal land and embankments unstable, causing huge loss of life and property damage. Various governments and international organizations have reported that because of climate change-driven sea-level rise and cyclonic storm surges, around 20 million people in coastal districts are expected to be displaced (Ali *et al.* 2012). Concerning the evacuation decision-making process, many previous studies have focused on warning systems, cyclone shelters, information dissemination, route selection, destination, and evacuation behavior during disasters (Ahsan et al. 2016; Haque and Blair 1992; Haque 1995; Paul 2012; Roy *et al.* 2015). Furthermore, several studies have investigated the factors that affect people's evacuation decisions during emergencies.

The coastal areas in Bangladesh are vulnerable to cyclone disasters. As various factors, including evacuees' behavioral responses, pose challenges to successful evacuation, it is important to evacuate early to reduce loss of life and damage to property (Paul 2012). People living in Bangladesh's coastal areas are at risk, but they usually decide to evacuate in the last minute; thus, it becomes very difficult to complete the evacuation, especially given the weather conditions (Haque and Blair 1992). Additionally, in coastal areas, over 90% of evacuees walk the evacuation routes, but poor road conditions and communication systems sometimes make travel from their home to the shelter impossible. This state of affairs reasonably agrees with the conclusions of previous studies that acknowledged distance as an important issue in evacuation decisions in coastal Bangladesh (Chowdhury *et al.* 1993; Ikeda 1995; Mallick 2014; Paul and Dutt 2010; Paul *et al.* 2010; Paul and Routray 2013). Risk perceptions and previous cyclone experiences influence evacuation decisions (Ahsan et al. 2016; Das et al. 2018; Paul and Dutt 2010; Paul et al. 2010). Many people could not evacuate during Cyclone Sidr in 2007 because they delayed acting and eventually realized that time was not enough for evacuation because of the distance to evacuation shelters and inconvenient evacuation modes (Paul and Dutt 2010). In the coastal area of Bangladesh at the community-level, Cyclone Preparedness Program (CPP) volunteers disseminate cyclone warning and other information among the

communities through hand-mikes, megaphones, sirens, and individual house visits and help them to evacuate to shelters or safer places (Paul 2009; Paul and Dutt 2010; Haque 2012). This research also investigated the involvement of CPP volunteers with local level authorities and the dissemination of warning information during Cyclone Bulbul. In Bangladesh coastal areas, people usually receive warning and evacuation information through radio and TV. However, no system has yet been developed to disseminate warnings through mobile phones. Besides, responsible local government authorities also disseminate the warning and other information directly to the community. Interviews with government representatives ensured that they gave warning dissemination and evacuation information through CPP volunteers to the individual community due to disruption of dissemination from the national government because of bad weather conditions. Interviews with CPP volunteers also noted that they went to individual communities to disseminate the information by megaphones, sirens, and sometimes individual households.

To ensure safe and complete evacuation, it is necessary to determine the preparation type and time required before starting the evacuation. Furthermore, it is important to identify the factors that influence the evacuation decision. This would help the responsible authorities adhere to the early evacuation time to ensure safe and successful evacuation to shelters or other safer places. Previous research did not pay close attention to early evacuation possibilities and the effects of the starting time of evacuation from home to shelters, which are very important for the completion of successful and safe evacuation. A previous study investigated early evacuation possibilities by considering people's perceptions and investigated gender-based evacuation preparation time before starting evacuation (Parvin et al. 2019) but did not calculate the number or percentage of early evacuation cases based on their starting time of evacuation. Similarly, Lindell *et al.* (2020) estimated the household evacuation preparation time based on six task completions before starting evacuation concerning hurricane disasters. All previous research mentioned earlier studied early warnings, investigated evacuation influential associated factors, and estimated evacuation preparation time. However, no previous research has investigated household evacuation preparation time, early evacuation possibility, and associated factors based on evacuation starting time. This research investigated the details of household evacuation preparation time and associated influencing factors related to not only evacuation but also early evacuation decisions and behavior. This research also investigated this aspect, which has implications for reducing disaster-related damage and managing disaster situations more effectively in the future. This research analyzed factors that affected peoples' perceptions about and decisions regarding early evacuation during Cyclone Bulbul, which struck on November 10, 2019, and past disasters. This study also investigated various factors such as primary warning, primary preparation, evacuation decision, household evacuation scenario, evacuation preparation type and time, evacuation route and destination, travel time, and shelter type, which influenced people's early evacuation decisions. It mainly focuses on factors that affect the outcomes of safe evacuation decisions during cyclone disasters. Demographic, socio-economic, and other household characteristics also play a role in evacuation decisions.

This study investigated early evacuation and evacuation behaviors during the 2019 cyclone disaster to shed light on the conveniences or inconveniences faced during evacuation. This understanding can help inform policy to ensure safe evacuation and reduce damage during future disasters, especially physical damage. First, the study presents the findings related to the evacuation decision-making process, such as previous disaster experience, preparation type and time, household evacuation scenario, and demographic conditions, and outlines the factors influencing early evacuation and evacuation decisions. Second, the study reveals the percentage of people who evacuated early during Cyclone Bulbul. This was done by classifying the respondents into two categories based on their evacuation starting time before cyclone landfall to distinguish whether they evacuated early or not. The study presents the results of the analysis of factors that prompted an evacuation response in people, including household evacuation scenario, evacuation preparation before the start of evacuation, the presence of vulnerable members in the house, distance to shelter, travel time, and demographic conditions during the disaster.

2. STUDY AREA

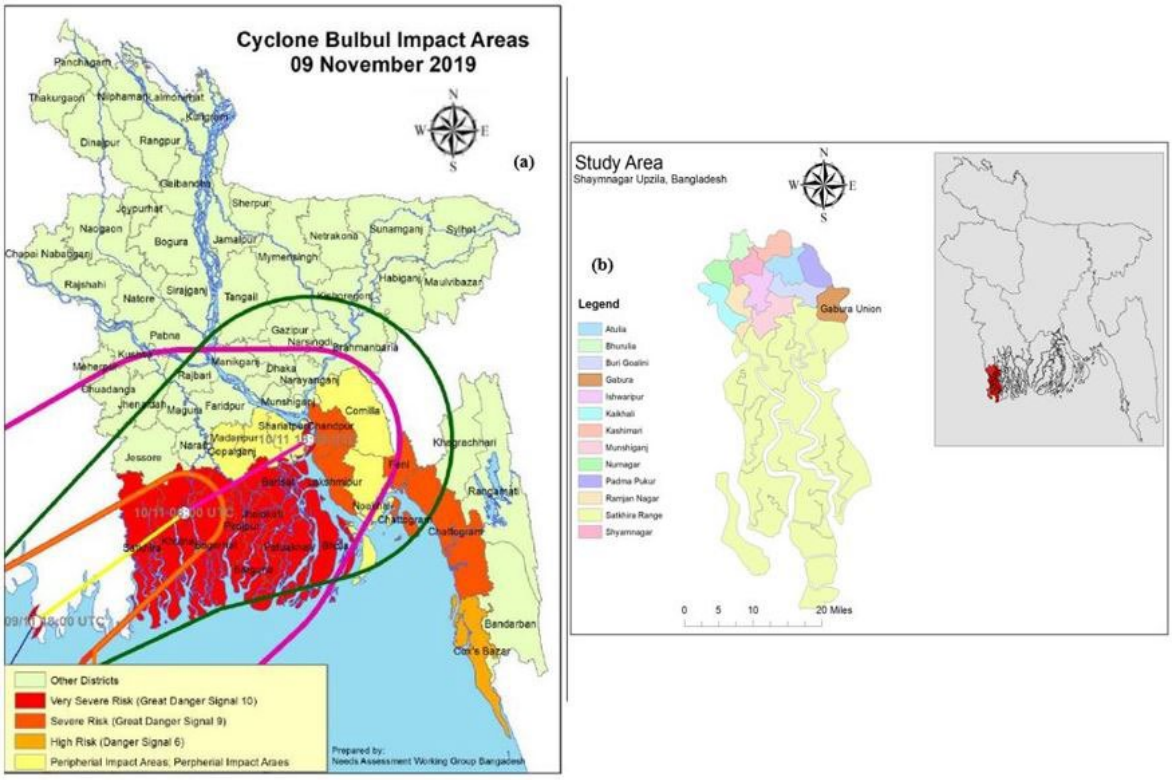

Figure 1. (a) Cyclone Bulbul Impact Areas (Need Assessment Working Group Bangladesh, November 9, 2019), (b) Study area (created by the authors using ESRI ArcGIS)

Cyclone Bulbul made landfall in Parsegonj, West Bengal, India on November 9, 2019, between 8:30 pm and 11:00 pm, and hit Bangladesh on November 10, 2019, at around 1:00 am

local time. The study area was Shyamnagar Upazila, Satkhira District, in the division of Khulna, Bangladesh. Shyamnagar is located at 22.3306°N and 89.1028°E. It has 46,592 households and a total area of 1968.24 km². It comprises 12 union parishads, 127 Mouzas, and 216 villages. Among these 12 unions, Gabura was selected for this study, as this union (Figure. 1) was the most severely affected community during Cyclone Sidr (2007) and Cyclone Aila (2009), as well as the recent Cyclone Bulbul.

Cyclone Bulbul directly affected 13 districts in Bangladesh's coastal region. Because of high winds and heavy rainfall, the cyclone highly affected the coastal area. Cyclone Bulbul—categorized as a "Category 2" cyclone—had an average wind speed of 130–148 km/h around the circulation center and average precipitation of approximately 100–200 mm/h. The cyclone lasted for approximately one-and-a-half days in Bangladesh, making it one of the longest-lasting cyclones that the country had witnessed in the last 52 years (Iqbal 2020). A Daily Sun news report (2019) quoted Md Shah Kamal, senior secretary at the Ministry of Disaster Management and Relief, as saying that nearly 0.3 million vulnerable people from Bhola, Barguna, Patuakhali, Barishal, Pirojpur, Jhalakathi, Bagherhat, Khulna, and Satkhira and their offshore islands and chars (smaller islands) had been moved to cyclone shelters or other safer places by noon. Bulbul was expected to damage over 250,000 hectares of croplands and 150 households in the 13 districts, with at least 25 people killed during or shortly after the storm. Among these 13 districts, Barisal, Satkhira, and Khulna were reportedly the worst affected. In Satkhira, 25,000 hectares of paddy crops were fully or partially damaged, while 2,000 hectares of vegetables, betel leaf, mustard, and plums were damaged (Dhaka Tribune report 2019).

3. RESEARCH OBJECTIVES

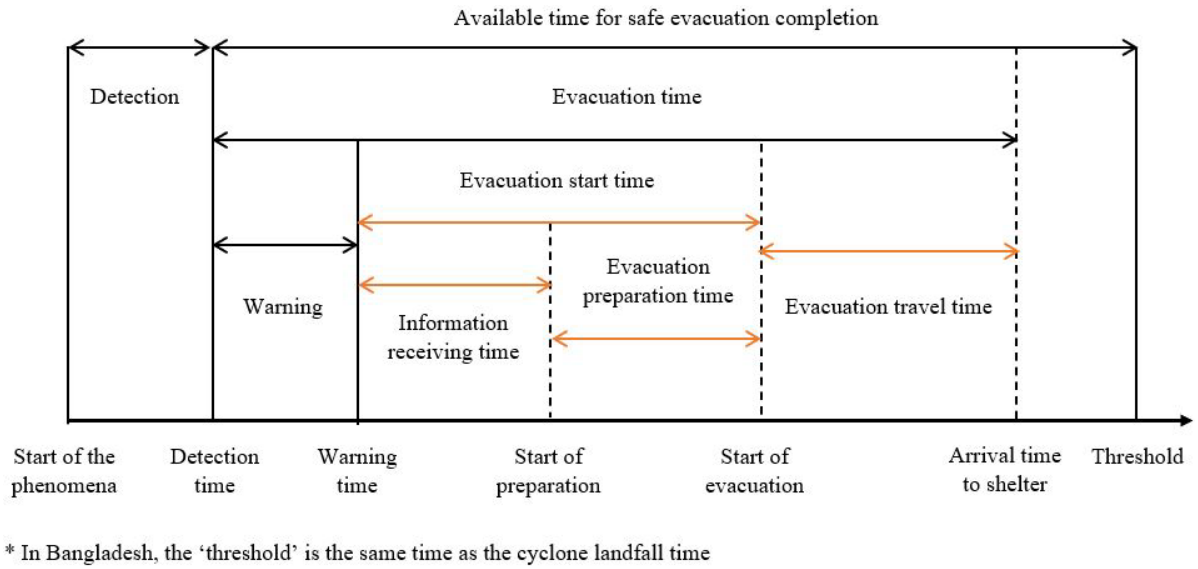

Figure 2. Schematic of the cyclone evacuation timeline (created by author)

The overall objective of this study was to analyze people's perceptions of and experiences with early evacuation decisions and early evacuation. Furthermore, it also attempted to evaluate the factors associated with early evacuation decisions, early evacuation, and emergency evacuation at different evacuation stages during the most recent cyclone Bulbul. According to Figure 2, after receiving a cyclone warning, respondents decided whether to evacuate. If they decide to evacuate, they then prepare for evacuation commencement. Following the cyclone warning signal, some respondents evacuated before the evacuation order, while others evacuated after the evacuation order. Based on the evacuation starting time concerning evacuation orders, identified who made early evacuation and emergency evacuation.

The specific objectives of this study were:

- To determine people's perception of weather conditions, the presence of vulnerable members in the house, previous disaster experiences, and demographic and socio-economic aspects affecting their evacuation decisions.
- To understand the consequences and complexities of early evacuation decisions for evacuees because of the different kinds of challenges they faced when attempting to come up with suitable solutions for the problems. Additionally, to determine the importance of household preparation time for safe and successful evacuation during a cyclone disaster, and
- To understand why only a few people evacuated early and many others did not during the cyclone, and to identify the critical factors that influenced people's early evacuation.

4. METHODOLOGY

In this study, both qualitative and quantitative approaches were applied to achieve its objectives. A field survey was conducted between mid-February and mid-March 2020, three months after Cyclone Bulbul made landfall on November 10, 2019 (local time around 1:00 am in the targeted area), in Gabura Union of Shyamnagar Upazila in the Satkhira district of Bangladesh. For the quantitative approach, a community-level structured questionnaire was used to conduct surveys in Gabura Union to understand people's perceptions about early evacuation possibilities and emergency evacuation. This type of questionnaire survey of the affected community made it possible to understand evacuation behavior and identify the factors influencing early evacuation decisions. The questionnaire comprised different variables related to people's perceptions about and the possibility of early evacuation, preparation, emergency response, evacuation order, and early evacuation decision-making issues. First, the author collected all household information, such as house numbers from the local government office. The primary data were collected via personal visits to the field from community members in the designated area using random sampling based on house numbers. If the randomly selected household respondents were absent during the survey, the household respondents were interviewed later. Although we mentioned 413 households, each household's response to the questionnaire had one household head representative. Here, household respondents are the

household heads responsible for household decision-making. Primary data were collected using questionnaires targeting 413 households from 1,971 total households in one union in three wards or villages in the study area, most affected by cyclone Bulbul 2019. According to government representatives, these three wards are recognized as hard-to-reach areas, and internal communication is not good. People face difficulties accessing social service facilities during the rainy season and disaster time. The questionnaire comprised three sections and a total of 38 questions. The questionnaire sections used were 1. Early preparedness and warning for Cyclone Bulbul, 2. Evacuation decision, preparation time, and scenario information during Cyclone Bulbul and 3. General information about respondents and households before conducting the survey. The author tested the validity of the questionnaire through dummy data collection with several households and then modified the questionnaire again for the survey. For data collection, there was one college teacher and two former NGO members who went to individual households to gather responses according to the questionnaire. The author also joined alternatively with each selected person during data collection. It took approximately 20 to 30 minutes to complete the questionnaire responses for each household. The original questionnaire survey was drafted in English and distributed in the selected area after being translated into the Bengali language.

The qualitative research approach was based on a literature review and analysis of the collected survey data. The qualitative research approach focused on distinct threats, challenges, and problems prevalent in the early evacuation context. It also determined the relevant consequences for evacuees when they considered the possibility of early evacuation. To obtain clear information about distinct problems and challenges, this study conducted interviews with four people to obtain qualitative data. People were selected based on their knowledge and involvement with the evacuation process during emergencies. The objective of each interview was to obtain information about each person's judgment about the evacuation process during a disaster. However, the interviews did not exactly follow the strict list of questions. Among the four persons, there was a chairman (head of the union) and, a member (head of one ward in the union) local government representative, a college teacher, and a CPP unit team leader respectively. The interview with the chairman and CPP unit team leader took place at the local government office, while interviews with members and college teachers took place at community meetings.

By analyzing the results through descriptive statistics, this study examined the relationships among different variables, such as reasons for non-evacuation, preparation type and time, evacuation companions, livestock, evacuation mode, route selection, travel time from home to shelter, distance, and demographic characteristics to determine how they influenced early evacuation and evacuation decisions. Furthermore, the study analyzed factors that affected evacuation completion during Cyclone Bulbul based on the starting time of evacuation and the travel time to shelters for each household.

5. RESULTS

5.1 Cyclone Primary Stage/ Warning Stage

The cyclone warning stage, occurring between 10 hours and 36 hours before the predicted landfall of a cyclone, defines the cyclone primary stage. When people receive the first warning signal, they consider or start making evacuation plans. They begin preparations for evacuation and plan when to evacuate. All survey respondents said they received a warning about Cyclone Bulbul.

The results of the questionnaire survey revealed that all respondents (100%), both men and women, received the primary warning signal (Table 1). The results confirmed the success of local and national authorities in disseminating the primary warning, but the communication did not happen simultaneously in the same area.

Table 1. Receipt of primary warning signal during Cyclone Bulbul

Gender	Yes (%)	No (%)	Total (%)
Male	324 (100)	0 (0)	324 (100)
Female	89 (100)	0 (0)	89 (100)
Total	413 (100)	0 (0)	413 (100)

5.2 Reasons for Non-Evacuation During Cyclone Bulbul

There are different reasons why respondents did not evacuate during Cyclone Bulbul. Of the 413 respondents, 185 did not evacuate during Cyclone Bulbul, with these respondents citing 16 reasons for not evacuating. Among the reasons cited, the main reasons for non-evacuation varied for men and women.

As shown in Figure 2, male respondents had five main reasons, with 61.5% of respondents saying, “I thought I would be able to move during the cyclone,” followed by 60% who said, “the weather outside was dangerous.” Approximately 55% of respondents said that they could not move because the road was damaged, 45% said they wanted to protect their home by not evacuating, and 55% reported feeling that their house was safe to stay. Although the percentages were not very high, the presence of a sick member in the house (33%), work (31.5%), a distance of the cyclone shelter from home (22%), and unsafe cyclone shelters (22%) were also cited as reasons for not evacuating.

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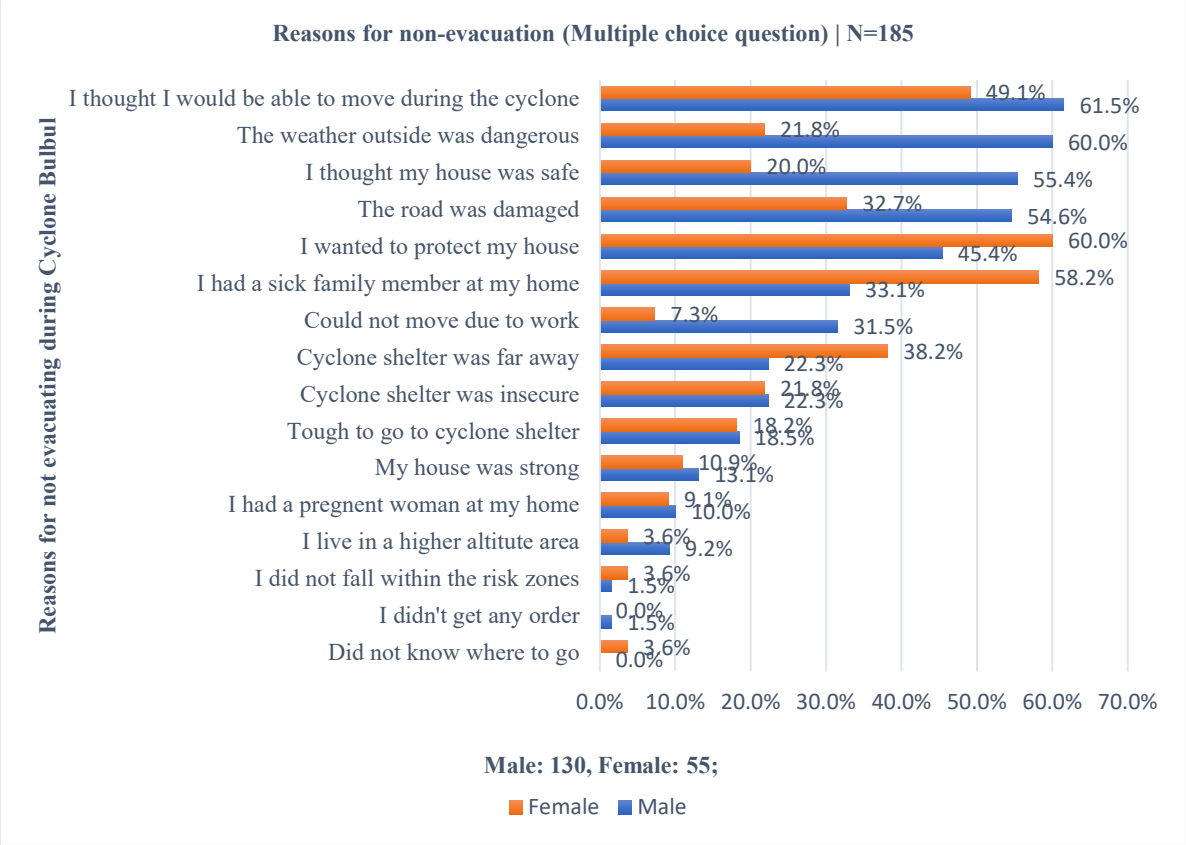

Figure 3. Reasons for non-evacuation during Cyclone Bulbul

Female respondents cited four main reasons, as shown in Figure 3. Sixty percent of the respondents said, "I wanted to protect my house," followed by 58% who claimed that they had a sick member in the house, which is not surprising as women are usually responsible for taking care of family members. Like male respondents, around 49% of female respondents said, "I thought I would be able to move during the cyclone." Furthermore, around 38% of respondents mentioned that the shelter was far away, and 33% said the road was damaged, making it difficult to go to cyclone shelters. Although the percentages were not very high, the dangerous weather outside (22%), unsafe cyclone shelters (22%), and their belief that their house was safe to stay in (20%) were also cited as reasons for not evacuating.

5.3 Previous Disaster Experience

Previous disaster experience is an important factor that guides people in making more effective decisions during future emergencies. Figure 4 shows people's past experiences of a super-cyclone before Cyclone Bulbul. The survey results showed that of the 413 respondents, 188 (45.5%) had experienced a cyclone four times in the past, followed by 148 respondents (35.8%) who had experienced a cyclonic disaster three times, and 63 respondents (15.3%) had experienced a cyclone twice. Thirteen respondents (3.1%) had experienced a cyclone five times, and one respondent had experienced a cyclone once in the past.

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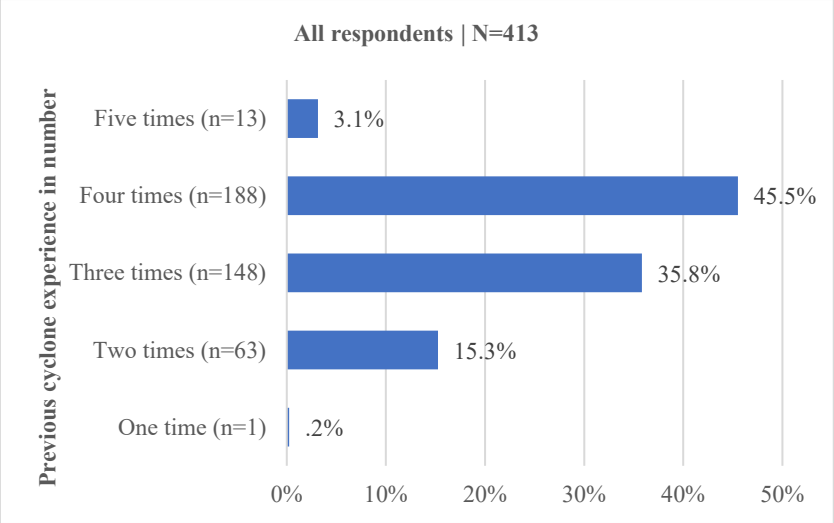

Figure 4. Respondents' previous cyclone experience before Cyclone Bulbul

5.4 Evacuation During Cyclone Bulbul

Table 2. Evacuation during Cyclone Bulbul

Gender	Yes (%)	No (%)	Total (%)
Male	194 (59.9)	130 (40.1)	324 (100)
Female	34 (38.2)	55 (61.8)	89 (100)
Total (%)	228 (55.2)	185 (44.8)	413 (100)

In Bangladesh, males are generally the head of the household and are in charge of making household decisions. Those households that represent female respondents mean that they are divorced, widowed, or the male stays outside the village due to work or other reasons. Thus, those females are now responsible for taking care of households and households' decisions on different issues. Table 2 shows the percentage of respondents who evacuated during Cyclone Bulbul by gender. Of the 324 male respondents, 194 (59.9%) said they had evacuated. Only 34 of the 89 female respondents (38.2 percent) said they had evacuated. The evacuation rate is lower among women than men because the latter is usually the head of the household and responsible for making decisions and executing them, while women are more likely to be involved in caring for family members and managing household activities.

5.5 Evacuation Preparation and Preparation Time

People prepare themselves and for evacuation after receiving a cyclone warning, by organizing things that they will need before or just after the cyclone makes landfall. According

to Parvin *et al.* (2019), the preparation process from the time of receipt of warning to cyclone landfall and the prioritization of activities ahead of evacuation vary from person to person depending on individual considerations. Most people prioritize organizing emergency goods that they would need at the shelter. They also consider the safety of domestic animals and want to bring their animals along with them when evacuating to shelters or other safer places. Thus, evacuation preparation and preparation time depend on people's perceptions of the type of preparation needed for either emergency evacuation or early evacuation (Parvin *et al*. 2019).

People were involved in various activities before the start of the evacuation during Cyclone Bulbul, and they believed that all of those activities were important. As shown in Figure 5, people prioritized activities such as organizing drinking water and medicine (87%), preparing all family members (85.5%), and preparing food for use at the shelter (82.5%). They were also engaged in other similarly important activities, such as ensuring the safety of the house (80%) and attending to children (77%) and older members (79%) who needed special care before evacuation. Therefore, if there are children or older members in the house, a longer preparation time is needed to prepare them for evacuation.

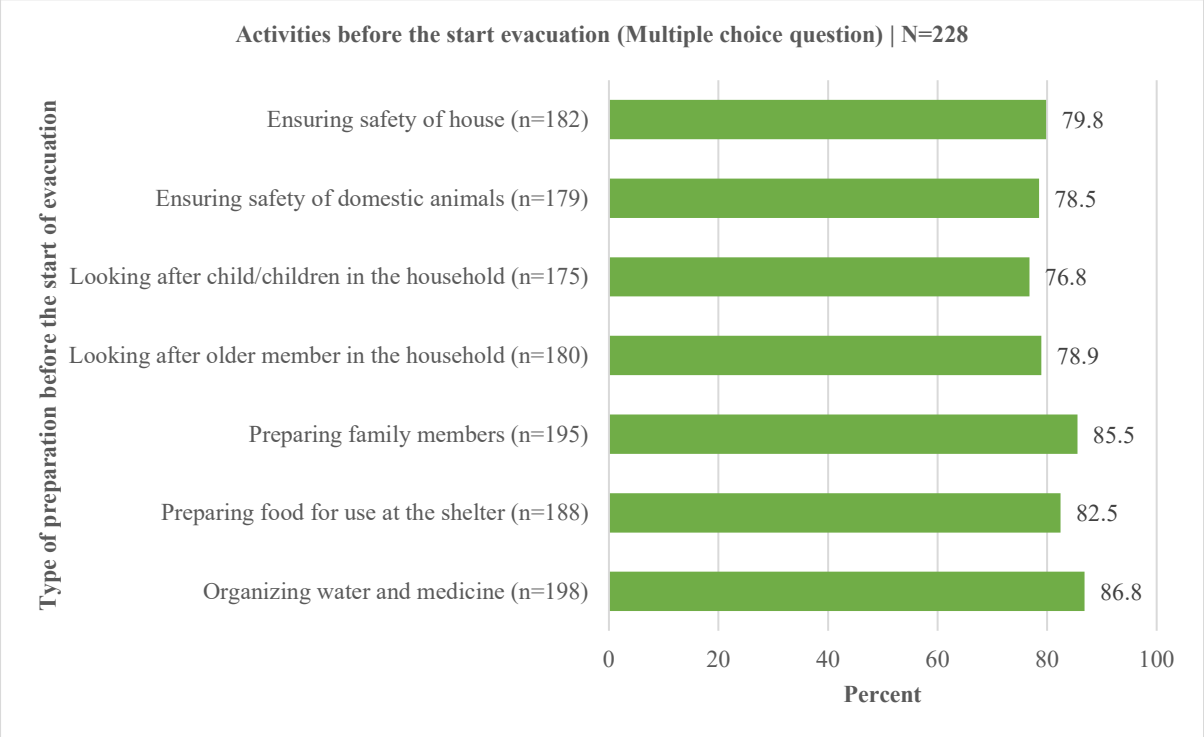

Figure 5. Respondents' activities before the start of evacuation

Figure 6 shows the respondents' responses regarding individual household preparation time before the evacuation commencement during Cyclone Bulbul. Most of the respondents (73%) said their preparation time ahead of evacuation was 2 hours. Very few respondents (18%) said

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they only took one hour, while about 9% of the respondents took between 3 and 6 hours to prepare for evacuation.

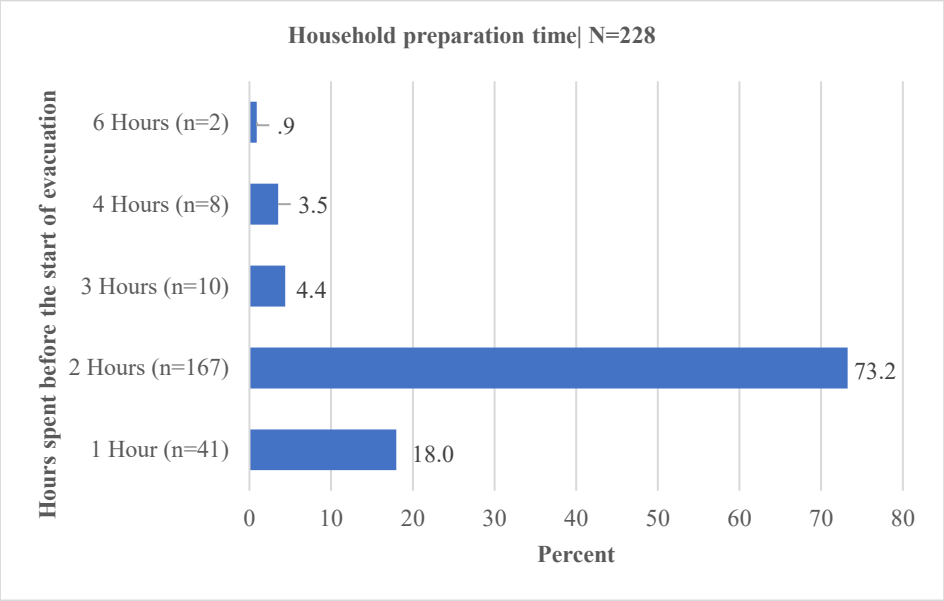

Figure 6. Household preparation time before the start of evacuation during Cyclone Bulbul

5.6 Early Evacuation Decision During Cyclone Bulbul

Table 3 shows the percentage of respondents who made an early evacuation decision during Cyclone Bulbul by gender. Of the 324 male respondents, 171 (52.8%) decided to evacuate early, while only 23 (25.8%) of the 89 female respondents made an early evacuation decision.

Table 3. Early evacuation decision during Cyclone Bulbul

Gender	Yes (%)	No (%)	Total (%)
Male	171 (52.8)	153 (47.2)	324 (100)
Female	23 (25.8)	66 (74.2)	89 (100)
Total (%)	194 (47.0)	219 (53.0)	413 (100)

5.7 Early Evacuation Based on Starting Time of Evacuation During Cyclone Bulbul

This research analyzed the target population's starting time of evacuation from their house based on the time Cyclone Bulbul made landfall on November 10, 2019 (local time 1:00 am in the targeted area). The starting time of evacuation before cyclone landfall depended on various

factors associated with household characteristics, risk perception, and the prevalent situation. As seen in Figure 7, the resulting cumulative distribution graph confirms that among the respondents who evacuated during Cyclone Bulbul, most began evacuating 8 to 12 hours before landfall. Approximately 40% of household respondents started their evacuation 8 h before landfall—categorized as emergency evacuation. Around 33% started evacuating 10 to 18 hours before landfall—categorized as early evacuation. Only 20% started their evacuation 1 to 7 h before the cyclone made landfall.

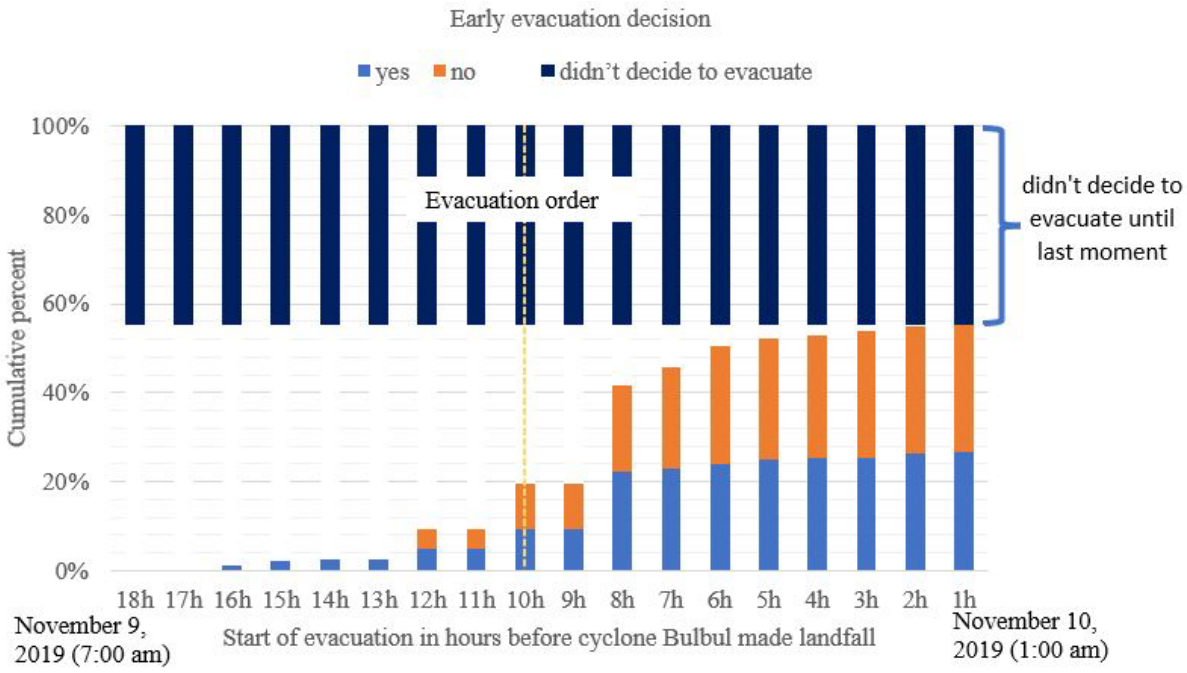

Figure 7. Relationship between early evacuation decision and starting time of evacuation of individual households before Cyclone Bulbul made landfall

6. FACTORS PROMPTING EARLY EVACUATION DECISION AND EARLY EVACUATION

This research analyzed the factors that influenced early evacuation decisions and actual early evacuation during Cyclone Bulbul and the relationship between those factors and the actual evacuation commencement.

6.1 Factors Prompting Early Evacuation Decision during Cyclone Bulbul

As part of the questionnaire survey, respondents were asked whether they evacuated family members individually or together, with 100% saying they evacuated all members together showing great concern for the family during a disaster. The household members here are

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categorized as relatives, disabled members, older members, and others. Notably, disabled members are those who cannot move alone, and therefore need assistance from other members during evacuation. While categorizing others, they mention their neighbors or surrounding households who are not well-known to each other. Figure 8 reveals the relationship between evacuation companions and early evacuation decisions during Cyclone Bulbul. The survey results indicated a significant correlation between evacuation companions and early evacuation decisions. Approximately 46% and 28% of respondents with children and older members in their household, respectively, decided to evacuate early. Conversely, around 50% and 37% of respondents with children and older members in their household, respectively, did not make early evacuation decisions.

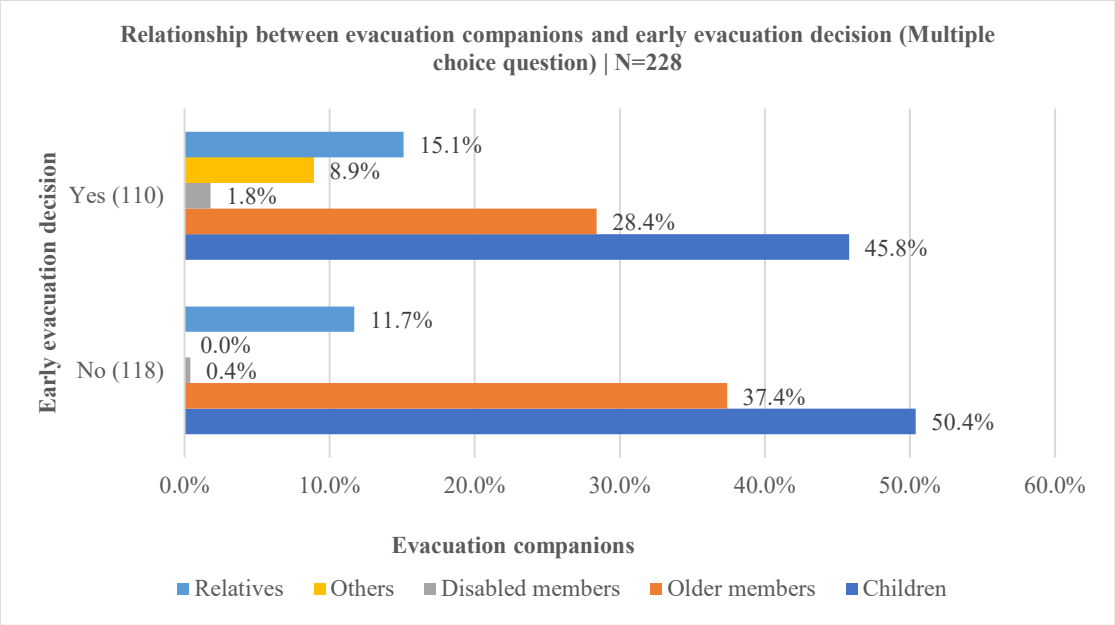

Figure 8. Relationship between evacuation companions and early evacuation decision during Cyclone Bulbul

Respondents were asked about their preparation time before evacuation to determine the relationship between preparation time and early evacuation decisions. Figure 9 illustrates, among respondents who made an early evacuation decision, around 71% took 2 hours as preparation time, while around 11%, 9%, and 7% took 1 h, 3 h, and 4 h, respectively, as preparation time before evacuation. Conversely, among those who did not make an early evacuation decision, the majority (75%) took two hours, while only around 25% took one hour.

This study also adopted demographic and socio-economic approaches to determine the relationship between factors that prompted an early evacuation response (based on people's perception) among the respondents during Cyclone Bulbul. Eight factors were considered in this study. Table 4 shows that of the eight factors, four are demographic variables, namely respondent gender, age group, household size, and the presence of a sick member in the house.

Only two of these four demographic variables, respondent gender and the presence of a sick member in the house, were found to have a significant correlation with early evacuation decisions. Approximately 53% of male respondents made early evacuation decisions. Then again, only around 26% of the female respondents made early evacuation decisions, indicating that women are less likely to be involved in the decision-making process and more likely to be engaged in taking care of family members during a disaster. A relatively high percentage of respondents with a sick member at home (approximately 74%) did not make an early evacuation decision, indicating that having a sick member in the house makes it difficult to evacuate because the travel time and shelter distance pose a great challenge. Age group and household size had no significant influence on the early evacuation decisions.

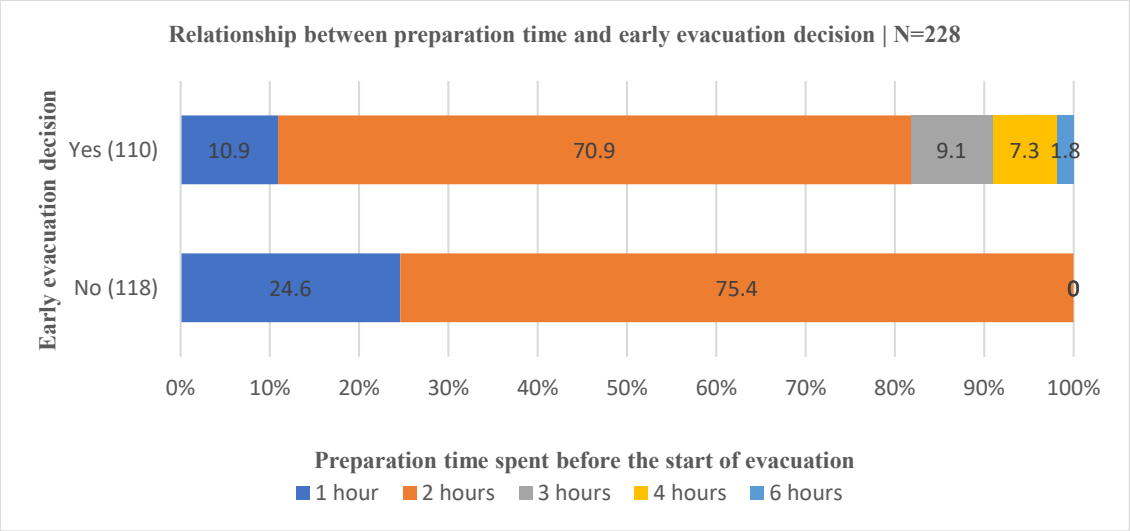

Figure 9. Relationship between preparation time before evacuation and early evacuation decision during Cyclone Bulbul

Concerning the two socio-economic variables, occupation category, and income group, occupation category had no significant correlation with early evacuation decisions. The survey results showed that most respondents in the study area were either farmers or daily workers. All occupation category respondents showed similar trends in early evacuation decisions. However, the income group had a significant influence on the early evacuation decisions. Around 81% of the respondents whose income was higher than 5,000 BDT (around $59) and around 47% of those whose income was less than 5,000 BDT did not make an early evacuation decision.

Table 4. Factors prompting early evacuation decision during Cyclone Bulbul

		Early evacuation decision during Cyclone Bulbul					
		Yes		No		Total	
Respondent gender P=.000*	Male	171	52.8%	153	47.2%	324	100.0%
	Female	23	25.8%	66	74.2%	89	100.0%
Age Group P=.632	18–40	77	46.1%	90	53.9%	167	100.0%
	41–60	85	48.6%	90	51.4%	175	100.0%
	>60	32	45.1%	39	54.9%	71	100.0%
Occupation Category P=.847	Housewife	7	36.8%	12	63.2%	19	100.0%
	Farmer/Daily Worker	174	47.2%	195	52.8%	369	100.0%
	Retired	4	66.7%	2	33.3%	6	100.0%
	Business/Job	9	47.4%	10	52.6%	19	100.0%
Income Group P=.000*	500–5000 BDT	180	52.9%	160	47.1%	340	100.0%
	>5000 BDT	14	19.2%	59	80.8%	73	100.0%
Household Size P=.663	<=5	138	46.3%	160	53.7%	298	100.0%
	>5	56	48.7%	59	51.3%	115	100.0%
Sick Member P=.000*	No	168	53.8%	144	46.2%	312	100%
	Yes	26	25.7%	75	74.3%	101	100%
Shelter Distance Group P=.000*	100–1000 m	68	40.2%	101	59.8%	169	100.0%
	>1000 m	42	71.2%	17	28.8%	59	100.0%
Travel Time to Shelter P=.000*	2–30 min	50	35.7%	90	64.3%	140	100.0%
	31–60 min	59	72.0%	23	28.0%	82	100.0%
	>60 min	1	16.7%	5	83.3%	6	100.0%

* The chi-square test statistic is significant at the 0.05 level

Table 4 also shows that the early evacuation decision rate was higher among respondents whose houses were far from shelters compared to those whose houses were near shelters. This difference confirmed a significant correlation between the shelter distance and early evacuation

decisions. Approximately 71% of respondents for whom the distance from their house to the shelter was over 1000 meters made an early evacuation decision, whereas the corresponding rate was around 40% for respondents for whom the distance was 100–1000 meters. Similarly, travel time to the shelter also showed a significant influence. According to the survey results, most respondents (140 out of 228) took less than 30 minutes to travel from home to the shelter suggesting the distance to the shelter was 100–1000 meters for most of them. The evacuation decision rate was higher for those who took 31–60 min to evacuate at 72%. Conversely, the percentage was much lower among the other groups; six respondents (17%) took over 60 minutes to evacuate.

6.2 Factors Prompting Early Evacuation Based on Evacuation Starting Time during Cyclone Bulbul

Table 5. Respondent category based on their actual evacuation starting time

Starting time of evacuation (before cyclone landfall)	Number	Percent
Less than 10 hours	147	64.5
10 hours or more	81	35.5
Number of evacuated people	228	100

According to the Bangladesh Meteorological Department (BMD), a cyclone evacuation order is given at the cyclone great-danger stage or 10 h before the cyclone landfall time. Based on this evacuation order time, this study divided respondents into two groups considering the actual time when they began evacuation during Cyclone Bulbul. One group evacuated 10 hours or more before the cyclone made landfall, while the other group evacuated less than 10 hours before the cyclone made landfall. Respondents who evacuated 10 hours or more before landfall were categorized into the early evacuation group, and the other group was categorized as the general or emergency evacuation group. Table 5 shows the distribution of respondents based on the starting time of evacuation to a safer place during Cyclone Bulbul. The percentage of respondents who carried out emergency evacuation (147 of 228 [64.5%]) was higher than that of early evacuees (81 228 [35.5%]).

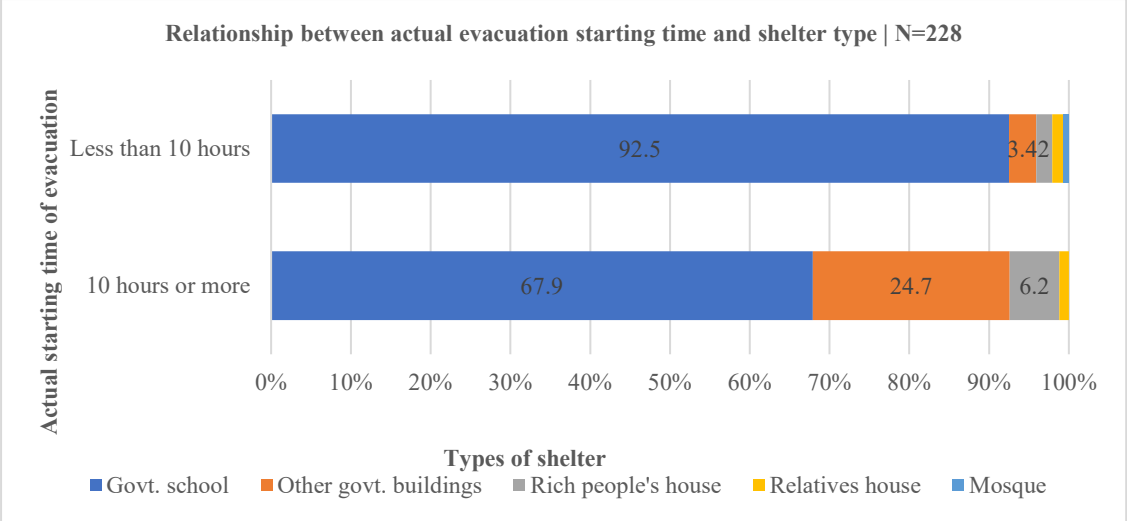

Figure 10. Relationship between actual evacuation starting time and shelter type during cyclone Bulbul

Respondents were asked about the types of shelter that they evacuated during Cyclone Bulbul. Figure 10 shows the relationship between the actual evacuation start time and shelter type chosen by the respondents. Among respondents who evacuated less than 10 hours before the cyclone made landfall, the majority (92.5%) chose a government school as the designated cyclone shelter, while 3.4% and 2% chose other government buildings and rich people's houses, respectively, as their evacuation places. The survey results revealed more variation in the choice of cyclone shelter when respondents carried out an early evacuation. Nearly 68% of the respondents chose a government school, around 25% chose other government buildings, and some 6% chose rich people's houses as their evacuation place.

Figure 11 shows the relationship between evacuation companions and early evacuation during Cyclone Bulbul. The results indicated a significant correlation between evacuation companions and early evacuation. Among respondents who did not evacuate early, around 49% said they evacuated with children, and 40% evacuated with older members. A significantly lower percentage of respondents evacuated with others and relatives at approximately 2.1% and 8.3%, respectively. Similarly, among respondents who carried out early evacuations, approximately 47% said they evacuated with children. A relatively lower percentage of respondents confirmed that they evacuated with older members, with others, and with relatives at around 21%, 8%, and 22%, respectively. Households with older members tend to evacuate early because they already know the consequences of evacuation, such as longer preparation times and longer travel times. Considering these difficulties, for their safe and complete evacuation, they are more likely to evacuate early.

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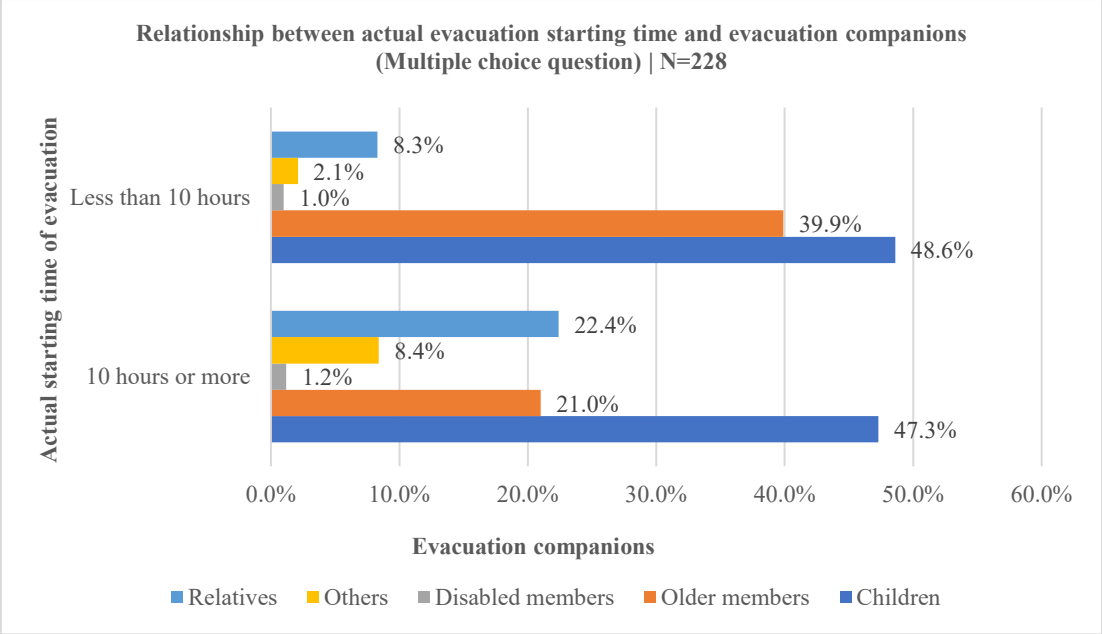

Figure 11. Relationship between actual evacuation starting time and evacuation companion during Cyclone Bulbul

The survey results showed that only 24.5% of households had sick members at home. Figure 12 shows that among respondents who did not evacuate early, only around 12% said they had a sick member, while the percentage was much higher at around 32% among early evacuees during Cyclone Bulbul. If sick members in the house were also intended to evacuate early because of longer preparation and travel times.

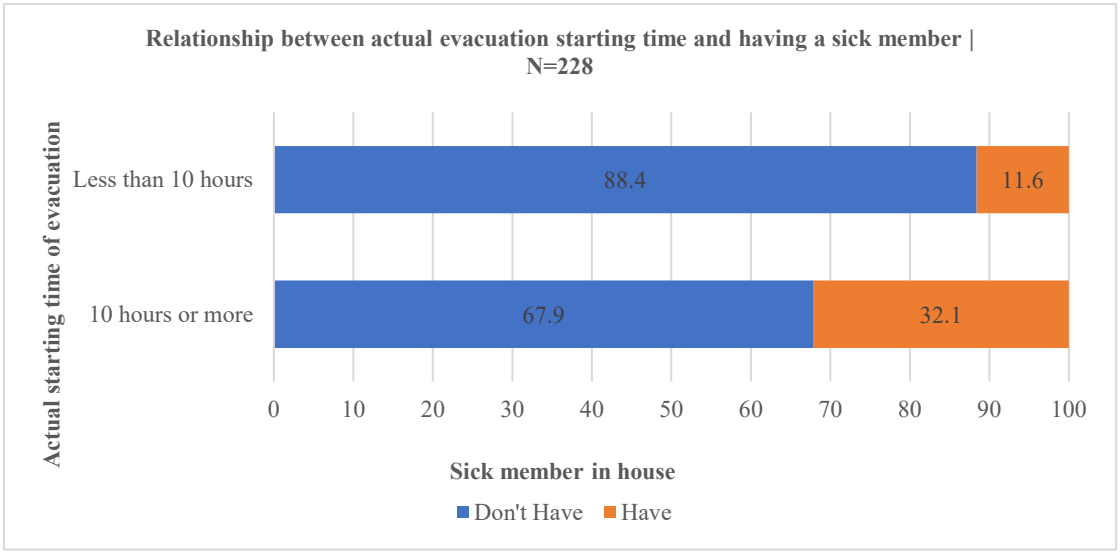

Figure 12. Relationship between actual evacuation starting time and having a sick member in the house

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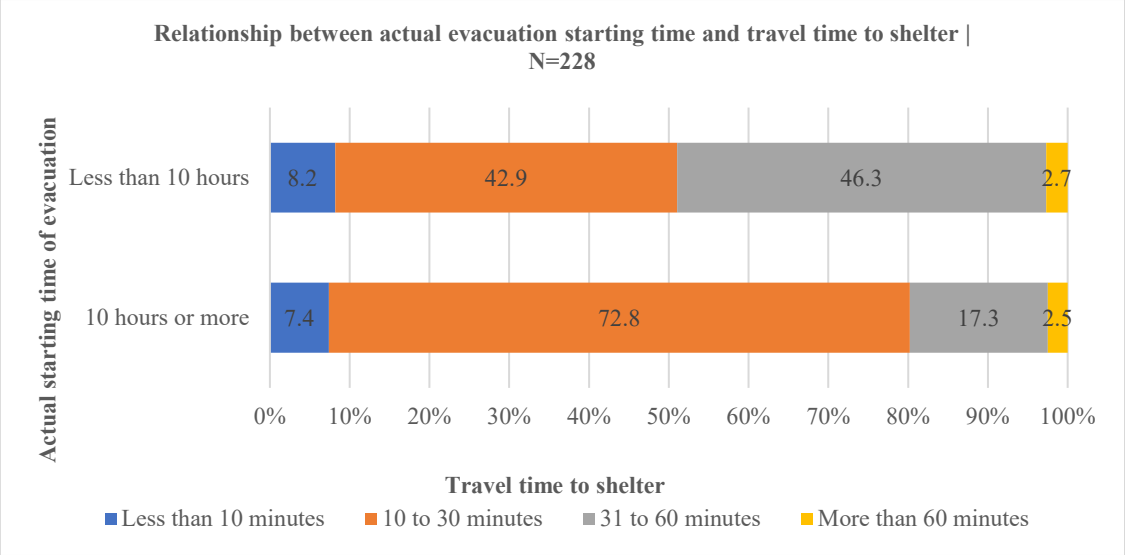

Figure 13. Relationship between actual evacuation starting time and travel time to shelter

The travel time from home to shelter is also an important factor that influences evacuation decisions. Figure 13 suggests that most of the household respondents in both groups took 10–60 minutes of evacuation travel time. Among respondents who did not evacuate early, nearly 43% took 10 to 30 minutes and 46% took 31 to 60 minutes in evacuation travel time. Among respondents who were early evacuees, the majority (73%) took 10 to 30 minutes, while only around 17% took 31 to 60 minutes in evacuation travel time during Cyclone Bulbul. For respondents in both groups, the distance from their house to the shelter was between 100 and 1000 m, explaining why they took a similar time even though the percentage was different.

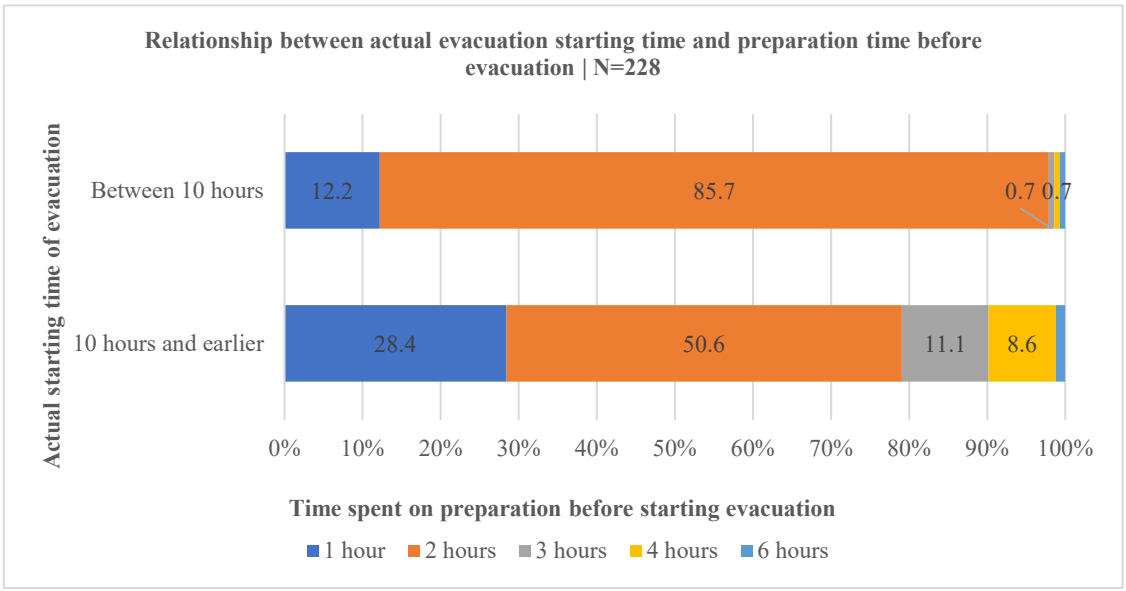

Figure 14. Relationship between actual evacuation starting time and preparation time

Respondents were asked about their preparation time before starting the evacuation to determine the relationship between the preparation time and actual evacuation starting time. Figure 14 shows that a little over half of the early evacuees (51%) took 2 h in preparation time, while approximately 28%, 11%, and 9% took 1 h, 3 h, and 4 h, respectively. Among those who did not evacuate early, the majority (86%) took two hours, while only around 12% took one hour. Earlier evacuation shows a variation in preparation time—ensuring sufficient time for preparation before starting evacuation.

7. FACTORS PROMPTING EVACUATION RESPONSE DURING CYCLONE BULBUL

Figure 15 shows that among respondents who were not driven to take steps to evacuate during Cyclone Bulbul, around 26% had experienced a disaster two times in the past, 40.5% three times, 31% four times, and 2% five times. Among those who were prompted to evacuate, nearly 7% had experienced a disaster twice in the past, 32% three times, 57% four times, and 4% five times. The result indicated that those who had experienced disasters more times took effective evacuation decisions compared to those who had less experience, showing their effectiveness during an emergency.

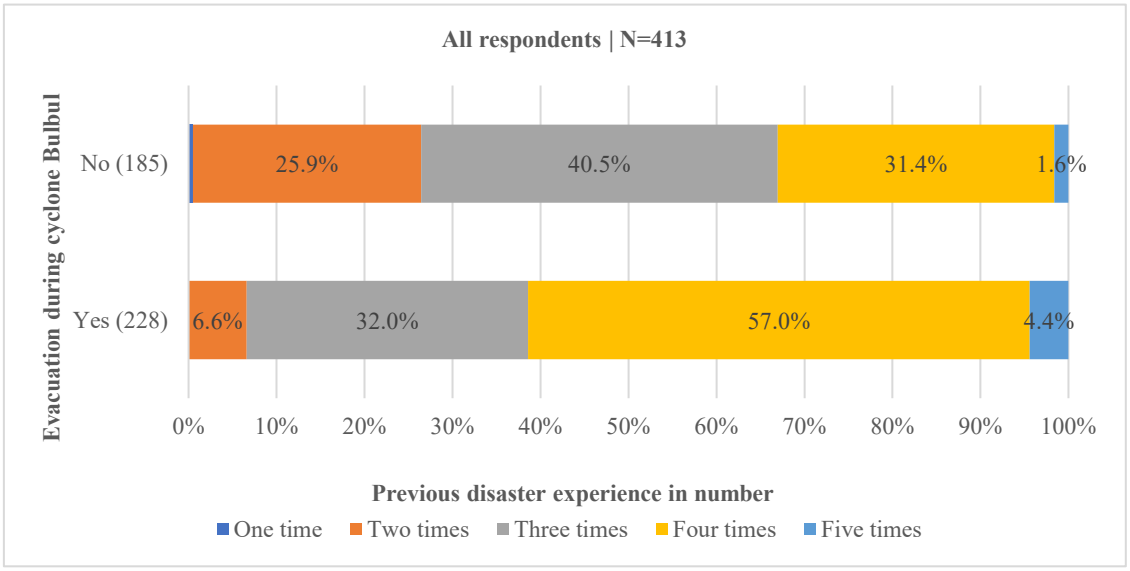

Figure 15. Relationship between previous disaster experience and evacuation during Cyclone Bulbul

Table 6. Factors prompting evacuation during cyclone Bulbul

		Evacuation during Cyclone Bulbul					
		Yes		No		Total	
Respondent gender P=.000*	Male	194	59.9%	130	40.1%	324	100.0%
	Female	34	38.2%	55	61.8%	89	100.0%
Age Group P=.179	18–40	83	49.7%	84	50.3%	167	100.0%
	41–60	103	58.9%	72	41.1%	175	100.0%
	>60	42	59.2%	29	40.8%	71	100.0%
Occupation Category P=.004*	Housewife	3	15.8%	16	84.2%	19	100.0%
	Farmer/Daily Worker	212	57.5%	157	42.5%	369	100.0%
	Retired	4	66.7%	2	33.3%	6	100.0%
	Business/Job	9	47.4%	10	52.6%	19	100.0%
Income Group P=.000*	500–5000 BDT	172	50.6%	168	49.4%	340	100.0%
	>5000 BDT	56	76.7%	17	23.3%	73	100.0%
Household Size P=.579	<=5	162	54.4%	136	45.6%	298	100.0%
	>5	66	57.4%	49	42.6%	115	100.0%
Sick Member P=.003*	No	185	59.3%	127	40.7%	312	100.0%
	Yes	43	42.6%	58	57.4%	101	100.0%

* The chi-square test statistic is significant at the 0.05 level

This study used demographic and socio-economic approaches to determine the relationship between factors that prompted an evacuation response among respondents during Cyclone Bulbul in the same way as it did for early evacuation decisions. Six factors were considered in this study. Table 6 shows that of these six factors, four are demographic variables, namely respondent gender, age group, household size, and the presence of a sick member in the house. Only two of the four demographic variables, respondent gender and the presence of a sick member in the house, had a significant correlation with evacuation. Approximately 60% of the male respondents evacuated during Cyclone Bulbul. Only 38% of the female respondents evacuated. The results also showed that the evacuation rate was higher among respondents who did not have a sick member in the house (59%) than among those who had (43%), suggesting

that it was difficult and unsafe to evacuate with a sick member. Age and household size had no significant influence on evacuation.

Table 6 shows that both the socio-economic variables, occupation category, and income group, had a significant influence on evacuation during Cyclone Bulbul. Respondents from all occupational categories had almost similar trends for evacuation except housewives as they are more likely involved in taking care of family members and related things than in managing evacuation during a disaster. Similarly, the income group also had a significant influence on evacuation. The evacuation rate was around 77% among those whose income was higher than 5,000 BDT and around 51% among respondents whose income was less than 5,000 BDT. An informal conversation during the questionnaire survey confirmed that low-income people always want to protect their house during a disaster, they are therefore reluctant to evacuate and want to stay home during an emergency.

8. FINDINGS AND DISCUSSION

This study analyzed survey data to evaluate perceptions about the early evacuation and emergency evacuation during Cyclone Bulbul, including the factors that influenced evacuation decisions and the reasons for non-evacuation. The survey results revealed that evacuation with all family members was a great concern in both early and emergency evacuations. The findings of this study are significant as they shed light on the reasons for non-evacuation and people's evacuation behavior. This understanding can contribute to a safe and successful evacuation during a cyclone or related disaster. The key findings of this study are explained in detail.

Regarding people's response to an evacuation order and reasons for not evacuating during a cyclone, many previous studies conducted in the last two decades have focused on different perspectives. This research acknowledges the reasons for non-evacuation during cyclone disasters identified in previous research. According to Bern et al. (1993), trust in warning signals/evacuation orders is important, as most of the respondents did not follow the evacuation order during the 1991 cyclone because of their previous experience of receiving a false warning. The lack of cyclone shelters and facilities and the distance to shelters are also important reasons for non-evacuation during a cyclone (Haque et al. 2012; Paul and Rahman 2006). During Cyclone Bulbul, all respondents admitted that they received an early warning, but half of them did not follow evacuation orders (Table 3). For male respondents, the four main reasons for non-evacuation were "I thought I would be able to move during the cyclone," "the weather outside was dangerous," "I thought my house was safe," and "the road was damaged." For female respondents, the three main reasons for non-evacuation were "I wanted to protect my house," "I had a sick family member in my house," and "I thought I would be able to move during the cyclone" (Figure 2). Therefore, it is important to understand the reasons for non-evacuation from both male and female perspectives, which will make it easier to address gender-specific reasons carefully. The analysis of the survey results showed that the reasons for non-evacuation during Cyclone Bulbul were mostly related to weather conditions and

shelter characteristics. Because of the bad weather conditions before the cyclone made landfall, the condition of the roads deteriorated and made it difficult to travel to shelters. Furthermore, shelter distance and lack of proper facilities were major reasons for non-evacuation.

After receiving the warning, it is necessary to make evacuation decisions at the right time to ensure safe evacuation, given the risks involved. With early evacuation, the risk of property damage could be minimized by sending vulnerable members to the shelter earlier and having the household head stay at home and evacuating later (Roy et al. 2015). The present study acknowledges previous research by focusing on early evacuation decisions during Cyclone Bulbul. Early evacuation during cyclones could be beneficial for household evacuation. People who consider early evacuation during a disaster have certain priorities. For most respondents, the safe passage for specific members in the house like children or seniors is the main concern. After making an early evacuation decision, people undertake various activities and preparations before starting an evacuation. The decision to evacuate early gives people enough time for preparation. The questionnaire survey showed that households that made an early evacuation decision took 1 to 6 hours for preparation, with most respondents in this group taking two hours for preparation before evacuation. Conversely, households that did not make an early evacuation decision spent either 1 or 2 hours for preparation time, with the majority taking two hours for preparation. Demographic and socio-economic characteristics play a key role in early evacuation decisions. There was a significant difference between male and female involvement in early evacuation decisions. People along the coastal regions of Bangladesh are very poor and always evacuate since their houses are not strong enough to protect them during a disaster. The rate of early evacuation decisions among households with sick members was relatively low, given the difficulties in moving them from home to shelters. Bad access roads because of weather conditions and shelter-related aspects were cited as the main reasons for making an early evacuation decision. People who lived far from the shelter thought it would take around 30 to 60 minutes to cover the distance, it would therefore be better to evacuate early before the weather worsened.

Early evacuation ensures effective disaster preparedness and completion of evacuation to a safer place during a tsunami disaster (Yun and Hamada 2012). However, a cyclone does not strike as quickly as a tsunami; consequently, there is enough time to evacuate during a cyclone, but the consequences and complexities of evacuation are comparable. This research identified factors that influence early evacuation—a key concern for safe and successful evacuation during a cyclone disaster. The survey results indicated that around 47% of respondents made early evacuation decisions, but only around 35% of them followed up with their decisions during Cyclone Bulbul. Although most of the respondents who evacuated early chose a government school or designated shelter for evacuation, they had enough time to choose from different options. Among those who did not evacuate early, over 90% had to choose the designated shelter even when they did not know if the shelter was already full (Figure 10). This sometimes made some shelters overcrowded, but evacuees could not move to other places because of bad weather conditions. It is difficult to make evacuation decisions when there are children and elderly members in the house who need special care during evacuation (Yun and Hamada 2015; Shoji and Murata 2020; Thompson et al. 2017). Households with children,

seniors, or sick members were sometimes unable to decide whether to evacuate early because they thought it would be safer to stay at home with them, whereas other households thought if they reached the shelter at any cost, they would be safe. The preparation time and evacuation travel time also had a significant impact on early evacuation. Among households that evacuated early, half of them took two hours for preparation, while the remaining half took one hour or two to six hours. Among households that did not evacuate early, the majority took two hours (Figure 14). Respondents who evacuated early could choose any shelter regardless of the distance and faced relatively fewer difficulties as the weather was not as bad as it was just before the cyclone landfall. Concerning evacuation preparation time, female respondents took a longer time than male respondents for evacuation at different warning stages (Parvin *et al.* 2019). Therefore, to ensure safe evacuation, coastal residents must be made aware of the severity of a cyclone and have enough time for preparation before evacuation. According to the survey results, people need a longer preparation time and evacuation travel time if a vulnerable member is present in the house (Table 4, Table 6, and Figure 13).

Recently, technological advancements in natural disasters have enabled great initiatives to reduce disaster risk in various sectors. For disasters such as cyclones, typhoons, hurricanes, floods, disaster preparedness, early warning mechanisms, evacuation, and recovery after a disaster has become more systematic and effective. Despite the improvements in warning dissemination and evacuation order mechanisms, many people still did not evacuate to cyclone shelters or other safer places during Cyclone Bulbul. This study analyzed evacuation behavior during a cyclone and the factors influencing evacuation behavior. Previous disaster experience plays an important role in guiding an individual or household to be better prepared for a disaster (Figure 15). According to Lindell and Perry (2000), people who have previous disaster experience are aware of the risks and effects of the different stages of a disaster—helping them handle the situation more effectively. The analysis of the survey results found that respondents' previous disaster experiences had a significant impact on evacuation during Cyclone Bulbul. Respondents who did not evacuate had less experience with disasters than those who did. This research found that demographic and socio-economic characteristics also influence people's evacuation decisions. Gender is an important issue in the evacuation decision-making process. Ikeda (1995) noted that women are vulnerable in different ways during a disaster in terms of disaster preparedness, evacuation decisions, and sheltering stages. This study found that female respondents faced difficulties when evacuating with a sick or other vulnerable member and sometimes felt unsafe evacuating alone. Most respondents cited the presence of a sick member in the house as an important factor influencing their evacuation decisions during the disaster. People who are poor and struggle to survive daily were more concerned with protecting their properties than with evacuation, which had a significant impact on their evacuation decisions.

9. CONCLUSIONS

This research sought to determine the factors influencing early evacuation decisions, early evacuation, and emergency evacuation based on the evacuation situation during Cyclone

Bulbul. Cyclone Bulbul was identified as a very severe cyclonic storm and 0.73 million people in 29 Upazilas in the coastal area of Bangladesh were affected directly. Compared to past cyclone disasters in Bangladesh, the evacuation rate increased during Cyclone Bulbul because of improved disaster preparedness plans, better early warning systems, increased number of designated cyclone shelters, and increased awareness among people about evacuation. Additionally, the CPP plays an important role in issuing and disseminating early warnings and providing evacuation guidance to the community during the evacuation, even when essential services such as electricity are not functional. This enables the safe evacuation of evacuees to shelters or other safer places (Miyaji *et al*. 2017). Sometimes, it is difficult for local authorities to reach the community, especially when the weather condition worsens. However, informal interviews with respondents and CPP unit team leaders also mentioned that CPP volunteers assist people evacuating, but sometimes it is also difficult for them to reach the individual household as weather conditions are worse. Accordingly, it is recommended that CPP volunteers participate in the evacuation process with local authorities to make the evacuation more effective and complete it in a safer location. According to Haque and Blair (1992), people in coastal areas in Bangladesh consider evacuation at the very last moment—usually a barrier to complete and safe evacuation. This research found that, even though the evacuation rate increased, many people still did not evacuate because of the poor road network, distance to cyclone shelters, delayed dissemination of evacuation orders, concern for protecting household goods and livestock, and the presence of vulnerable members in the house. However, it is important to focus on safe evacuation to reduce physical damage, particularly casualties and injuries during a cyclone. Follow-up surveys should further explore safe evacuation as many have died over the past years because of natural disasters and people in Bangladesh's coastal areas are expected to face similar disasters in the future. Because people in Bangladesh's coastal areas lack ample knowledge about the severity of cyclones, they are worried about their timely and safe evacuation. The results revealed that household respondents are also concerned about their houses and other belongings that are needed for their daily life, and they have to protect them. Therefore, it is also necessary for the government to take initiatives to help coastal people build their houses in low-risk zones and therefore provide possible support for this, considering the long-term disaster preparedness plan.

Parvin *et al*. (2019) revealed the gender-based evacuation preparation time before starting evacuation during Cyclone Aila in 2009, which could be a great issue for evacuation at the right time. However, evacuating with household members, especially with vulnerable members, is also a great concern, particularly when it comes to early evacuation concerning evacuation preparation time. This research investigated household evacuation preparation time rather than individual time because the coastal community usually evacuates with household members, not individually. The results showed that if there are vulnerable members in the house, those households need longer preparation times and longer evacuation travel times. Similarly, this research found that women face difficulties while evacuating with sick members during a disaster. Therefore, it will be better to identify and recognize such types of households and help them safely evacuate future disasters. The data also showed that the early evacuation rate was relatively lower among households with vulnerable members. People want to evacuate early when they have vulnerable members in the house to ensure safe and successful evacuation

because they are aware of the difficulties of evacuating with such members, especially when they must evacuate by walking. Therefore, responsible authorities should focus on effective preparedness for early evacuation and plan for safe and complete evacuation during a disaster. Although this research investigated specific vulnerable members in the house in detail, it is also necessary to include the pregnant member, therefore analyzing the possible consequences of safe evacuation as well. Steps such as the early issue of evacuation orders should be taken to increase the possibility of early and safe evacuation in the future, especially when there are vulnerable members in a house. Furthermore, disaster management efforts should focus on the preparation time, as the amount of time available for organizing things before evacuation decides whether it would be an early evacuation or emergency evacuation. Identifying the right time for evacuation is important for safe and successful evacuation because various associated factors affect evacuation time, which can delay the evacuation time. Therefore, early evacuation could be an advantage for effective and safe evacuation. However, the early evacuation time is different for different disasters (Yun and Hamada 2012). The most significant contribution of this research is that it provides a better understanding of people's perceptions about early evacuation decisions and sheds light on the factors influencing early evacuation based on an analysis of the evacuation-related difficulties they faced during Cyclone Bulbul. This research revealed that almost half of the household respondents took early evacuation decisions, but in actual cases, they did not. This research recommends the issue of proper and timely evacuation orders and proper guidelines, which would help increase the early evacuation rate among coastal residents, especially when they have vulnerable members in their household, by ensuring that they have enough time to complete the evacuation safely and successfully before the weather condition changes from bad to worse during a disaster. This research recommends the issue of proper and timely evacuation orders, which would help increase the early evacuation rate among coastal residents, especially when they have vulnerable members in their household, by ensuring that they have enough time to complete the evacuation safely and successfully before the weather condition changes from bad to worse during a disaster. Responsible authorities should review existing policy actions and modify their approach where necessary to improve the possibility of early evacuation during future disasters. This may help reduce the risk of injuries and casualties during cyclones in the Bangladesh coastal regions.

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Original paper

Living with Landslides: Perceptions of Risk and Resilience in Far West Nepal

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Abstract This study presents an analysis of risk and resilience perceptions in two villages of Far West Nepal, Sunkuda and Bajedi, located in the upper Karnali River Basin. The area has been affected by deep-seated and shallow landslides, which have had a devastating impact on many rural lives and livelihoods. While both villages are exposed to landslides, Bajedi is situated in a higher risk zone. Using structured surveys, semi-structured interviews and insights from stakeholder workshops, the risk and resilience perceptions of household residents of the two villages are elicited. The objectives of the study are 1) to understand how residents perceive their risk and resilience to landslides, and 2) to provide evidence and insights on the factors that influence risk perception. Results show that landslides are perceived as an existential risk in both villages, although risks are perceived as more serious in Bajedi. The higher risk perception in Bajedi is shown to be mainly driven by households' ability to cope, including their energy sources, whether they know whom to call in case of a landslides, as well as household savings and income sources. In Sunkuda, risk perception is shown to be influenced by households' access to and status of community forests, expenditure on medication, the seasonality and types of water sources, and ethnicity. In both villages, additional drivers of risk perception include households' social networks, their perceived triggers of landslides, their outstanding loans, and who collects the water. The results demonstrate the interconnectedness of risk perception and indicators of resilience. By elucidating the risk perception of Sunkuda and Bajedi, this study has important implications for local risk management strategies and policies.

Keywords: Risk perception, Resilience, Landslide, Boosted Regression Trees, Five Capitals

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1. INTRODUCTION

In many regions of the world, landslides represent a major risk to human lives, property, and resources. This is particularly true for Nepal where the world's highest mountain range, the Himalayas, is located. Petley *et al.* (2007) observed an upward trend in occurrences of landslides in Nepal since 1978, with Nepal accounting for 10% of all fatal landslides globally (Froude and Petley 2018). In Nepal, landslides are driven by a complex combination of factors, including seasonality, seismic activity, climate change (*e.g.*, heavy rainfall events) and other anthropogenic stressors (*e.g.*, road construction, land conversion) (McAdoo *et al*. 2018; Petley *et al.* 2007).

Many mountain areas in Nepal are physically and economically marginalized (Department for International Development 2013). In Far Western Nepal, where poverty, food insecurity, and social inequity are severe, many of the most productive members of rural households opt to migrate for better economic opportunities (Thieme 2003). Thus, land-use change to connect rural communities with outer markets is considered as one of the drivers of landslides in rural Nepal (Froude and Petley 2018; McAdoo *et al.* 2018; Sudmeier-rieux *et al.* 2019)

Until recently, landslide risk had received little attention from Nepal's policymakers due to budgetary restrictions, underreporting of associated losses, siloed institutions with poor interdepartmental collaboration, and competing disaster paradigms that focus largely on disaster response rather than preparedness (Vij *et al*. 2020). Thus, mountain communities and households are typically left to devise their own strategies to mitigate and enhance their resilience to landslide risk.

Understanding how members of communities perceive their risk and resilience to landslides is critical for developing effective DRR and resilience-building action plans. According to the United Nations Development Programme (UNDP 2015:7), disaster risk is defined as "the probability of harmful consequences — casualties, damaged property, lost livelihoods, disrupted economic activity, and damage to the environment — resulting from interactions between natural or human-induced hazards and vulnerable conditions". This is conventionally expressed as a combination of hazard likelihood, exposure, and vulnerability (IPCC 2020). For the purpose of this study, risk is characterized as a combination of the likelihood of a landslide event and its impact.

Risk perception is a subjective judgment that people make about the characteristics of hazards and the severity of their impacts (Sjöberg *et al.* 2004). A basic premise is that risk perception is inherently subjective due to the complexity of human response to the hazards they perceive (Slovic 1980). There is substantial literature on the concept and measurement of risk perception from psychological, anthropological, and sociological perspectives (Hernández-Moreno and Alcántara-Ayala 2017). Slovic *et al.* (1980) argue that risk perception is influenced by the nature of the risk, in particular the risk's voluntariness, controllability, familiarity, immediacy of consequences, and threat to future generations. The perception of risk has also

been shown to differ with the proximity to a hazard (Aboagye, Dari, and Koomson 2013), previous experience (Hernández-Moreno and Alcántara-Ayala 2017), demographic characteristics including socio-economic status (Peacock, Brody, and Highfield 2005), as well as individual worldviews (Douglas 1979). Importantly, in highly vulnerable communities the impacts of landslides and other hazards depend strongly on the ability and capacity of communities to recover their health, property, and livelihoods in response to the hazard. Risk perception is closely interrelated with resilience.

Resilience is generally defined as the capacity of individuals or groups to cope, adapt, and transform in the face of uncertainty or shocks through learning from the past, planning for the future, or reorganization in the face of uncertainty (de Weijer and McCandless 2015). Resilience is composed of many interlinked dimensions, ranging from tangible economic factors, such as wealth and livelihood, to other household assets, including human, natural, physical and socio-political capital (Keating *et al.* 2017). In light of this complexity, numerous resilience measurement approaches have recently emerged (Cai *et al.* 2018; Schipper and Langston 2015; Sharifi and Yamagata 2016). The Five Capitals (5C) framework was developed as part of the Sustainable Livelihoods Framework (DFID 1999) for ensuring disaster resilience. The framework is based on five 'capitals' or dimensions: human (human skills, knowledge and health), socio-political (social and institutional networks), natural (natural resources and other ecosystem services), physical (infrastructure and services), and financial (economic resources such as savings, remittances, loans) (Harris 2020; Keating *et al.* 2017). The 'capitals' terminology is commonly used to describe the static dimension of resilience and typically calculated as the state of a community before and after a disaster (Serfilippi and Ramnath 2018). A further commonly used framework is proposed by Béné *et al.* (2012), who argue that resilience emerges as the result of three capacities: absorptive, adaptive, and transformative, each leading to an outcome of persistence, incremental adjustment, or transformational responses, respectively.

Therefore, considering how and why households feel 'resilient' to landslides is not only key to developing resilience strategies that are tailored to the local needs of stakeholders, but adds insight into the complex layers of risk perception. Again, risk and resilience perception are intricately linked. Landslide risk perception has been investigated in communities in South East Asia (He and Zhai 2015; Ho *et al.* 2008), Europe (Antronico *et al.* 2020; Calvello *et al.* 2016), South America (Nathan 2008; Tobin *et al.* 2011), and North America (Butler and DeChano 2012; Peacock *et al.* 2005); yet little is known about the influences of landslide risk perception in Nepal. The purpose of this study is twofold: A first aim is to understand how residents in two highly exposed villages in Far West Nepal (Sunkuda and Bajedi) perceive their risk and resilience to landslides (Section 4.1). A second aim is to identify those factors that contribute to the resident's perception of risk (Section 4.2). Those factors related to resilience are grouped according to three composite capitals: financial, natural-physical, and socio-political (Sections 4.2.1-4.2.4). Since the two villages are different in terms of their risk exposure and resilience, we also draw comparative insights. By elucidating the underlying factors influencing risk and

resilience perception, the study draws conclusions for local risk management strategies and policies.

2. STUDY SITES

Two mountain villages were chosen for this study: Sunkuda, a village in Bithadchir Rural Municipality of Bajhang District, and Bajedi, a village in Budhiganga Municipality of Bajura District. There are about 606 households consisting of 4000 residents in Bajedi and 329 households with 1645 residents in Sunkuda. Both sites are located in the upper Karnali River Basin in west Nepal (figure 1), an area affected by a complex interplay of hazards, including landslides, floods, and earthquakes. The two study sites are subject to deep-seated slides and more commonly to shallow slides that have the greatest impact on rural livelihoods (Sudmeier-Rieux *et al.* 2012). A major deep-seated slide devasted parts of Bajedi in 2013 and 2019, causing river blockages through landslide debris, and as recently as July, 2020, six households were displaced and ten families evacuated due to a rainfall-triggered slide (RSS 2020; Singh 2018). The last major landslide event in Sunkuda took place almost 50 years ago (Cieslik *et al.* 2019). Both locations experience frequent seasonal shallow soil (Sunkuda) or rock (Bajedi) slides.

The impact of landslides in the study areas includes loss of lives, livelihoods, assets, destruction of agricultural land, and damage to drinking water sources and irrigation canals. These impacts are expected to intensify due to climate change, unsustainable land-use practices, and poorly regulated development (Sudmeier-rieux *et al.* 2019; Vuillez *et al.* 2018). The expanding area affected by landslides in the study sites has led to diminished or complete loss of agricultural land owned by individual households, depriving these communities of their primary source of livelihood.

Sunkuda and Bajedi villages differ in several aspects. Sunkuda village shows signs of greater development and structural investment. It is connected by the Jay Prithvi Highway (a tarmac road) making the village accessible in case of a disaster. While households in Sunkuda rely on solar power for electricity, electrical wires currently run through the village to the rural municipality, and there is a hydropower plant under development in the region. Furthermore, Sunkuda benefits from the presence of active non-governmental organizations (NGO), *e.g.*, the Red Cross, Practical Action and Mercy Corps, each working in collaboration with community-based organizations. With support from NGOs, households in Sunkuda are involved in livelihood diversification measures, such as vegetable farming, and have set up an informal banking system through which households can take out loans and place savings.

Bajedi, in contrast, is more remote and accessible only by foot or mud tracks that are mostly unsuitable for large vehicles. Households in Bajedi receive little help from development projects or NGOs. With a greater proportion of mud houses compared to Sunkuda, Bajedi is

particularly vulnerable to landslides. Moreover, households in Bajedi are also subject to landslide damage to their agricultural land. The soil frequently exhibits cracks that can eventually lead to slope collapse during heavy rainfall. Households in Bajedi have attempted a range of landslide risk management measures, such as revegetation, restriction of open grazing, channelling excess water outflows from agricultural land, and establishing temporary shelters during the monsoon (Cieslik *et al*. 2019). The response, however, is less organised than in Sunkuda.

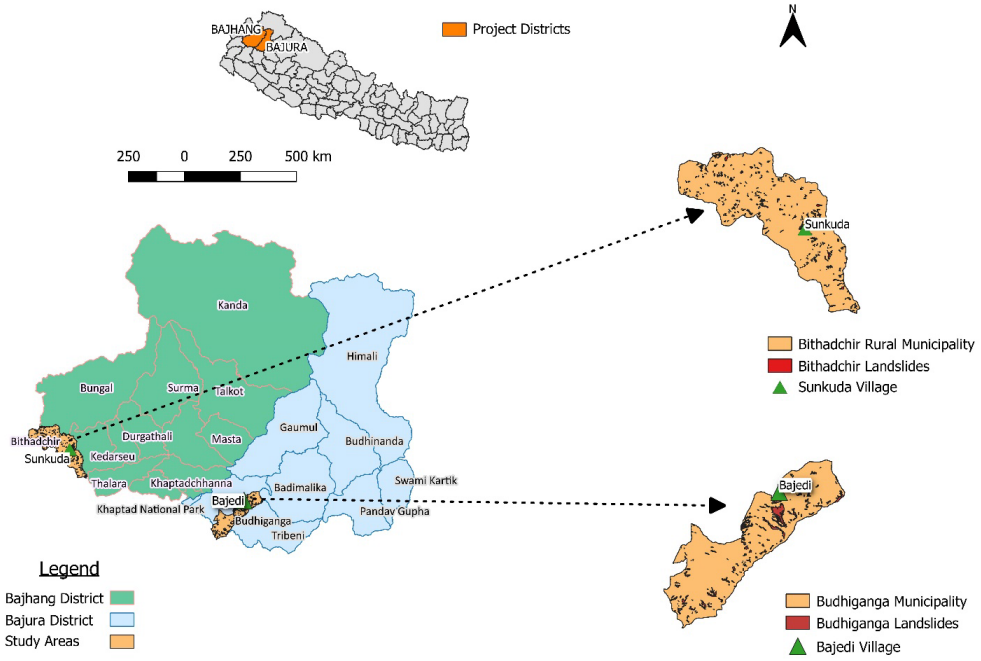

Figure 1. Study areas of Far West Nepal. Source (A. Muñoz-Torrero Manchado, S. Allen 2021)

3. METHODS

3.1 Household Survey, interviews, and workshops

Structured household surveys were carried out in Sunkuda and Bajedi during March and May 2019. The survey questions (Appendix 1) were designed to elicit views of landslide risk and resilience at the household level. The survey was organized according to six main categories: 1) general demographic data; 2) perception of risk and resilience; 3) household assets; 4) household livelihoods, finances, and hazards; 5) community services 6) risk preparedness and responses. A total of 193 households were included in the study, of which 72 households are located in Sunkuda village and 121 households in Bajedi village. The household survey includes seven statement entries on landslide risk and resilience perception shown in table 1. The responses are measured on a five-point Likert scale (1 = Strongly Agree, 2 = Agree, 3 = No Opinion, 4 = Disagree, 5 = Strongly Disagree).

Table 1. Statement entries on landslide risk perception and subjective resilience

Risk indicators	**Statements**
Fear	I am worried about the danger of landslides in my region.
Impact	Another landslide would have severe consequences for my household.
Likelihood	My household and land are located on or near a slope that has a strong landslide hazard potential.
Future risk	The risk of landslides in my region will increase in the future, i.e., more frequent and/or more severe.
Resilience indicators	
Coping capacity	Considering the last major landslide event in my area, if a similar landslide had recently occurred, my household could cope with it and fully recover within six months.
Adaptive Capacity	If landslides were to become more frequent and severe in the future, my household can adapt to the threats and survive, for example by diversifying our livelihood.
Transformative Capacity	If landslides were to become more frequent and/or severe in the future, my household can transform its way of living, *e.g.,* by migrating out.

Recent literature and experience have emphasized the importance of the five capitals (5C) framework, which provides greater richness of data about communities' sources of resilience than any single metric (Keating *et al*. 2017). For this reason, the 5 Capitals (5C) framework (DFID 1999) was used as the guiding structure to classify risk perception drivers. The 5Cs consist of Socio-cultural, Human, Physical, Natural and Financial Capitals. Recognizing the use of this framework for capturing the multidimensional nature of risk and resilience perception, the survey was structured around the 5C framework, which will guide the discussion of the risk perception results. It additionally includes indicators of risk perception based on previous studies (Hernández-Moreno and Alcántara-Ayala 2017; Jones 2018; Jones and Tanner 2017; Liu *et al*. 2018). Respondents' key demographics are presented in Appendix 2.

Household survey data were supplemented by semi-structured interview data with households and key informants (local political leaders and community elders) (N=19), and with field observations conducted throughout multiple site visits during 2018-2020. Additionally, a series of stakeholder workshops and consultations on emerging governance issues were held in 2018 at the municipal level. These workshops involved discussion groups and brought together teachers, principal of the school, red cross officials and elected officials (N=71). Workshop reports can be found in the Supplementary Materials.

3.2 Statistical analysis

The statistical analysis of the household survey data is based on boosted regression trees (BRTs) (Gelman and Hill 2006). This approach was chosen because the assumptions underlying alternative approaches, such as linear, generalized linear, and nonlinear regression models, are violated by the survey data, including linearity, independence between independent variables and homogeneity. By being semi non-parametric, BRTs can accommodate complex nonlinear relationships and missing data. As their name suggests, BRTs are composed of a series of regression trees that describe the relationship between the dependent and independent variables using recursive binary splits and gradient boosting (an adaptive approach used to aggregate simple models to improve predictive performance). As such, the predictive performance of BRTs is often superior to traditional modelling methods (see Elith *et al.* 2008).

Data are clustered by village (Sunkuda and Bajedi) to account for the different risk and resilience profiles of the villages, for which two separate models are calculated. As the BRT method is non-parametric, i.e., it does not assume a normal data distribution, we measure the influence of a variable influence by its contribution to overall Mean Squared Error (MSE) variability. The completed BRTs have an out-of-sample MSE of 0.21 and 0.15 for Sunkuda and Bajedi, respectively. More information on these methods is provided in the supplementary materials.

4. RESULTS AND DISCUSSION

4.1 Perceptions of risk and resilience in Sunkuda and Bajedi

An overview of responses to the seven statement entries on landslide risk and resilience perception (table 1) by the 193 respondents is illustrated in figures 2 and 3. Concerning risk perception, the results (figure 2) show that almost all respondents in Bajedi and Sunkuda fear landslides (slightly more strongly in Bajedi), and 88% and 69% of respondents in Bajedi and Sunkuda, respectively, believe that future events would have fatal consequences for their households. The heightened concern in Bajedi is not surprising given the greater number of communities (90% versus 66% in Sunkuda) reporting (‘strongly agreeing’ or ‘agreeing’) that they live near slopes with high landslide potential. Finally, respondents in both villages (96% and 91%) ‘strongly agree’ or ‘agree’ that landslide risk will increase in the future. Interviews carried out in the region supported and extended these results, namely that increasingly sporadic and heavy rainfall was considered a main trigger of landslides in Bajedi, and road construction and weak geology were considered main triggers in Sunkuda.

As shown in figure 3, respondents in both villages exhibit similar perceptions of their household’s resilience, as evidenced by their responses to questions on their coping, adaptive and transformative capacity. Respondents in Bajedi (91%) and Sunkuda (66%) reported that if they were exposed to another landslide, they would not be capable of fully recovering

('strongly agreed' or 'agreed'); 80% (Bajedi) and 69% (Sunkuda) reported that they could not fully adapt, *e.g.*, by changing their livelihoods ('strongly agreed' or 'agreed'); and 72% (Bajedi) and 78% (Sunkuda) that they would not be able to transform their lives, *e.g.*, by migrating to somewhere safer.

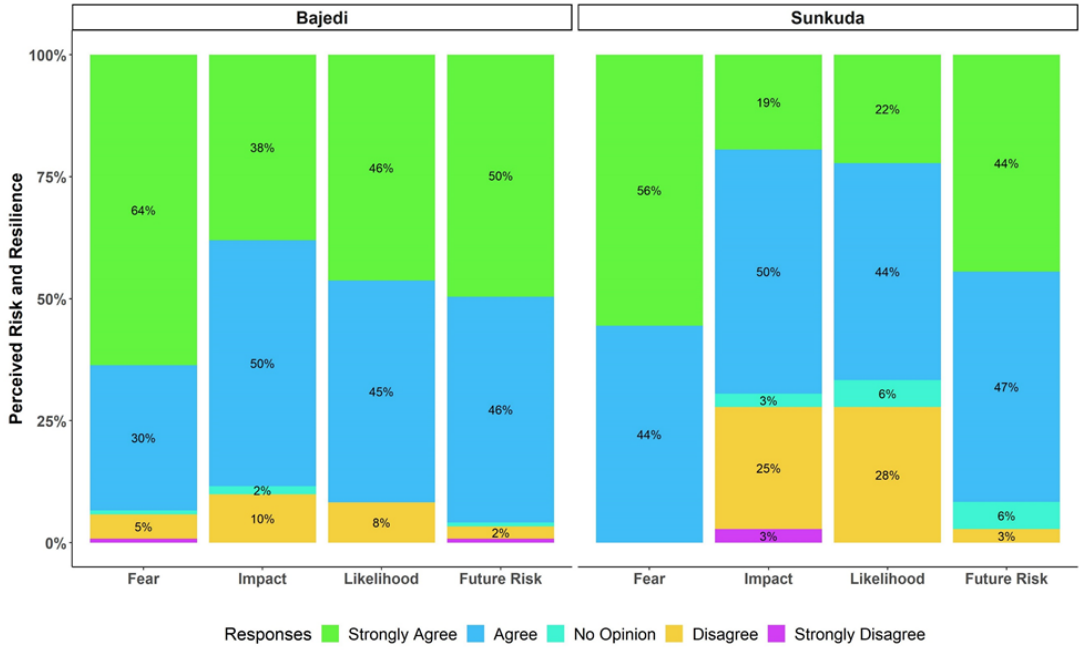

Figure 2. Responses to the four statements concerning risk perception in Bajedi (left) and Sunkuda (right)

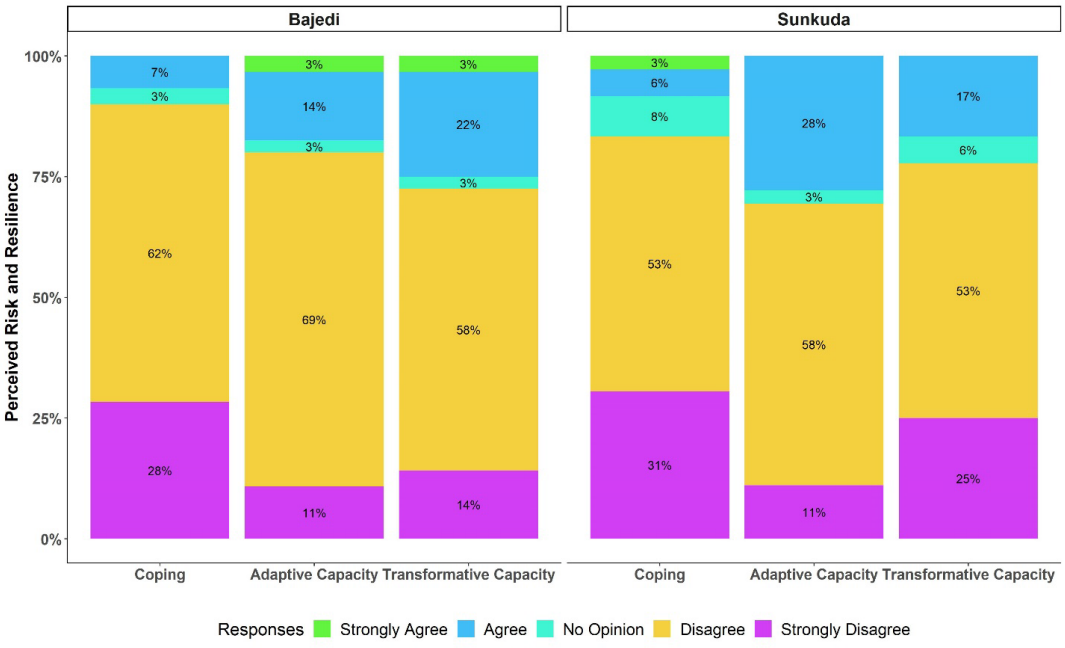

Figure 3. Responses to the three statements concerning resilience perception in Bajedi (left) and Sunkuda (right)

The results provide strong evidence that landslides are perceived as a major and worsening, even existential, risk by almost all respondents in the surveyed households. The results also show that an overwhelming majority of respondents view their resilience in terms of their coping, adaptive and transformative capacity as low. Perceived risk indicators are somewhat higher in Bajedi, which has suffered more extreme landslides in the recent past.

4.2 Drivers of risk perception

This section delves more deeply into the factors influencing risk perception at the household level in Sunkuda and Bajedi. For this purpose, 'risk perception' is specified as a compound dependent variable composed of two (of the four) aspects of risk perception shown in table 1, namely the perceived impact of a landslide event and its perceived likelihood. This is consistent with the definition of risk discussed in section 1. The geometric mean of the likelihood and impact variables is calculated, where lower values indicate lower perceived risk and higher values indicate higher perceived risk on a 5-point Likert scale. Figure 4 shows the distribution of the computed risk perception variable in each village.

Figure 4 confirms earlier results by once more highlighting a higher perceived risk in Bajedi, whereas risk perception is more evenly distributed in Sunkuda. The survey variables that exhibit the greatest influence on risk perception in Bajedi and Sunkuda are extracted using Boosted Regression Trees (BRTs). A description of each independent variable is provided in table 2.

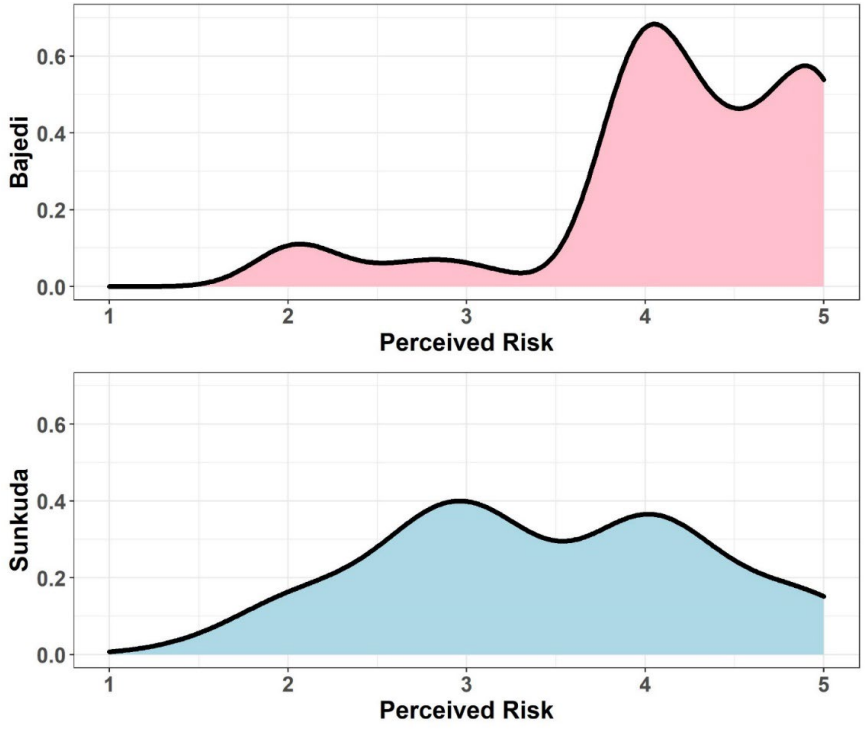

Figure 4. Kernel density plots of risk perception in Bajedi (top) and Sunkuda (bottom)

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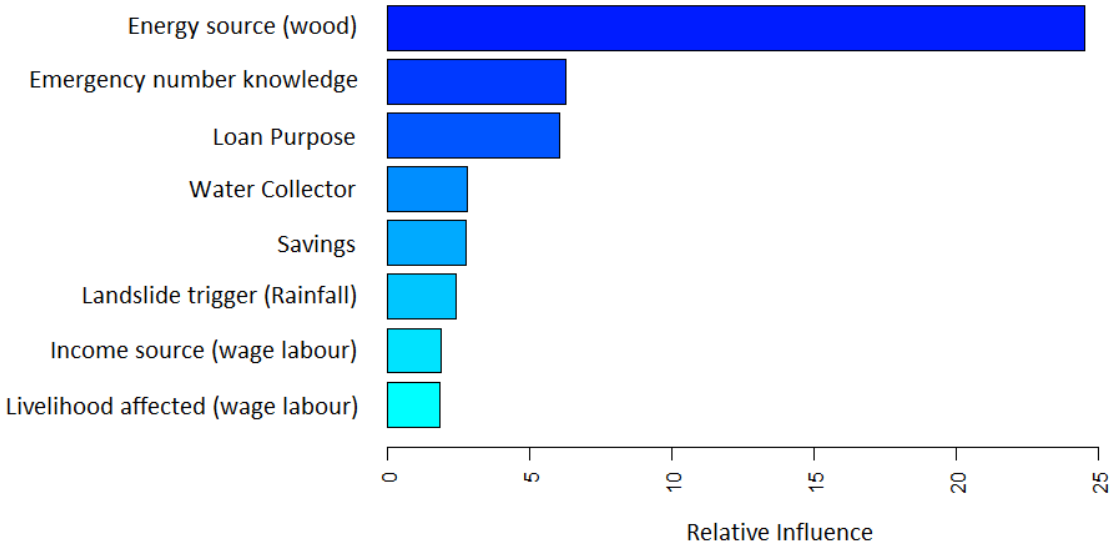

Figure 5. Bar plot of the variables having the most influence on risk perception in Bajedi

Figure 5 shows the main drivers of risk perception in Bajedi, which include mainly factors relating to the resilience of the households. Foremost is the household's energy source. Drivers with less but still important influence include knowledge of an emergency number, outstanding loans (depending on their purpose), the household member collecting water, and household savings. Interestingly, the single explanatory variable relating directly to the hazard itself is the landslide rainfall trigger.

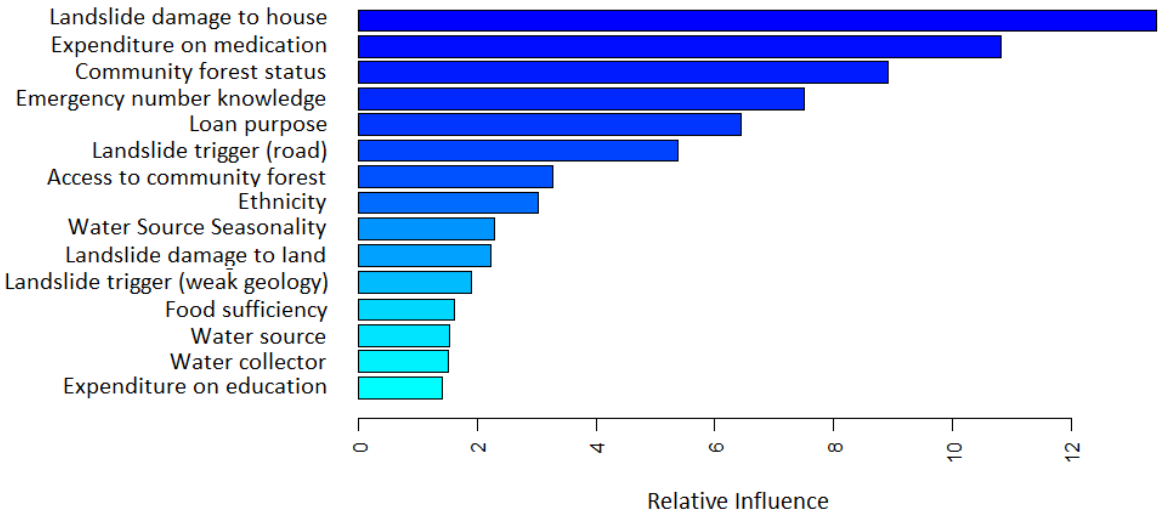

Figure 6. Bar plot of the variables having the most influence on risk perception in Sunkuda

Table 2. Description of the variables driving risk perception

Variables	**Corresponding survey question**
Energy source	Q 5.2) Please rank your main energy sources
Emergency number knowledge	Q 6.5) Do household members know which number to call in case of a landslide?
Loan purpose	Q 4.14) In the past 10 years, has your household taken out a loan? For what purpose?
Water collector	Q 5.7) Who mainly collects water for the household?
Savings	Q 4.12) Does your household have enough savings or other assets to enable all household members to survive in the event of a landslide?
Landslide trigger	Q 4.5) Which of the followings do you think are the major contributors to landslide hazards in the past 10 years?
Income source	Q 3.4) Please rank the following income sources in terms of their relative share of your total income.
Livelihood affected	Q 4.9) When landslides occur, how are your livelihood activities affected?
Landslide damage to house	Q 4.6) Over the last 10 years was your house affected by landslides?
Expenditure (on medication, on education)	Q 3.4) Please rank your annual expenditures in the last 2 years
Community forest status	Q 5.25) What is the status of community forest compared to non-community forest: better; similar; or worse?
Access to community forest	Q 5.22) Does your household have access to community forest?
Ethnicity	Q 1.1) What is your household's ethnicity?
Water source seasonality	Q 5.5) Does your water source change seasonally?
Landslide damage to land	Q 4.8) Over the last 10 years, has your land been affected by landslides?
Food sufficiency	Q 4.3) Generally, in 2017-2018 how many months of food can you produce from your own fields per annum?
Water source	Q 5.4) Where do you obtain your drinking water?

A contrasting and more multi-faceted picture emerge in Sunkuda. As shown in figure 6, the most influential factor on risk perception, not surprisingly, is related to the household's risk exposure, namely whether the house has been damaged by a landslide in the preceding ten years. Other risk-related factors include landslide triggers and damage to land. The most influential resilience-related explanatory variables include the household's expenditure on

medication, the community forest status, knowledge of the emergency number and household loans (depending on their purpose)

A striking observation from the analysis is the extent to which risk perception is related to how the respondents view their household's coping, adaptive and transformative capacity, or resilience. In Bajedi, all significant risk perception drivers are related to resilience and not to the hazard likelihood or exposure. This is not the case in Sunkuda, where, consistent with risk perception literature (Bustillos Ardaya, Evers, and Ribbe 2017; Damm *et al.* 2013), hazard and exposure, including past landslide damage to the house and land, play a significant role. Indeed, in Sunkuda, a respondent's house having been damaged by a landslide in the last ten years is the most important factor increasing risk perception. Yet, even in Sunkuda indicators of resilience are important explanatory factors. The analysis hence highlights the strong links between risk, resilience, and vulnerability. Although these concepts are well defined in literature, there is no reasonable consensus on their overlap and the nature of their relationships (Serfilippi and Ramnath 2018).

In what follows, we explore the role of resilience in explaining risk perception in Bajedi and Sunkuda. For this, we organize the survey results according to the capital framework (DFID 1999) by grouping the explanatory variables into four (not five) composite capitals: financial, natural-physical, social-political and human. We draw on the survey results plus interviews, workshops and focus groups held in the region.

4.2.1 Financial capital

In Sunkuda and Bajedi, a majority of surveyed households (53%) are engaged in two or more economic activities, mostly combining subsistence farming with occasional wage labour although paid jobs are in short supply in the study areas (Cieslik *et al.* 2019). Agriculture is increasingly at risk from earthquakes, landslides, and other climate-related hazards, and hardly provides a subsistence for most households. This has led to increasing out migration and dependence on remittances, not only in the studied villages, but throughout Nepal (Gartaula, Niehof, and Visser 2012).

Lacking insurance, vulnerable households in Nepal and across the developing world have traditionally financed post-disaster recovery with a combination of savings and credit, informal kinship arrangements, government relief and international donor support (Linnerooth-bayer *et al.* 2019). As illustrated in figures 5 and 6, financial factors are important driving forces in household respondents' risk perception. Indeed, three out of the eight most influential variables are related to financial capital in Bajedi, and three out of 15 in Sunkuda, highlighting the greater financial hardship faced by households in Bajedi. Respondents from households with meagre if any savings (figure 7), outstanding and past loans (figure 8) and especially loans for house repairs or medication, and insecure income sources, feel themselves to be more at risk from landslides.

Savings have been shown to represent key strategies at household level to cope with disaster risk (Ahmad and Afzal 2020; Berman, Quinn, and Paavola 2015). Savings can take the form of cash or bank deposits, as well as stockpiles of food, grains, seeds, and marketable assets, such as livestock, which serve to smooth consumption during crises. Household savings in Bajedi and Sunkuda mostly take the form of livestock and their sale, including food, manure, and cash income (*e.g.*, from selling milk). The loss of productive assets after a disaster is a major factor trapping poor households in poverty (Barnett, Barrett, and Skees 2008; Linnerooth-Bayer and Suarez 2011). It is striking that most surveyed households report savings that can assure their survival for only two days (3% of respondents) to one month (58% of respondents), and very few households had savings for more than one month (N=15, or 13%). Figure 7 shows that generally in Bajedi the greater the household's savings, the less the respondent felt at risk from landslides. This trend was less clear for households with no savings, which exhibit a larger data spread. These results confirm the importance of sufficient financial assets as means for households to feel less at risk.

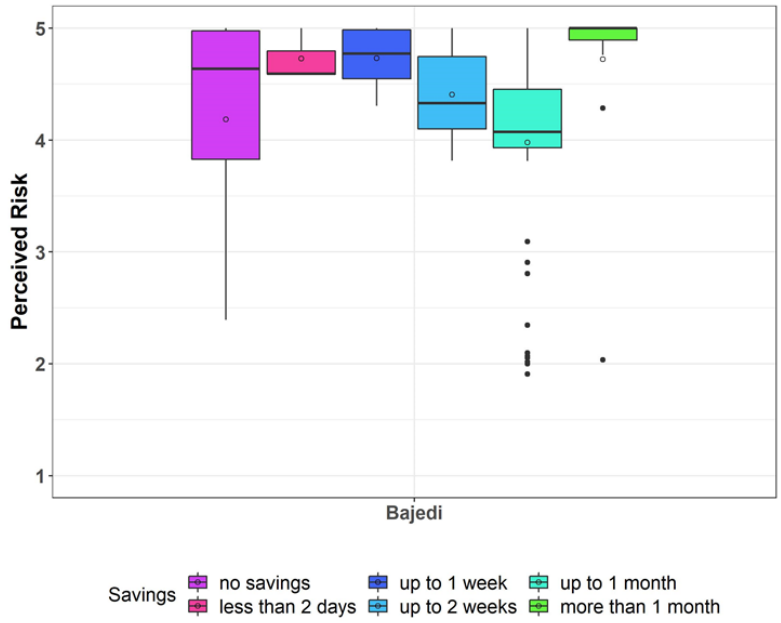

Figure 7. Boxplots of risk perception by the length of time for which households possess savings to survive after a landslide in Bajedi

As a form of debt, loans are likely to play a negative role in household respondents' risk and resilience perception (Gash and Gray 2016; Poshan *et al.* 2013). Figure 8 shows that outstanding or re-paid debt from having received a loan in the past 10 years for education, farm equipment, housing, marriage or repairs and maintenance is an influencing variable for risk perception in both villages. In Bajedi, the highest risk to landslides is perceived when households had taken out loans for repair and maintenance of their houses or for 'other purposes', which include medication. A wider data spread is observed for households haven

taken out no loan. A possible explanation is that these loans had been intended for repair and maintenance in the aftermath of a landslide event. Consequently, based on their experience, those households would feel more at risk from landslides. It should however be noted that higher risk perception of those households having previously experienced landslides could simply be linked to being located in higher risk zones, depending on whether previous landslides were experienced elsewhere. In Sunkuda, households that had taken out loans for 'other purposes', including medication, felt most at risk from landslides. Loans for farm equipment or seeds are small, which can be explained by the very low returns for farming in these mountain villages.

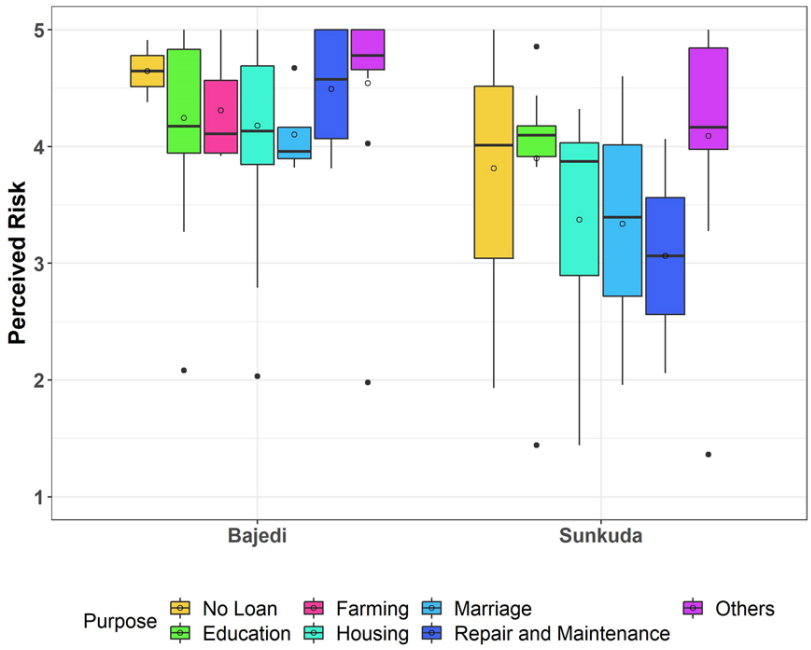

Figure 8. Boxplots of risk perception by the purpose of a loan taken out in the last 10 years in Bajedi (left) and Sunkuda (right)

The difficult economic situation in Sunkuda and Bajedi has led to increasing out migration, not only from Bajedi and Sunkuda, but throughout Nepal, causing a gradual shift from an agriculture-based to a remittance-based economy (Gartaula *et al*. 2012). Indeed, remittances are more than three times the size of official development assistance (World Bank 2016) and can be a significant contribution to post-disaster recovery. Remittances contributed to over a quarter of Nepal's national GDP in 2018/19 (Ministry of Finance 2019). The economic transition is also observed in this study area, where most households reportedly rely on remittances (30%) and non-farming activities (28%) as their main sources of income.

4.2.2 Natural and physical capital

In addition to arable land, essential resources for household survival in Bajedi and Sunkuda include forests for raw materials such as wood fuel, water for drinking and washing, and solar power for electricity. In this exceedingly poor rural area, physical capital is thus closely interlinked with natural capital. Homes are built from local natural materials, mainly adobe, and there are few additional physical assets. It is not surprising then that natural capital plays an important role in how household respondents perceive the risk of landslides.

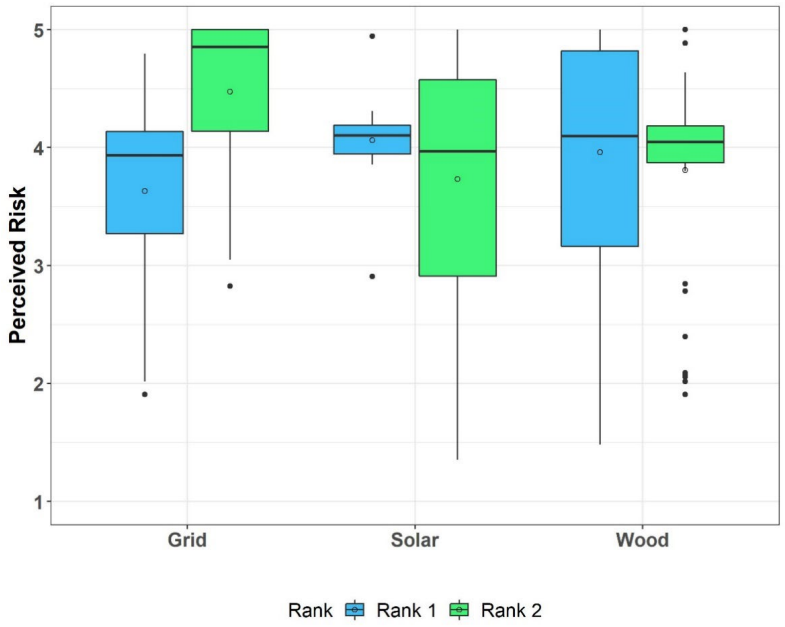

Figure 9. Boxplots of risk perception by main energy sources of households in Bajedi

In Bajedi, a main energy source for cooking and heating is wood (63%) with solar and the grid playing a moderate role for electricity generation (34%). Figure 9 shows how Bajedi household energy sources influence risk perception. Those households primarily relying on fuelwood have the highest risk perception. On the one hand, fuelwood is mainly harvested from community forests, meaning that accessibility and availability can decrease in the event of a landslide. Additionally, collecting wood often requires household members to travel long distances, further exposing them to landslides and consequently increasing their perceived risk. On the other hand, community forests are known to stabilize steep slopes, thereby decreasing landslide risk (Forbes *et al.* 2012; Promper *et al*. 2014; Sudmeier-Rieux *et al.* 2012). Results may then also signal the knowledge of forests' protective role from landslides. Figure 10 shows the influence of having access to a community forest on risk perception.

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Figure 10. Boxplots of risk perception by the existence of a community forest (left) and access to this community forest (right) in Sunkuda

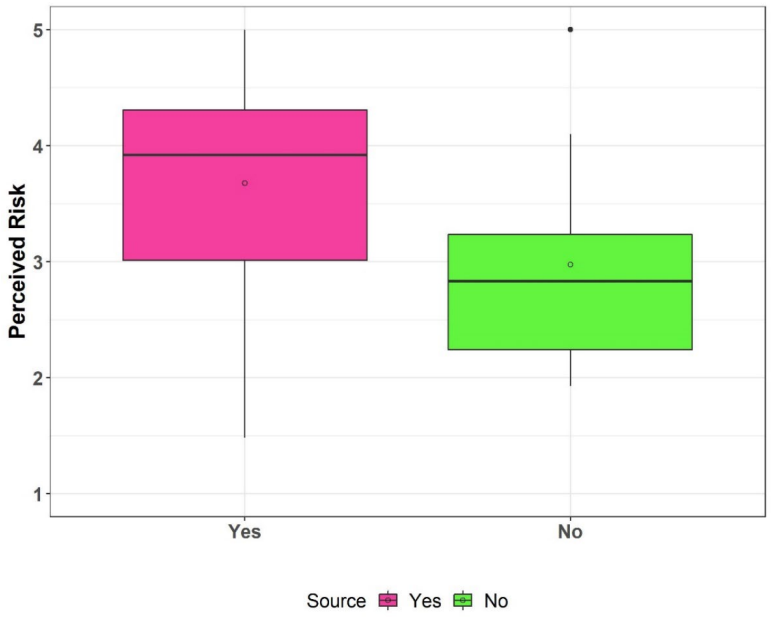

Figure 11. Boxplots of risk perception by whether households' main water source changed seasonally (left) or not (right) in Sunkuda

Another critical resource in the event of a landslide is potable water. The seasonal change of water availability is shown to be a key influence of risk perception in Sunkuda (figure 11),

where respondents from households whose drinking water sources change seasonally feel more at risk from landslides than those whose water source remains constant over the year. The link between water availability and risk perception was also noted in rural Chongqing (China), where household surveys revealed that insufficient water quantity is associated with higher disaster risk perception (Ho *et al.* 2019). Moreover, it appears consistent that diversified water sources would impact on how much a household respondent feels at risk from landslides. While diversification can provide security in case one source is impacted, at the same time those households relying on diverse water sources are likely to travel further when their nearest water collection point is unusable, increasing individual exposure to a landslide during these journeys. Additionally, Cieslik *et al.* (2019) note that daily activities such as fetching water often represent opportunities to observe and monitor surroundings for signs of upcoming landslides. Thus, risk perception of those households having to travel further to fetch water could also be higher because they are more likely to notice possible early signs of change, *e.g.*, cracked soil or increasing stream turbidity. A further result in both villages is the influence of which household member collects water on risk perception (figure 12).

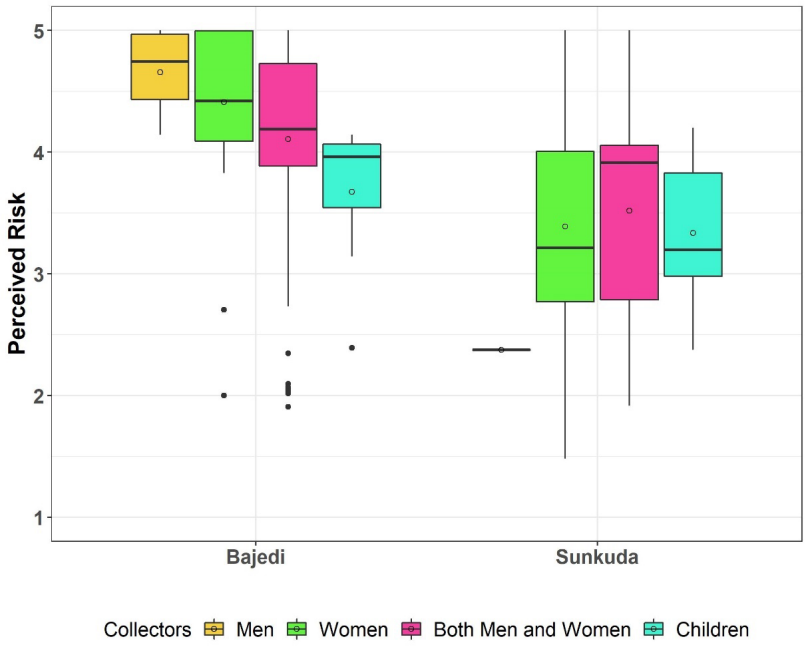

Figure 12. Boxplots of risk perception by the households' main water collector in Bajedi (left) and Sunkuda (right)

Findings show that once again, the general risk perception of respondents was considerably higher in Bajedi than in Sunkuda. In both villages, results show that risk perception of landslides is lowest when children collect drinking water for the household. This may mean that the main water source is nearby since children would only be able to carry water over short distances. In Bajedi, risk perception was highest when male members were the main water collectors. As male household members often migrate to nearby countries (mostly India) to

seek employment, households in which males collect water are likely to be those for whom outmigration is not an option, for example due to health reasons, or those in which men managed to secure a local employment or income. This data trend could therefore be explained by increased vulnerability (*e.g.*, illness or disability in a household) or dependence on the household's main earner. Data trends were less clear in Sunkuda, and when both men and women collected water.

4.2.3 Socio-political capital

4.2.3.1 Social networks

This section draws heavily on semi-structured interview data, which shows that Bajedi and Sunkuda households have developed complex social coping strategies to counteract what many views as inadequate support from municipal governments. This is most prominently demonstrated in the heavy reliance on social networks for materials, labour, finance, and knowledge transfer related to landside prevention and recovery. The study sites are characterized by a culture of mutual aid in the face of adversity. According to the interviews, households call on their social networks if they are struggling to cope after a landslide, for example by asking for shelter or food. As noted by a villager in Sunkuda:

In the event of disaster, neighbours are the ones who help. (Interviewee S114, 07/03/2020)

Whilst emergency aid such as food and shelter are given freely, other types of support like help with rebuilding or relocation is considered reciprocal, that is, interviewees reported expectations that this labour is returned in the future. This has resulted in an informal exchange economy with many affected households indebted to others; not only in the form of monetary loans, but in anticipated future labour (Thieme 2003) . As noted earlier, the existence of monetary debts has an impact on risk perception with in-debt households reporting an increased sense of risk (see figure 8). The networks in the study sites are highly dense and based primarily on kinship and proximity, which are often interchangeable. In Sunkuda, for example, the village is comprised of communities of identifiable clusters of houses that are typically inhabited by extended family members. Network density can have an impact on resilience as dense networks have been shown to have low levels of adaptability and transformative potential (Mark S. Granovetter 1973). Networks that have a higher number of non-connected actors have greater access to different types of knowledge and more information sources. Another weakness of dense networks is that close neighbours are likely equally affected by the hazard, rendering the support network less effective. As expressed by a member from a community located in close proximity to the Dhokla landslide in Sunkuda:

*If my house is in danger, even neighbours will be affected - so at that time everyone here will be affected by the hazard. (*Interviewee S135, 09/03/2020)

Knowledge transfer, social learning and social influence (such as discussing a hazard within social networks) are common mechanisms that shape risk perception (Helleringer and Kohler 2005). While non-connected networks may have access to more information sources, In Bajedi and Sunkuda, kinship networks are important for knowledge transfer in that they substitute for the poor communication from government officials. As one interviewee stated:

Information sharing [regarding landslides] especially takes place among family members, close relatives and neighbours and it's been helpful. Nothing has been done from the government side. (Interviewee S134, 09/03/2020)

Alongside local knowledge transfer, kinship networks can also impact risk and resilience perceptions via their relationship with outmigration. As discussed earlier, surveyed households rely heavily on remittances as an income source that is unaffected in the case of a disaster. This further highlights the importance of social networks and kinship for risk mitigation strategies.

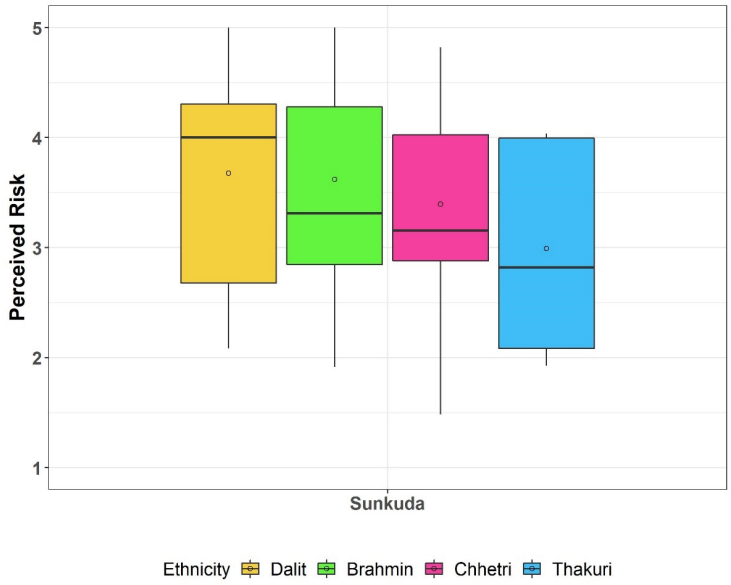

Figure 13. Boxplots of risk perception by households' ethnicities in Sunkuda

Closely related to social networks, the survey showed ethnicities to be a significant influencing factor on risk perception in Sunkuda. Figure 13 shows that high caste ethnicities, such as Brahmin, perceive landslide risk as higher compared to the low caste Dalit ethnicity. The main reasons behind this may be that high caste households are located closer to the landslide zone in Sunkuda, and they have greater financial assets (in this context meaning land and livestock), thus 'more to lose'. In this case, it is not 'ethnicity' that is the explanatory factor, but risk exposure.

Additionally, higher caste ethnicities often benefit from higher education levels, which are important for building risk awareness. The role education plays in increasing risk awareness

and preparedness is well documented (Bernhardsdottir *et al.* 2016; Cerulli *et al.* 2020; Education 2011; Muttarak and Lutz 2014). In 2005-2015, Nepal adopted a DRR framework (the Hyogo Framework for Action), which emphasized the role of education, especially, school disaster education for forming culture of disaster prevention (Ministry of Home Affairs Nepal; Dangal 2015). Nevertheless, research confirmed that initiatives taken for disaster education in Nepal are not yet sufficient (Shiwaku *et al.* 2007; Tuladhar *et al.* 2014).

4.2.3.2 Governance

In Nepal, disaster governance - legislation, institutions, and procedures - are evolving. At the national level, paradigms of governance have changed from an emphasis on response and recovery to more attention to disaster risk reduction (DRR). However, at the local level the responsible municipal institutions have focused primarily on disaster response and recovery, especially in Far West Nepal and including the field study sites (Vij et al., 2020). The dominance of a 'response and recovery' paradigm is partly due to the limited presence of NGOs and INGOs in the far-western region (ibid). Moreover, due to the recent federalization processes in Nepal, the local governments have not had sufficient time to design and implement disaster governance plans and strategies. Interview respondents mentioned that barriers to better disaster risk management include a lack of clarity among local governance functionaries, political and bureaucratic struggles, and corruption. In the words of two interviewees:

> *Nothing has been done for development or disaster risk reduction. It's mainly because of political reasons. Leaders are more concerned about individual benefits than community development work. It's a trend everywhere, those who are educated and influential are focused on individual profit.* (Interviewee S154, 06/03/2020)

> *Nothing has been provided from the municipality. But even if they provide [support], they give it to their own party's people*. (Interviewee S026, 09/03/2020)

The interviews also reveal mistrust in government authorities, which has resulted in low expectations in case of a landslide. While local governments have access to emergency funds, there are no standard operating procedures on how to mobilize these funds. Furthermore, despite the existence of a disaster management committee - a committee formed under the chairmanship of the municipal mayor and ward heads after the introduction of the Nepal Disaster Risk and Management Act 2017 (Nepal, Khanal, and Pangali Sharma 2018) - few of its members are trained in DRR-related issues.

> *They form [disaster management] committees, and they elect chairs and members. Today they form a [disaster management] committee here, and tomorrow in another village, but after that they do nothing.* (Interviewee S148, 12/03/2020)

Consequently, there is a lack of clarity on roles and responsibilities during disaster situations. The lack of communication and support from the government was reinforced by the interviews. As one interviewee put it:

> *...no one has told us once that we are at risk or that they [the government] will help us. We have not heard a single word from any person [authority or leader] here.* (Interviewee S026, 09/03/2020)

Workshop discussions revealed concern about the disaster response from the local government, which was viewed by many participants as too slow, and risk reduction measures as extremely limited. Another identified governance gap was the failure of the government to include local, traditional knowledge in its management practices. For instance, locally observed early warning signs for landslides, such as changes in land subsidence, drying up of water sources or changes in the orientation of rocks, are reportedly not included in landslide monitoring. Such knowledge could be particularly useful for citizen science approaches attempting to fill information gaps in this data-scarce region (Parajuli *et al.* 2020).

Apart from these insights elicited from workshops and interviews, governance factors elicited in the survey were noticeably absent as drivers of risk perception. This reinforces the previously highlighted sense of dissociation between risk experienced at the local household level and the policy decisions taken at the institutional level.

4.2.4 Human capital

The survey and interview results show that the most prevalent risk perception drivers, as discussed above, relate to financial, natural-physical, and socio-political capitals. Indicators of human capital as derived from survey questions on disaster preparedness (Appendix 1, Part 6) and household education (Appendix 1, Part 5) played a negligent role in explaining risk perception in the two villages. The results are thus interesting in what they do not show, namely that factors relating to human capital are significant drivers of risk perception compared to the other four capitals, despite the recognition of education's critical role in influencing disaster vulnerability (Muttarak and Lutz 2014).

One exception is the significance of the lack of knowledge of an emergency number in case of a landslide (figure 14).

As shown in figure 14, most surveyed households do not know whom to call in the case of a landslide, although less so in Sunkuda. This lack of information has significant, although mixed, results on risk perception. The results signal, moreover, a lack of disaster preparedness communication on the part of the authorities. In the words of an interviewee:

> *We know about [landslides] from the media. They inform about the weather forecast and tell us to be prepared [for landslides]. But at the local level, there are no practices of sharing information (...) nor has any initiative been taken about it.* (Interviewee S144, 12/03/2020)

Relating to this, the analysis also reveals a more deeply rooted problem than lack of communication from leaders in case of a landslide: government authorities themselves often lack the information to provide early warning of landslides. As noted by an interviewee:

If they [the government officials and leaders] have heard [about landslide risk], they give us this information, but if they are not informed themselves, how do they tell us? (Interviewee S154, 06/03/2020)

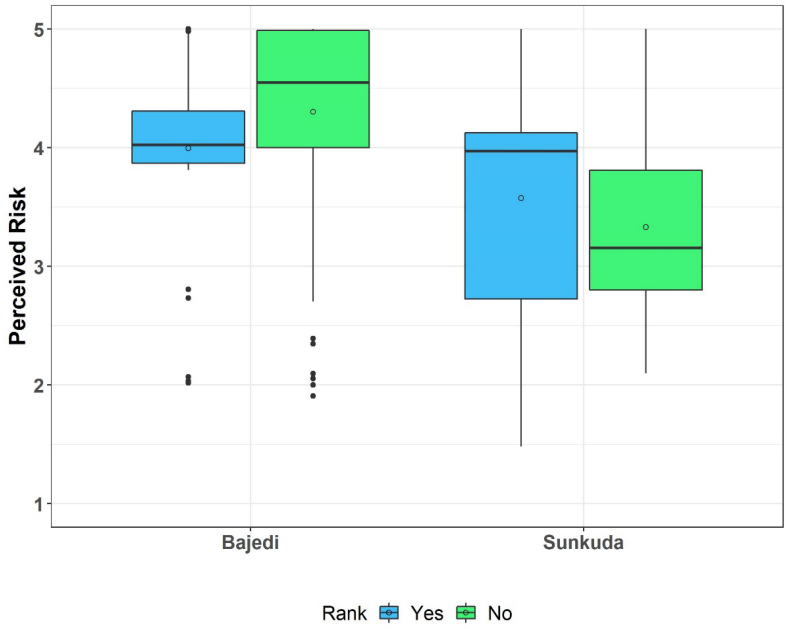

Figure 14. Boxplots of survey responses to the question "Do you know who to call in case of a landslide?" in Bajedi (left) and Sunkuda (right)

The results raise the science and policy issue of providing for a landslide early warning system (EWS). While EWS are gaining attention as important disaster risk mitigation strategies, their application to landslides remains limited due to the complexity of slope monitoring and underlying geomorphological processes (Calvello 2017; Kanta Kafle 2017). In Nepal, EWS for landslides have been shown to be hampered by a lack of policy and legal frameworks (including the absence of a national early warning centre, ineffective monitoring and evaluation, inadequate funding, and the lack of coordination among responsible bodies) resulting in fragmented capacity building efforts that have mainly emerged from individual development projects (Kanta Kafle 2017).

5. CONCLUSIONS

Based on structured surveys, interviews and stakeholder workshops, this study presents insights into landslide risk and resilience perceptions in two villages in rural Far West Nepal and distils key drivers of risk perception at household level.

Results show that landslides are seen as a worsening existential threat in both villages. Findings also show that an overwhelming majority of respondents view their resilience in terms of their coping, adaptive and transformative capacities as low. Perceived risk was higher in Bajedi, which is more vulnerable to landslides owing to its remoteness, lack of infrastructure and recent experience of extreme landslides. Risk perception in this village is mainly driven by financial factors, such as the household's savings, income sources and loans. Factors related to natural and physical capitals, such a household's main energy source and main water collector, also played key roles in driving risk perception.

In Sunkuda, risk perception is influenced by previous risk experience (*i.e.*, a previous landslide having damaged respondents' houses), as well as natural capitals including the seasonality and type of water sources and access to a community forest. Financial factors, such as expenditure on medication and loans, were also important risk perception drivers. The risk perception of respondents in both villages was shaped by whom collected water in the household, existing loans, and debts, and by whether household members knew whom to call in case of a landslide.

The analysis highlights the complexity of perceived landslide risk and resilience, which are inextricably linked in our results. Indeed, risk perception was mainly driven by what is often defined as resilience indicators (*i.e.*, the five capitals). The study findings show that risk perception was primarily driven by financial capital, closely followed by natural and physical capital, which were often overlapping due to the villages' direct dependence on natural resources such as water and firewood. This was particularly true in Bajedi, where remoteness and lacking infrastructure has increased vulnerability. Factors relating to socio-political capital were also crucial, yet harder to quantify in the survey results. Indeed, interviews revealed that kinship and social networks are fundamental for coping with disasters, as help and support is primarily provided by neighbours. In terms of political capital, it is mainly the absence of efficient risk governance structures that played a role in influencing risk perception. Disaster response and mitigation expectations from local authorities and leaders were low to non-existent. Interviews also highlighted the mistrust in a government which has, according to interviewees, so far neglected villagers when landslides occurred. Human capital was little represented in the results, and mainly influenced risk perception in terms of emergency number knowledge. The paper thus emphasises the multi-dimensional nature of risk and resilience perception and signals the need for systemic approaches and solutions to increase disaster risk reduction and mitigation strategies in this region.

The UN Sendai Framework (UNISDR 2015) calls for investment in risk mitigation and preparedness, rather than solely focusing on emergency response. Yet, our findings show that although progress has been made in disaster risk governance in Nepal, disaster paradigms still largely focus on disaster response rather than preparedness. Interviews and stakeholder workshop results clearly reveal a mismatch between communities' risk perception at the household level and DRR decision-making at the municipal and national level. This is further emphasized by traditional knowledge on landslides' early warning signs currently being

unaccounted for in risk mitigation strategies. Thus, the use of indigenous and traditional knowledge on landslides represents an important potential data source for enhancing landslide risk management. The overwhelming majority of surveyed households felt unprepared for landslides and were not engaged in (or even informed about) any possible mitigation measures, highlighting a gap in the sites' current risk governance. Our findings are thus of importance to guide authorities in designing future bottom-up risk reduction and mitigation measures, which are currently limited in the studied sites.

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