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Review:

A Systematic Review of the Factors Affecting the Cyclone Evacuation Decision Process in Bangladesh

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Researchers are investigating a broad spectrum of factors affecting positively and/or negatively the evacuation decision-making process occurring after people at risk receive cyclone warnings and advisories. Previous studies suggest that early warnings themselves do not propagate evacuation processes to be investigated but, rather, that human risk perceptions do so. This in turn encourages the sociopsychological dimensions of risk perception to be evaluated, which must be done within a country's own cultural context. In applying content analysis here, we review the literature on evacuation decision-making processes during rapidonset hazards, i.e., tropical cyclones, in coastal Bangladesh. We focus on three broad overlapping themes – early warning, risk perception, and evacuation decision-making. Major content-analysis findings suggest that two things – a lack of credibility in early warning messages and an inefficient dissemination process – tend to affect the risk perception of people at risk and are likely to eventually determine the success of evacuation decision-making. Findings also show that different socioeconomic and socio-cultural issues related to risk perception appear to be more influential than formal warning messages in propagating decisions to evacuate during a cyclone. Based on these results, we suggest specific policy recommendations for improving local evacuation efficiency.

Keywords: cyclone, evacuation decision, early warning, risk perception, protective response, Bangladesh

1. Introduction

Authors of large studies on cyclone evacuation have tended to focus on how individuals interpret warning signals and messages, how they perceive hazard risk, and what protective countermeasures they choose [1–3]. Little in the literature touches on Bangladesh, however, and even the few studies addressing cyclone evacuation focus just on the decision-making process itself or the different factors affecting this process [4–8].

In the sections that follow, we review the literature on early warning and evacuation during rapid onset hazards, i.e., tropical cyclones, to help identify and assess important dimensions of the evacuation decision-making process in Bangladesh.

Specifically, we look at three issues:

(i) Early warning features and roles within social communication processes.

(ii) Different social dimensions of risk perception.

(iii) Evacuation decision-making focusing on protective responses in Bangladesh.

In Sections 3–5 on early warning, risk perception, and evacuation decision-making, we discuss general issues and link them to the Bangladesh context. Given the ever-increasing threat from tropical cyclones, we conclude by presenting policy recommendations providing specific strategies for enabling a more efficient evacuation process.

2. Methods

Our review consists of a quantitative statistical approach and qualitative content analysis. For identifying the most suitable documents and the most representative indicators in line with our scope, i.e., evacuation, we conducted two-step quantitative analysis and while analyzing thematic issues, we performed qualitative content analysis.

2.1. Quantitative Approach

2.1.1. Document Selection

Documents were selected based on a relatively broad multifaceted search strategy using academic databases, i.e., Scopus and Web of Science, to select documents – articles, books, and book chapters published in English. Our timeline for considering these documents is 1975–2015. To search comprehensively for documents within the natural hazard domain, we used three words – evacuation,

Table 1. Document selection.

Source	Search criteria	Results	Refined by	Results	Refined by key-words	Selected
Scopus, Web of Science	evacuation; AND cyclone OR hurricane	870	Social science	209*	91	25
			Bangladesh	16	16	16
			Total document selected			**41**

*after duplicates are excluded

cyclone, and hurricane – as shown in **Table 1**. These provided nearly 900 results in round 1. These were further refined in round 2, which consisted of searching using specific terms, i.e., social science and Bangladesh. After excluding duplicates in round 2, we obtained 209 articles for social science and 16 for Bangladesh. We further refined results into 209 documents by applying the following key words, i.e., evacuation decision, evacuation process, evacuation behavior, and evacuation strategies, which resulted in a further 91 documents. Of these 91, a careful reading of abstracts for relevancy resulted in 25 documents – 22 articles, 2 book chapters, and 1 book. This led to a final total of 41 documents, of which 25 were from social science themes excluding Bangladesh and 16, of which 15 articles and 1 book chapter concerned Bangladesh in connection with evacuation during rapid-onset hazards, i.e., cyclones.

2.1.2. Indicator Selection

To determine indicators most likely to influence evacuation decisions, we analyzed 225 documents ($= 209 + 16$ (column 5 in **Table 1**). We used VOSviewer, a free software program[1], to determine evacuation-related indicators occurring in titles and abstracts of the 225 documents, regardless of how many times a specific indicator was cited in a document. We set the threshold frequency, i.e., the number of times an indicator appears in selected documents, at 20, all of which were to be considered using VOSviewer, which eventually provided 29 indicators from the 225 documents. Setting a threshold frequency of more or less than 20 provided either too many or too few indicators. Of the 29 indicators, we categorized the top 15, $\approx 52\%$, shown in **Table 2**. We divided these 15 under three broad themes: early warning, risk perception, and evacuation decision-making. **Table 2** lists grey cells indicating specific themes related to each indicator.

2.2. Qualitative Content Analysis

We analyzed content by comparing similarities and differences between general findings regarding early warning, risk perception, and evacuation decision-making in 25 documents with a non-Bangladesh context and 16 documents with a Bangladesh context. We analyzed these 41 documents ($= 25 + 16$) by using QSR NVivo (version 10) software – a program that uses descriptive coding for qualitative analysis – to code individual documents for references to early warning, risk perception, and evacuation decision-making. NVivo analysis consisted of three general issues:

(a) early warning: features (language, terms, threat information, etc.), components (source, channel, receiver, etc.), and recipient characteristics (literacy level, asset possession, connection with peers, etc.)

(b) risk perception: vision and hearing, language/family/peer-network, credibility of warning source, specificity of risk information, perceived hazard characteristics, stakeholders' perceptions

(c) evacuation decision: facilitators and impediments, gender issues and social norms, dependency ratio in the household, distance to safe havens

Of these 41 selected documents, four ($\approx$10%) address early warning, risk perception, and evacuation decision-making; five ($\approx$12%) address only early warning; nine ($\approx$22%) address only risk perception; 11 ($\approx$27%) address only evacuation decision-making processes; and 12 ($\approx$29%) address combinations of two of these themes. All 41 are presented in Appendix 1 based on their associated themes, dimensions, factors, and context (general/ Bangladesh).

We selected the published documents within the scope of this paper by using the Scopus and Web of Science

Table 2. Indicators with themes and (co-)occurrence scores (N=225).

Serial	Indicators	Occurrence*	Co-occurrence*	Themes: Early warning	Themes: Risk perception	Themes: Evacuation decision-making
1	Evacuation	135	729	■	■	■
2	Risk	89	519		■	
3	Hurricane	79	455	■		■
4	Evacuee	72	451	■	■	■
5	Warning	71	392	■		
6	Response	71	444		■	■
7	Information	69	448	■		
8	Individual	63	391		■	■
9	Households	57	359		■	■
10	Resident	56	329			■
11	Analysis	56	342		■	
12	Model	53	336		■	■
13	Decision	47	284	■		■
14	False alarm	43	283	■		■
15	Preparedness	42	229	■	■	■

* For detail explanation, please surf at http://www.vosviewer.com/getting-started#VOSviewer manual
Source: Analysis from VOSviewer.

1. www.vosviewer.com

search engines without considering library databases such as Academic Search Premier, Google Scholar, University of Colorado at Boulder's natural hazards center library, the University of Delaware's disaster research center library, PubMed, or FEMA's (Federal Emergency Management Agency) resource and document library. We consider these library databases within the scope of future studies on cyclone evacuation research.

As mentioned in the introduction, we start by focusing on the general themes of early warning, risk perception, and evacuation decision-making (Sections 3, 4, and 5 respectively), then related these to the Bangladesh context. The general discussion is mostly based on content analysis from 25 documents (row 1, **Table 1**) and the Bangladesh discussion is based on content analysis from 16 documents (row 2, **Table 1**).

3. Early Warning

Just over 31% of the documents emphasize understanding underlying factors affecting evacuation decisions in pre-states of disasters [3, 9, 10–12]. Warning features such as message content and style, channel(s) through which it is conveyed, frequency, and traits associated with its source have been focal points of previous studies as mentioned in 12% of selected documents [3, 13–14]. These studies for understanding evacuation in terms of protective response suggest that trust is the critical factor in a warning message that eventually leads to a decision to evacuate. Given this fact, the more specific and less ambiguous the warning is in terms of information and credibility, the more likely that a protective response, i.e., evacuation, occurs. In other words, warnings that are heard, understood, and believed are very likely to trigger evacuation.

As suggested by 14% of selected documents, a warning functions similar to a social process involving a range of activities and carrying a message transmitted from the source via a channel to the recipient and resulting in a protective response depending on the recipient's characteristics [15–19]. While different individuals may receive the same warning, not all may understand the basic message the same way. Responses to warning messages depend, in part, on how recipients interpret the message [20]. Individuals are, after all, stimulated by different environmental and social cues such as sights and sounds, and by the behavior of their neighbors and peers [2]. Even a shout of "Fire!" is likely to be heard, apprehended, interpreted, and responded to differently by different individuals in the same shopping mall.

One way of investigating why evacuation compliance to warnings varies is to determine how individuals receive, apprehend, interpret, and trust warnings, as suggested by just over 7% of the documents addressing general issues [3, 11, 14]. Some 13% of documents addressing both the general and Bangladesh contexts indicate that individuals are affected by physical, psychomotor, cognitive, and economic abilities along with their social networks [2, 6, 21–23]. Reviews of early warning systems by Mileti and O'Brien [3] and Sorensen and Sorensen [19] determined several environmental, social, and psychological attributes are likely to influence the early warning process, although these reviews suggest that only a few of these attributes can be influenced to make the warning process more efficient and effective. The response to a warning message is thus likely to vary with the message source, content, and style, channel attributes, frequency, source credibility, and recipient characteristics [3, 6]. If those at risk do not trust the warning and/or doubt the level of the threat, then protective response is likely to be low.

The process of early cyclone warning dissemination in Bangladesh has improved over the last three decades, although key challenges remain in using information collected in dynamic contexts where information must be dissiminated at multiple levels through a number of channels. In current early warning dissimination, shown in **Fig. 1**, the process starts with the Storm Warning Centre (SWC) of the Bangladesh Meteorological Department (BMD) and ends with coastal communities/households at risk. These are dispatched through a number of channels such as Coastal Preparedness Programme (CPP) units/volunteers, local administrations, and state-operated radio and television[2]. About 31% of Bangladesh related studies assessing cyclone evacuation compliance during – Gorky, a category 4 tropical cyclone in 1991; Sidr, a category 4 tropical cyclone in 2007, and Aila, a category 1 tropical cyclone in 2009 – suggest that evacuation decisions by households were influenced more by social, individual, and household attributes than by the actual warning messages themselves [4, 6, 16, 18, 22]. This is because warning messages during the above cyclones lacked credibility due to the absence of specific and accurate information such as the time of the cyclone's possible landfall, exact trajectories, wind speed, and surge heights [6, 22]. Several false alarms such as a tsunami warning in September 2007 and warnings for Cyclones Rashmi in October 2008 and Bijli in April 2009 also brought into question the accuracy and credibility of the Bangladesh warning system, as indicated by 19% of documents [4–5, 8]. This fact necessitates reexamination of links between early warnings and the responses of people at risk as addressed in contemporary evacuation studies.

Tropical cyclones making landfall recently in coastal Bangladesh have caused significantly more economic and other damage than fatalities among exposed populations [25]. In this context, as suggested by about 31% of Bangladesh-related studies, responsible agencies' poor understanding of local evacuation processes often leaves hundreds of persons in open spaces trying to reach safe havens and thousands in their destroyed homes in low-lying exposed zones, as happened during Cyclone Gorky in 1991 and Cyclone Sidr in 2007 [5–6, 16, 26]. In the absence of accurate estimates, the Centre for Research

2. At present, while issuing a first warning for any cyclone, a Standing Order for Disaster (SOD) is also followed by the BMD. This SOD contains the subsequent guidelines for all stakeholders regarding how to respond to the imminent cyclone threat.

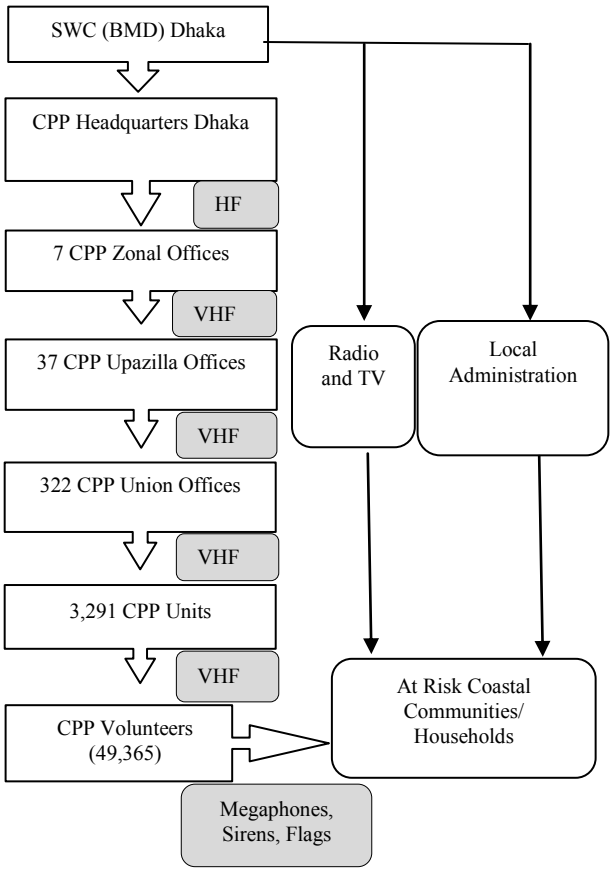

Fig. 1. Cyclone warning dissemination process in Bangladesh. Source: [6, 24].

on the Epidemiology of Disasters (CRED), the World Bank, and the Government of Bangladesh (GoB) reported approximately 140,000 fatalities along the southeastern coast during Cyclone Gorky and 3,400 fatalities along the southwestern coast during Cyclone Sidr [27–29]. While there were only 190 fatalities and just over 7,000 severe physical injuries during Cyclone Aila when nearly 75% of at-risk households did not evacuate due to doubts about the validity of warning messages [30]. The understanding of how to better motivate evacuation thus remains a critical question. In this connection, apart from the early warning dissemination process itself being an important factor in evacuation decision-making, an equally important factor here is how individuals perceive risk.

4. Risk Perception

Risk perception in disaster domain integrates the broader associations of threat perception, protective response options, and actors concerned within this schema [2]. Thus, focusing only on early warnings may provide a partial scenario of the complicated evacuation decision-making process. Risk perception generally becomes complicated due to the high degree of uncertainty within the situational context, such as determining the probability of different impact levels. Hence, emergency managers face a mammoth task in attempting to estimate and understand both hazard probability and response, as indicated by about 8% of documents [31, 32]. Emergency agencies expect people at risk to behave rationally, i.e., receive warnings, understand danger levels from warning messages, and evacuate to safe havens; but those at risk very often do not comply with advisories by taking suggested protective measures [1, 30]. In understanding evacuation decision-making process, nearly 20% of the selected documents suggest risk perception as a focal point consisting of risk identification and risk assessment [1, 9, 12, 35, 37]. In this case, knowledge of hazards alone does not expedite the evacuation decision-making process. Rather, available information must be translated into a meaningful message about pending havoc [1]. The magnitude of risk is considered either from a technical perspective based on the likelihood of an adverse event occurring together with the degree of impact from it [21], and/or from a nontechnical (i.e., social) perspective based on psychomotor (e.g., vision and hearing), cognitive (e.g., languages, including dialects), and social (e.g., family and peer-network) resources [2, 33–34].

Sjöberg [35] assessed the risk perception concept from a hazard perspective using psychometric and cultural approaches. He investigated the nexus among heuristics, biases, and risk perception where he suggested that the heuristics phenomenon resembles a presumption of congnition-driven belief distortion, while bias relates to beliefs of value-driven tendencies. Interestingly, Sjöberg and Biel [36] found a strong correlation between beliefs and values. Lindell and Perry [2] argued that risk perception is a cross-product of the concern individual's capacity (i.e., attention, comprehension, and interpretation capacities), and social and environmental cues. Considering risk perception on a common platform, they attempted to identify mutual links among threat perceptions, protective response perceptions, and stakeholder perceptions, which constitute the response pattern toward an imminent hazard threat. Individual, socio-cultural, and environmental determinants are thus treated as inevitable aspects when hazard risks are analyzed and understood. This implies that, in the case of an impending hazard threat, information processed in socio-cultural contexts is likely to influence an individuals' capacity to identify and assess the degree of danger. Otherwise, such a degree of danger is very likely to increase if potential threats become perceived threats and vague perceptions of potential damages eventually become real [1, 37].

A remarkable finding from 12% of documents suggests that during cyclone evacuation, risk perception is more important than negative threat appeal[3] or fear-arousing communication [38–40]. For those at risk in coastal areas, such a perception is seemingly affected by notions of the "misses," "nearly misses," and "hits" of the impending cyclone. So a common notion indicates that a previous un-

3. Negative threat appeal or fear arousing communication refers to a persuasive message that is likely to arouse fear and divert people's behavior through the threat of impending danger.

necessary evacuation provokes a lower likelihood of evacuation in future cyclones. A false alarm, also known as "crying wolf" [41], may challenge the credibility of future warnings, eventually reducing compliance with evacuation advisories [42]. Slightly over 31% of documents addressing the Bangladesh context suggest that over a 17-years period, i.e., from Cyclone Gorky in 1991 to Cyclone Sidr in 2007, the average evacuation rate increased from slightly below 27% to about 33%, indicating only a 6% increase in evacuation rate – not at all satisfactory considering the goals for motivating people in evacuation compliance adopted within the cyclone preparedness scheme by stakeholder agencies [5–6, 16, 18, 22]. Among the factors inhibiting those at risk from evacuating, nearly 38% of documents specifically indicated false alarms were a very common factor [4–8, 18]. During category-4 Cyclone Sidr, for instance, about 19% of respondents specifically reported that they did not trust cyclone warnings, and one of the reasons behind this disbelief was a false tsunami warning in coastal Bangladesh two months prior to Sidr's landfall [18]. This percentage might be relatively small, but it underscores the need to look into the mutual link between at-risk population's risk perception and the warning message's trustworthiness – or lack thereof.

During 2009 tropical Cyclone Aila, a category-1 cyclone that significantly damaged much of southwestern coastal Bangladesh, the fatality rate was very low at 190 people killed due to timely evacuation by those at risk [30]. Although only about 25% of households were found to be willing to evacuate during this cyclone, spillover effects of a paradigm shift from post-disaster rehabilitation to pre-disaster preparedness under the disaster management program by the Bangladesh government were found to be effective over time [25, 30, 43]. Local CPP volunteers, NGOs, disaster management committees steered by the local government, and available media informed those at risk of the tentative trajectory of Aila 26 hours before landfall. This was further validated by findings from the indigenous knowledge of people at risk that eventually helped them decide to evacuate to the nearest safe havens within a reasonable time frame [43–44]. The most notable phenomenon in this case was the way households at risk started preparing for evacuation by using information from their peer networks and indigenous knowledge such as the roar of the wind together with the movements of ants and acquatic species indicating an imminent hazard, given their limited access to both required information and resources. Similar to the experiences of evacuees from developed countries reported by Dow and Cutter [21], during Aila, evacuees did not encounter traffic delays but experienced insufficient space in cyclone shelters and the absence of well-directed evacuation routes [30]. In light of this scenario, just over 31% of Bangladesh focused documents investigated factors affecting evacuation behavior/decisions during cyclones [4–6, 8, 18] suggesting that households who delayed evacuating were less likely to find the space they required inside cyclone shelters and this delay was mainly governed by their personal "optimistic bias" [39]. Ex-post cyclone householders who reached rehabilitation aid quicker, especially for reconstructing damaged houses, were less likely to experience adverse impacts over a longer period [46–47]. Hence, risk perception appears to have had a greater effect on the rapidity of the decision-makdecision-making process of those at risk before, during, and after cyclone states.

A poor understanding of a community's risk perception is likely to make even well-planned policies ineffective [48]. Risk perception is thus critical in understanding how individuals decide to evacuate – or not. In the coastal Bangladesh context, whether individuals in high-risk[4] zones or risk[5] zones or low-risk[6] zones intend to evacuate as a devastating cyclone approaches, understanding how individuals decide about an imminent hazard posing risk to themselves and their families is of great significance when addressing cyclone evacuation decision-making issues. This may also lead the way to redesigning evacuation messages incorporating essential information from forecasting. Otherwise, deviations in forecast messages may lead to confusion and distrust that eventually drive people at risk not to evacuate as reported by Roy et al. [45] during Cyclone Sidr in Bangladesh. It is therefore very important to understand how people proceed from receiving evacuation messages to deciding to evacuate, which is a process addressing both warning compliance and risk perception.

5. Evacuation Decision-Making

Research on evacuation decision-making has mainly considered the intrinsic characteristics of evacuees and non-evacuees as suggested by 25% of documents [1, 4–6, 11, 13, 17, 22, 34, 49]. Apart from general issues (e.g., safe haven features, transport, and routes etc.); specific issues such as impediments associated with evacuation (e.g., the certainty of getting space for household members inside safe havens) during cyclones are addressed by 12% [3, 5–6, 34, 42], evacuation compliance by 10% [5, 18, 34, 42], and household and community aspects by 12% [5, 17, 18, 33–34] of the selected 41 documents. Again, nearly 12% of documents (general context) applying different models addressing evacuation decision considered risk perception, sheltering, fear-arousing communication, hazard characteristics, and certain versus probablistic hazard outcomes [2, 3, 5, 17, 38].

Lindell and Perry [2] developed the Protective Action Decision Model (PADM), a multistage model describing overlapping processes likely to trigger evacuation compliance during natural hazards. The PADM integrates the processing of information obtained from different social and environmental cues with specific messages that social sources disseminate through different media and channels to those at risk.

The PADM focuses on three processes:

4. Within 50 km. from the sea shore.
5. Within 51–75 km. from the sea shore.
6. Within 76–100 km. from the sea shore.

(i) Reception and comprehension of warning-messages or exposure

(ii) Attention to social/environmental cues

(iii) Interpretation of social/environmental cues, considered to be critical predecision functions that precede remaining functions.

All subsequent functions are based on three core perceptions – threat, protective response, and stakeholder, as mentioned in the section on risk perception. Together these form a platform for decision-makers on how to respond to an impending hazard.

Lindell and Perry [2] show a mutual relationship in their model among perceived threat, personal risk, and protective response, i.e., evacuation. This work has been comprehensive in introducing both social and environmental contexts to the forefront in modelling evacuation decision-making. As pointed out by Lindell and Perry [2], however, this model has a shortcoming in that hypothesizing each successive variable mediates the link between the variable that precedes it and the variable that succeeds it.

Huang et al. [11], in contrast, focused on contextual factors in the household's evacuation decision-making process. Their study presents the importance of formal warning messages, perceived storm characterisitcs, and previous hazard experience; which are likely to affect expected personal impacts of evacuation decisions. This study suggests that emergency agencies must carefully understand their target groups to ensure transmission of concrete messsages through appropriate channels to raise low expectations of personal impact or to lessen the overestimation of evacuation hindrances.

In line with core findings from studies by Lindell and Perry [2] and Huang et al. [11], 50% of primary data based documents on Bangladesh also denote the distinct influence of social factors, e.g., the social custom of maintaining "purdha" (a kind of curtain) by adult women, on the household's cyclone evacuation decision-making processes [4–6, 18, 22, 26, 50]. Findings from these documents show that households at risk in coastal Bangladesh are expected both to manage situational contexts and to deal with socio-cultural hurdles in the event of an imminent cyclone threat. Regardless whether a household belongs to a southwestern coastal community composed of mostly rural areas or a southeastern coastal community composed of both rural and urban areas, it is very likely to work in its own distinct way regarding the common objective of evacuation, and thus a cohesive evacuation compliance is hardly to be found even within one area type – urban/rural or solely rural. Again, among documents on Bangladesh, nearly 19% point out that gender and the number of dependent members in the household [4, 18, 50], a distrust of warning messages [5, 16, 18], the characteristics of public shelters [5, 22, 51], and the income level of the household [8, 18, 49] significantly influence evacuation decision-making. The same trend is exhibited in nearly 13% of documents addressing the literacy level of decision-makers [4, 18], the number of disabled members in households [5–6], and the fear of burglary [4, 51] in coastal Bangladesh. These factors, subject to situational contexts, are likely to either motivate people to – or dissuade them from – the evacuation process. A major influnece is the social custom of purdha among adult women. This concept implies *a curtain*, used figuratively to indicate the separation of women from men, which must be maintained when adult women go outside [50]. Some 19% documents show purdha to be a pivotal factor either dissuading or delaying household members' evacuation [6, 18, 50]. In addition, about 13% of documents indicate that lessons learned from previous hazards at the household level affect evacuation decision-making [6, 52]. By summarizing the above findings, households in Bangladesh are influenced specifically by the process of receiving the early warning message, identifying and assessing potential damage to structural and nonstructural assests from the impending hazard(s) while interpreting the message, and finally choosing the best possible protective response.

In connection with the above factors, results from primary data-based studies after Cyclones Gorky, Sidr, and Aila in Bangladesh suggest that a number of specific factors, categorized under four broad types, stand out as significant determinants for successful evacuation compliance:

(i) Public cyclone shelters, e.g., location and availability of *killas*[7] adjacent to the shelter

(ii) Characteristics of early warning messages and the status of disaster preparedness training

(iii) Risk perceptions of households

(iv) Socioeconomic conditions of households at risk [4–6, 22]

Subject to the availability of early warning systems, CPP units, and emergency teams of the local government, the above determinants may affect evacuation processes differently within and between areas [51]. This implies that even though some similarities exist among the factors affecting evacuation decision-making in general, distinct differences also emerge. As pointed out in nearly 31% of documents, for example, during category-4 Cyclone Gorky making landfall in southeastern coastal Bangladesh, the fear of burglary, inefficient and less-credible cyclone warning messages, and insufficient disaster preparedness training were found to be the major factors influencing household evacuation decision-making [22, 26, 50–51, 55]. During another category-4 cyclone, Sidr, that made landfall in southwestern coastal Bangladesh, as indicated by nearly 19% of documents, difficulty in understanding cyclone warning messages, previous false alarms, distance to the nearest public cyclone shelter, poor maintainance of existing cyclone shelters, and the availability of *killa* in the neighborhood of a cyclone shelter were reported to be the most important

7. A *killa* is a heightened earthen platform for safekeeping livestock during natural hazards such as cyclones and floods.

factors influencing/determining the onset of the evacuation process [5–6, 18]. During both events, however, common factors were:

- Insufficient cyclone shelters
- Overcrowding situation inside shelters
- Warning signal problems
- The absence of the dissimination of previous cyclone experience among those at risk.

Interestingly, the impact zone of Cyclone Gorky consisted of both urban and rural areas, whereas the impact zone for Cyclone Sidr consisted mostly of rural areas, some periurban areas, and some least urbanized areas, suggesting that diverse spatial attributes, e.g., road network or proximity to exposed areas, in rural, urban, and periurban areas were likely to affect the evacuation decision-making in different zones in coastal Bangladesh.

6. Discussion and Recommendations

Sections 3-5, issues of concern were discussed in general, then connected to the Bangladesh context, which we focused on next. In this light, major findings from content analysis for early warning, risk perception, and the evacuation decision-making process in Bangladesh are summarized into the following:

First, the credibility of warning messages appears to be a very important determinant in evacuation compliance. Content analysis findings show that only one agency, the Bangladesh Meteorological Department (BMD), prepares forecasting and warning messages without the support of any other specialized unit (e.g., the Regional Specialized Meteriological Center, analysis and forecasting units, and regional and local liaison teams), and without using advanced forecasting systems (e.g., high-resolution satellite images, CLIPER5[8]). This tends to lack forecasting accuracy (e.g., intensity level, cyclone landfall time, and storm trajectory). Hence, during cyclone events, less advanced forecasting systems fail to provide sufficiently accurate forecasts and may even produce false alarms, as has happened on several occasions.

Second, no study exclusively applying either psychometric, cultural, cognitive, or affective approaches has been conducted in Bangladesh to assess the different dimensions of risk perception in evacuation research.There thus exists a knowledge gap on concern drivers, together with sources of objective and subjective risk perceptions (i.e., electronic media versus the roar of the wind) of people at risk in coastal Bangladesh.

Third, critical factors affecting the evacuation decision-making process apper to be governed by socio-cultural determinants (e.g., purdha), although these determinants are not addressed in depth by studies conducted in Bangladesh up to now.

In addition, issues specific to developed countries such as "shadow evacuations," i.e., situations when people from areas outside a declared evacuation area voluntarily evacuate, causing road congestion that inhibits the egress of those evacuating from an area at risk, have not been studied in Bangladesh, since these are the least likely scenarios to occur during cyclone evacuations there.

Content analysis findings suggest that determinants of early warning, risk perception, and evacuation decision-making are not mutually distinctive but overlap in some occasions. The mutual relationships among these three themes is thus not unidirectional, but is rather bi- and/or multidirectional.

Risk perception, is likely to be affected by the content-specificity of the warning message on the one hand, while evacuation compliance on the other hand depends largely on the degree of risk perceived by those at risk. This seemingly simple relationship may not be simple at all because there may be other determinants likely to affect the evacuation process both at the individual and household levels. In this context, we may consider the given knowledge level of an individual or the main decision-maker at the household. Depending on the knowledge level, an individual is likely to look for critical information about impending hazards from reliable sources and consequently cross-check among sources if information is incomplete or confusing (e.g., unknown scientific terms in warning message and different messages from different sources). Again, using this knowledge level, individuals may, depending on their physical and mental capabilities, be able to perceive the degree of risk from the hazard and finally able to decide to evacuate within a reasonable time frame. Interestingly, this knowledge level depends on factors such as literacy level, media access, (e.g., TV and radio), indigenous knowledge, previous hazard experience, connection to local emergency agencies, and disaster preparedness training. These clearly imply that it is very difficult to conclude that a single determinant exclusively affects early warning or risk perception or evacuation decision-making. This is also true for those at risk in coastal Bangladesh with a lesser degree of access to resources for making evacuation decisions during tropical cyclones.

Studies conducted in Bangladesh on early warning and cyclone evacuation decision-making are mostly qualitative, and did not apply any exclusive models on psychometric, cultural, cognitive, or affective approaches [16, 22, 26, 49, 51, 55]. So far the most comprehensive quantitative studies applying multivariate analysis have been done by Paul [18] and Ahsan et al. [4], in which the themes of social cognitive theory (SCT) [18, 56–57] and the PADM [2] have been applied. SCT conventionally considers factors such as ethnic and immigration status of early-warning recipients and the cost and availability of public transport, which are not widely applicable in the context of Bangladesh and thus not incorporated in the multivariate analyses by Paul [18]. The PADM, as explained in Section 5, was originally developed for the industrialized countries (e.g., the USA) and therefore

8. This is a statistical storm-track prediction model based on climatology and persistence [54].

cannot be directly applied to assess evacuation scenario in an agrarian country (e.g., Bangladesh). Many of the variables used in both of these studies are categorical and the outcomes of the decision model are more likely to be inductive and eclectic, indicating the necessity to incorporate more relevant continuous variables that would make evacuation behavior more predictable both in the Bangladesh context and a regional context.

At this point, we believe that apart from the result of Paul's [18] and Ahsan et al.'s [4] studies, other studies by Paul et al. [6], Paul and Dutt [5], Haque [16, 22], and Paul and Routray [7] have also contributed substantially to the understanding of the evacuation decision-making in coastal Bangladesh.

In light of the above findings and discussion, we would suggest two policy recommendations:

First, with a view to addressing the forecasting challenge, a rational approach would be to upgrade the existing cyclone forecasting system used by the BMD. At present the BMD utilizes three consecutive steps for cyclone forecasting:

(a) Collection, interpolation, and analysis of wind data

(b) Determination of steering airflow

(c) Forecasting of cyclone trajectory and intensity [45]

These steps are assimilated by using

(i) Storm track prediction (STP) and

(ii) Steering and persistence (STEEPER) [58–59].

Technically, neither of the methods is sufficiently advanced to generate forecasts with an accuracy more than 12 hours ahead [45, 60]. So introducing the cyclone-forecasting version of the Weather Research and Forecasting (HWRF) model [60] would be a distinctive advantage as it can generate a more precise long-term cyclone track along with intensity forecasts in support of other required logistics such as the Global Telecommunication System (GTS) and NOAA's high resolution sattelite images [45]. Because BMD is already operating WRF to forecast rainfall, such adoption of HWRF would be compatible with meteorologists' regular forecasting at no additional training, cost, or logistics for such new adoption [45]. Cyclone forecasting using HWRF is likely to enhance the credibility of warning messages. The likelihood of false alarms would also be decreased. Simultaneously, along with other available channels, warning information could be disseminated more efficiently by using the existing countrywide mobile phone network and community radios [61–64]. Voice messages in Bengali prepared in different local dialects by the same source could be disseminated as warning messages and advisories to locations at risk. While designing voice messages, designated emergency agencies must understand how users draw risk conclusions and their capacity for interpreting warnings and assessing the safety of families and assests.

Second, to narrow the knowledge gap, more quantitative studies must be carried out in coastal Bangladesh. In this context, the following lessons from empirical studies in coastal Bangladesh by Haque and Blair [51], Haque [16], Paul et al. [6], Paul and Dutt [5], Ahsan et al. [4], and Paul [18] on evacuation compliance during Cyclone Gorky (in 1991), Cyclone Sidr (in 2007), and Cyclone Aila (in 2009) can be considered while designing quantitative studies:

(i) When households at risk feel that they should stick to actions best for them even when agencies instruct otherwise, evacuation likelihood lessened

(ii) When households had experienced evacuation when they could save lives and assets, evacuation likelihood increased

(iii) For larger household sizes with proportionatly more dependent members and a large number of livestock, evacuation likelihood lessened

Further quantitative studies taking into account the above-stated lessons are likely to provide specific insights into why the change in the evacuation rate in Bangladesh over 17 years (1991–2007) has been unsatisfactory in identification and assessment of hazard risks and response. In this context, intended quantitative studies must incorporate more representative variables to obtain empirical findings that would eventually be helpful for policy-makers in determining ways to enhance evacuation compliance in coastal Bangladesh.

7. Conclusions

Our main aim here has been to review literature and identify and assess critical determinants affecting the evacuation decision-making during tropical cyclones in Bangladesh. In this context, our major findings suggest that cyclone evacuation compliance is governed by a number of overlapping factors considered under the themes of early warning, risk perception, and evacuation decision-making. The challenges of current forecasting system for disseminating early warning messages and the knowledge gap in evacuation research for policy-making in Bangladesh are identified as critical issues in addressing cyclone evacuation compliance. Against this backdrop, we have suggested introducing an advanced cyclone-forecasting system for generating precise, more accurate cyclone information (i.e., intensity and trajectory), which is likely to enhance warning message credibility. The dissemination of voice messages in Bengali using the mobile phone network is also suggested. To overcome the current knowledge gap, we suggest further quantitative research incorporating a sufficient number of socio-cultural variables.

In closing, we would like to mention a recurring challenge in evacuation research, especially in the social science domain, i.e., the problem of recall, also noted by Dash and Gladwin [1]. Once a tropical cyclone makes landfall or misses and time passes, the affected populations are likely to have difficulty remembering precisely

what happened during a storm and how their insights of the situation changed during the decision-making process. Generally studies are carried out in the aftermath of a cyclone when some respondents provide divergent statements of their actual countermeasures at the time of the hazard. This requires more careful, systematically designed simulteneous pre- and post-cyclone studies to deal with "recall bias" problems addressing evacuation decision-making processes in coastal Bangladesh as well as globally. Such endeavors are likely to provide a breakthrough in developing efficient ways to enhance evacuation compliance, along with framing constructive guidelines for all stakeholder agencies.

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Appenddix A. List of documents used for content analysis

Themes	Dimension(s)	Factors	Documents selected for general contexts	Documents selected for Bangladesh contexts
Early warning	Psychological	a. Language b. Technical terms c. Threat information	Dash and Galdwin [1]; Huang et al. [11]	Haque [22]; Paul [18]; Dove and Khan [55]
	Socio-technical	a. Source b. Channel c. Recipients' knowledge level	Garcia and Fearnley [13]; Mileti and Sorensen [14]; Sorensen and Sorensen [19]; Mesa-Arango et al. [17];	Paul and Dutt [5]; Paul and Routray [7]; Haque [16]; Roy et al. [45]
	Psychological and Socioeconomic	a. Literacy level of the recipient b. Asset possession (e.g., TV and radio) c. Connection with peers	Mileti and Sorensen [14]; Mileti and O'Brien [3]; Lindell and Perry [2]; Hanson, Vitek, and Hanson [15]; Nigg [23]; Wilson and Tiefenbacher [20]; Dash and Morrow [10]	Paul et al. [6]; Ikeda [50]
Risk perception	Psychomotor	a. Vision (e.g., color of cloud) b. Hearing (e.g., color roar of the wind)	Sorensen [12]; Dow and Cutter [42]	Paul and Routray [7]; Paul [52]; Dove and Khan [55]
	Cognitive and social	a. Language b. Family c. Peer-network	Baker [9]	Paul [18]; Bern et al. [26]
	Psychological	a. Credibility of warning message source b. Perceived hazard characteristics	Dash and Galdwin [1]; Sjöberg [35]; Weinstein [39, 40]; Breznitz [41]	Paul et al. [6]; Paul [18]
	Quantitative, Cognitive, and Psychological	Specificity of risk information by warning message	Tierney [37]; Burton, Kates, and White [31]; Meissen and Voisard [32]; Sjöberg and Biel [36]; Mulilis and Duval [38]	
	Socioeconomic	Stakeholders' perception	Lindell and Perry [2]; Baker [9]	
Evacuation decision-making	Situational context	a. Facilitators (e.g., personal vehicle) b. Impediments (e.g., ambiguous information)	Lindell and Perry [2]; Baker [9]; Mileti and Sorensen [14]; Lindel, Kang, and Prater [34]; Dow and Cutter [42]	
	Social	a. Gender issue b. Social norm		Ikeda [50]; Alam and Collins [49]; Paul [52]; Dove and Khan [55]
	Socioeconomic and psychological	a. Dependency ration in the household b. Pet ownership c. Income-generating cattle ownership d. Literacy level of the key decision-maker at household e. Number of disable members in household f. Fear of burglary	Huang et al. [11]	Paul and Dutt [5]; Paul [18]; Paul and Routray [8]; Haque and Blair [51]; Haque [22]; Ahsan et al. [4]; Dove and Khan [55]
	Logistic	a. Distance to the safe haven (i.e., cyclone shelter) b. Space sufficiency in safe haven	Baker [9]; Lindel, Kang, and Prater [34]	Paul and Dutt [5]; Dhar and Ansary [33]; Paul [52]

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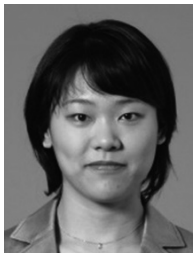

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