The Role of Perception, Warning and Human Factors in Flood Losses - A Case Study of Bangladesh Households

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Abstract

The importance of a multi-disciplinary approach to flood loss mitigation incorporating behavioural components is now well recognised. The behavioural components including individual perception and human factors are important to the hazard preparedness process. This paper focuses on this link. The analysis reveals that the level of flood perceptions among flood plain users in Bangladesh is quite high, which has positive bearing on the resilience-building or the flood loss reduction process. However, formal warning systems in Bangladesh often do not perform satisfactorily. Following the lack of effective warning systems, however, local knowledge process and informal warning systems, essentially developed through flood plain occupants' own perceptions and judgements, appear to play an important role in the damage-reduction decision making process. Community cohesion along with family kinship and household structure also play a significant role in the positive response to flood hazard.

Key words: Perception, formal and informal warnings, human factors, perceived and warning lead time, flood loss.

1 Introduction

It is now increasingly recognised that the approach to flood loss reduction needs to be based on multi-disciplinary perspectives (e.g. engineering, behavioural and economic), rather than only structural ones. Reducing vulnerability, or resilience-building, through hazard preparedness and responses can be regarded as a major non-structural approach of flood loss mitigation.

Hazard preparedness and the response process are heavily dependent on individual perception, whereas experience and knowledge of the surrounding environment have important bearing on the individual's perception capability. The susceptibility of property to flood water, awareness of the potential hazardousness and the awareness of the river water level are among the environmental factors that have potential links with individual perception capability and behaviour pattern. The 'time-to-peak' discharge interval and knowledge of the distance of the flood water entering the property locations are also likely to build up perception capability. Likewise, human factors such as education and experience are expected to be closely linked with perceptions. In particular, frequency of hazard events usually has a positive bearing on the perception. Perceptions in general are viewed as a function of a host of other socio-economic and environmental variables. Hence, the perception capability can be thought of as one of the means towards resilience-building or vulnerability-reduction.

2 Research Literatures, Concepts and Related Issues

In the research literature, perception is defined as the floodplain users' 'organisation of stimuli relating to an extreme event or a human adjustment' (White 1974). In essence, perception has two aspects: a phenomenal part and a behavioural part (Kirk 1952). The perceived 'images', 'ideas' and 'behaviour' derived as a result of the interaction with an individual's environment are viewed as potentially valuable factors in the process of hazard response.

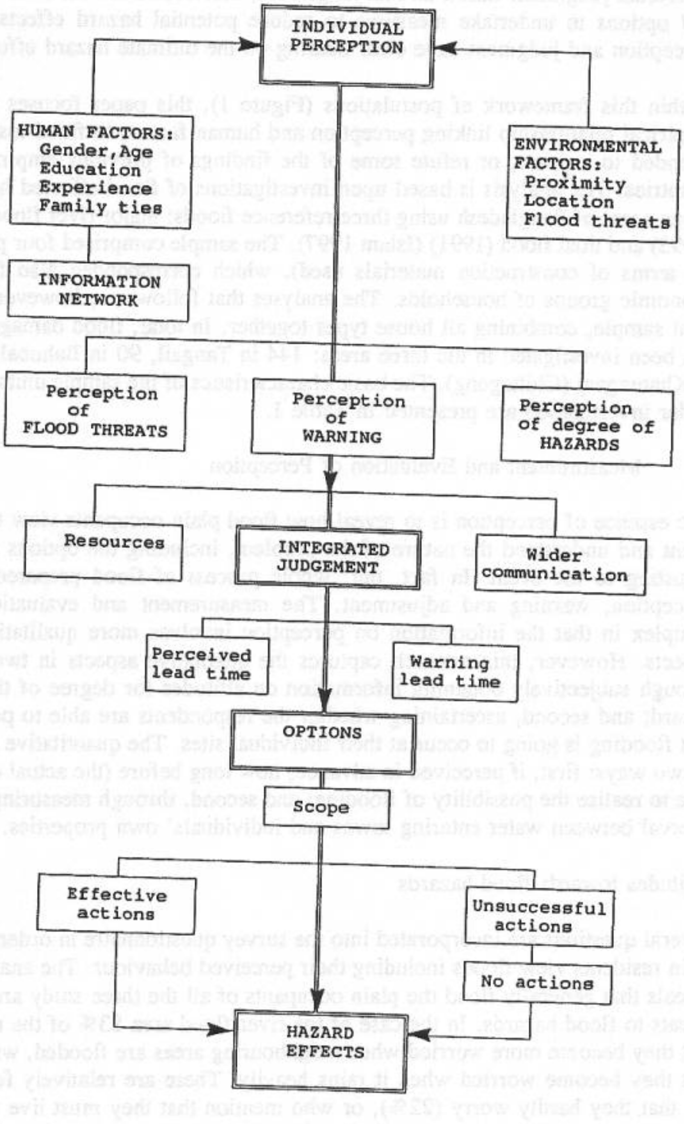
Inevitably, the hazard responses are rational and aimed at reducing the adverse effects of the event. Sorensen and White (1980) identified two categories of adjustments based on individual intents: incidental and purposeful. In incidental adjustments, an individual spontaneously takes some actions to reduce or absorb losses. In purposeful adjustments, however, an individual has several options: 1) accept losses by bearing or sharing 2) reduce losses by either preventing the effects or modifying the events, and 3) radical actions e.g. changing land-use or location (Alam and Chowdhury 1992). Within this model of decision making, individual perceptions play a vital role in the assessment of alternative options.

There exists a strand in literatures linking perception with various socio-economic variables. However, the findings are diverse. For example, James (1974) found that men are more likely to determine family response to flood hazard, while Kates (1971) and Parker (1976) found that gender is not related to an awareness of flood risk. Waterstone (1978) found that longer-time residents are more aware of hazard; Kates (1962), however, found otherwise. Davis (1978) revealed that the landless are more vulnerable, while Harding and Parker (1974) found that tenure has no significant relationship with flood awareness. The significant influence of age in determining perception was found in studies such as Handmer (1979), while findings in Baker and Patten (1974) have not supported this.

Baker and Patten (1974) established a clear association between education and perception, which led them to postulate that the flood plain residents with better knowledge and education have a greater awareness of flooding. Subsequent research by Leigh and Low (1983), however, found that no such relationship exists between education and perception. Chan (1995) found that human factors like family ties make flood plain occupants less vulnerable to floods. Waterstone (1978) and White (1973;1974) revealed that residents nearer rivers are more aware of the hazard and are more likely to make adjustments. Regarding the influence of past experience, the studies such as White (1973;1974), Harding and Parker (1974), and Parker (1976) revealed that past experience is associated with flood awareness and choice of adjustments whereas Jamaluddin and Ismail (1983) showed that the flood experiences do not affect adjustment. Personality traits are found to be influential in hazard perception in White (1974), while Parker and Harding (1979) concluded that there are no such relationships. Kates (1962) maintained that flood plain occupants often perceive the flood hazard and its potential effects rather imperfectly. Sewell (1969), however, maintained that even when there is accurate perception of the hazard, there might be no effective action available to deal with it.

The conclusions derived from the various studies mentioned above are diverse and even conflicting, presumably because the aspects such as hazard type, extent, severity, study methodologies and definitions of relevant variables are not compatible. Empirical research on the role of perception in flood loss potential via flood preparedness in Bangladesh is limited. In line with the discussion above, a few key elements of perception are postulated, which are demonstrated in Figure 1. The Figure illustrates the multi-dimensional elements of perception that are likely to ultimately act towards the building up of an integrated

Figure 1 : Typical individual perceptions and action process (to mitigate flood loss)



judgment capability on the individual's potential reality. A wider formal and informal information network within the community acts as a catalyst in the formation of the individual judgment. Based on this judgement, individuals are destined to explore the scope and options to undertake measures to reduce potential hazard effects. Hence, individual perception and judgment have clear bearing on the ultimate hazard effects.

Within this framework of postulations (Figure 1), this paper focuses principally upon an empirical relationship linking perception and human factors to flood losses. This analysis is intended to support, or refute some of the findings of previous empirical studies in other countries. The analysis is based upon investigations of flood affected householders in three urban areas of Bangladesh using three reference floods: major river flood (1988), flash flood (1993) and tidal flood (1991) (Islam 1997). The sample comprised four principal house types (in terms of construction materials used), which corresponded also four different socio-economic groups of households. The analyses that follow are, however, carried out on the total sample, combining all house types together. In total, flood damage in 356 households has been investigated in the three areas: 144 in Tangail, 90 in Bahubal (Habiganj) and 122 in Khatunganj (Chittagong). The basic characteristics of the sample units and the three floods under investigation are presented in Table 1.

3 Measurement and Evaluation of Perception

The essence of perception is to reveal how flood plain occupants view the occurrence of an event and understand the nature of the problem, including the options available to them in adjusting to the event. In fact, the whole process of flood preparedness may comprise perception, warning and adjustment. The measurement and evaluation of perception is complex in that the information on perception involves more qualitative than quantitative aspects. However, this research captures the qualitative aspects in two major ways: first, through subjectively obtaining information on attitudes (or degree of threat) towards flood hazard; and second, ascertaining whether the respondents are able to perceive, in advance, that flooding is going to occur at their individual sites. The quantitative aspects are gathered in two ways: first, if perceived in advance, how long before (the actual occurrence) they are able to realise the possibility of flooding; and second, through measuring the perceived time interval between water entering towns and individuals' own properties.

Attitudes towards flood hazards

Several questions are incorporated into the survey questionnaire in order to assess how flood plain residents view floods including their perceived behaviour. The analysis (not presented) reveals that generally flood the plain occupants of all the three study areas are aware of the threats to flood hazards. In the case of the river flood area 83% of the respondents mention that they become more worried when neighbouring areas are flooded, while about 73% state that they become worried when it rains heavily. There are relatively few respondents who say that they hardly worry (22%), or who mention that they must live with floods as these are the act of God (34%). In the case of the flash flood, some 83% of the occupants report

Table 1 : Basic characteristics of three types of flood under study

Characteristics	Flood type		
	Major river flood	Flash flood	Tidal flood
Urban area	Tangail	Bahubal (Habiganj)	Khatunganj (Chittagong)
Sample household(no)	144	122	90
Major flood variables	Inundation (Depth, Duration)	Inundation Velocity	Inundation Velocity, Storm, Salinity
Depth of flooding(m)	.78	.50	1.26
Duration of flooding(days)	18	3.2	6 hrs
Frequency of flooding	1.9	2.5	2.2
If formal warning given	No	Yes	Yes
Lead time (hrs)	NA	2.4	32.4
HH believed warning(%) (a)	Not applicable	13	2
HH perceived occurrence(%)	99	60	14
Perceived before(hrs) (b)	61	3	0.16
Hrs between water entered town & property	31	0.97	0.16
HH moved inventories(%)	100	93	13
HH evacuated(%)	64	52	96
Days stayed outside	16	7	6

Note: All figures represent averages.

(a) Believed at the initial stage when the message was received; no official warning was given in the case of major river flood

(b) Perceived means realising, with certainty (at some later stage), that flooding was going to occur at site.

HH = Households

that they check nearby river levels when it rains heavily[1]. After three consecutive occurrences in the past three months, the occupants generally (75%) are quite afraid when floods are forecast. At the same time, however, about 40% of the occupants believe that they must live with floods as these are the act of God. In the case of the tidal flood, about 69% mention that they become afraid when storms or floods are forecast[2]. Particularly when it rains heavily, they (64%) become scared on the apprehension of a cyclone or tidal bore. However, relatively a few (32%) occupants report that these are the act of God and they must live with that.

4 Awareness of Floods and Warnings

Perceptions of floods are also linked to perceptions of warning systems and their message. No official warning was given for the major river flood, but for the other two floods, formal warning was given. The level of awareness of the warning message among householders appears to be overwhelmingly high, as more than 90% of the respondents in the case of the flash flood, and 98% in the case of the tidal flood mention that they became aware of the warning message. However, it is generally apparent that very few flood plain users believed the message of warning when it was first received. In the second study area a formal warning message was disseminated by the local authority through loud-speakers. To a question as to whether the respondents believed the message of warning, some (12%) were either reluctant to answer or did not know about it. About 27% of the households stated that they were not certain, while 48% mentioned that they did not believe at all when they received the warning. Only 13% believed the message at the first instance. One reason for not generally believing the message in this area can be that one such warning message a few weeks ago proved partially false in the area. The average lead time according to sample respondents was about 2.4 hours (Table 1).

In the case of the tidal flood, the Bangladesh Meteorological Department was very precise to issue a 37-hour pre-landfall specific warning through national radio and television. Unfortunately, almost none of the sample householders, believed the message when it was given. About 31% of the householders stated that they were not certain about the warning message, while 67% did not believe it at all. Only 2% believed the message at the time of their receiving it. The average lead time according to sample respondents (measured according to when the message was received by the individuals) was about 32 hours (Table 1). The level of awareness of the official warning message, however, appears to be very high among the householders in the area, as almost all of them mentioned that they became aware of the message, mostly directly through radio or television and/or through friends and relatives.

Despite that few householders could rely on the warning, at some later stage, however, some

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[1] This urban location (*Thana* headquarters, a local level administrative unit) has some rural characteristics; the *Thana* was flooded twice (if not three times, in some places) in the three months period before the survey.

[2] The location, situated in the vicinity of the Bay of Bengal, is generally a cyclone prone coastal area.

started using their own judgement to realise the potential reality depending on the environment around them. The interactions of the residents with the environmental and other factors, comprising innumerable combinations, appear to be complex. Thus, it is apparent that some of the occupants in the study areas comprehended the occurrence even without warnings, and also before the water had entered the town, while some started realising only after the water had entered into their locality. On the other hand, some do not show apprehension, even on having received the warning or being aware of the water proceeding towards their locality. The analysis shows that in the case of the large river flood and the flash flood, the level of awareness of the time of water entering their town was quite high, which eventually helped them understand the reality.

Almost all of the occupants (99%) in the river flood area could perceive the possibility of flooding from their own judgement in advance, although at different points of time. The average time interval between the water entering the town and individual properties was 31 hours. The sample respondents perceived this, on average, about 61 hours before the actual occurrence. In other words, most of them realised the possibility, fairly long before the water entered into the locality, although a few perceived it only after the water had entered into the town. In the case of the flash flood, about 90% of the households were aware of the breach (reported to be man-made) in the embankment that facilitated the water entering into the town rapidly. However, some 60% of the occupants perceived the possibility of the flood at their own sites only after water entered into the locality. In the case of the tidal flood, however, only a few occupants (14%) could perceive the possibility of flooding.

Perception capability thus appears to be linked with the size and the type of floods. In a large river flood, the occupants have a higher scope for perceptions from a range of information networks including the communication link within the community members. The floods of flashiness (e.g. in a tidal flood with a storm) provide relatively limited scope for perception. The flood-to-peak interval and the state of awareness of the distance of the advancing flood water from the property locations appear to be crucially important factors influencing the perceptions and subsequent damage-reduction decision-making processes.

Source of awareness of the possibility of flooding

There are various sources of awareness of the possibility of flooding. In the case of the river flood, about 51% of the sample respondents became aware either from the rising levels of nearby rivers or from flooding in neighbouring rivers. Excessive rainfall (19%), newspapers (18%) and friends/relatives (9%) were also the sources of awareness.

In the case of the flash flood, rising levels of nearby rivers was the single most important source of awareness of the possibility of flood (57%), followed by flooding in neighbouring areas (35%). The next important sources were newspapers (3%) and excessive rainfalls (3%).

In the case of the tidal flood few could rely on the warning except that at the later stages, that is in the last hour and especially in the last ten minutes about 14% households comprehended that the tidal bore was imminent. Most of them, however, realised the reality only after water has entered into the locality or when the storm started. The sample householders perceived, on an average, only 0.11 hour (or 7 minutes) before the actual occurrence. The average time interval between the water entering the vicinity and individual properties is only .16 hour or 10 minutes (Table 1).

5 Effects of Perception and Warning

The preceding discussion suggests that perception and warning are closely related to flood loss potential. A number of independent variables is included in order to analyse the potential links with flood loss potentials. Flood damages are reduced by either moving contents to safer places or at least by raising their levels. Hence, flood damages are expected to be related to whether or not warning is given and whether or not people have trust in warning message (WARN). Flood losses are also expected to be inversely related to warning lead time (LEAD). In the current analysis, two surrogates are used to measure the perception variable. The first one is PERLEAD, defined as the time interval of the realisation (for sure) of the possibility of flooding and the actual occurrence. The second one is ENTER, defined as the time interval of entrance of water into the town and properties. It is likely that the two variables, PERLEAD and ENTER will have influence in the process of adjustment and damage-reducing measures. That is, it is postulated that the two variables will have inverse relationships with flood loss potentials. It is also hypothesised that the variable, FREQ-flood frequency, which is included as a measure of past experience would be inversely related to damages. Besides, demographic and social characteristics such as kinship and community ties are also expected to have a bearing on flood losses. In other words, the more a community is socially linked, the more expected is the extent of 'transferability', and more would be the damage-reducing and recovery activities; in effect, the less would be the flood losses. Thus it is postulated that certain demographic characteristics such as household composition and the state of the spirit of the community during the hazard would significantly influence the responses process to the hazard. Hence, the variable, COMTY (the state of the community spirit-measured in ordinal scale) and the variable, ADULT (the number of adult members in the households) are treated as intervening variables.

Hence, the flood damages are analysed as a function of warning lead time, perceived time, time between water entering town and property and other socio-economic variables. The results for the three different floods are presented in Table 2-A through to 2-C respectively.

The major river flood

Table 2-A presents the results of the major river flood (Tangail area), which was a country-wide flood, inundating about two-thirds of the country. The Table reveals that in the case of the river flood, even in the absence of a formal warning, an average householder succeeded in moving about 49% of their inventories by value to safer places, resulting, on average, avoided damage of TK 9629[3]. Damage avoided as a percentage of the total potential damages amounted to about 54%. It is evident that percentage of inventories moved to safer places and thus damage avoided, as expected, systematically increases with increase in PERLEAD and ENTER hours. For example, per household inventory damages avoided, for those who perceived 48 hours before the actual occurrence, is in the range of TK 8332, as compared to TK 12431 for those who realised the possibility of flood more than 72 hours

[3] Taka (TK) is Bangladesh currency; US $ = 40 TK (approximately).

Table 2-A : Damage as a function of warning, perception and social variables

Flood type 1 : major river flood

Variables	% of Contents moved	Per HH inventory damage avoided (92/93 TK)	Inventory damage avoided as % of potential damage	Struct. damage as % of value of building	Damage to other assets as % of value
WARN : Warning					
-No formal warning given	NA	NA	NA	NA	NA
PERLEAD : Perceived flood before actual occurrence					
-48 hrs before	43.9	8332	51	15	56
-48- 72 hrs	50.4	8466	54	14	63
-72 + hrs	53.9	12431	58	11	55
ENTER : Hrs between water entering into town and property					
- 12 hrs	37.3	6328	46	14	57
- 12-24 hrs	44.6	7685	53	19	62
- 24 + hrs	58.6	13714	61	9	55
FREQ : Frequency of flooding					
- 1	52.6	9948	56	11	58
- 2	44.6	12082	55	13	56
- 2+	37.8	5766	48	18	60
ADULT : Adult members in household					
- 2	48.9	6358	57	18	57
- 3	49.0	8540	51	15	61
- 3+	49.5	11763	54	10	56
COMTY : Community spirit					
- Lessened	48.2	7133	52	15	64
- Same	52.3	10546	59	10	55
- Heightened	48.8	10751	53	14	55
All households	49.3	9629	54	13	58

before. Pearson's correlations (denoted by r, and the asterisk * representing two-tailed significance at 95% level, but not presented here) of avoided inventory damages with the variables, PERLEAD and ENTER, are estimated as .30* and .47* respectively, which are highly significant. Similarly, the avoided damages as a percentage of potential damages are also found to be directly related to the variables, PERLEAD and ENTER, with the percentages systematically increasing with the increase in the two variables. The relationships, however, are found to be true for only inventory damages. The damages to structure or other assets are not generally related to the variables, PERLEAD or ENTER implying that, for structures or other assets, either the damage-reducing measures were absent or the meagre actions based upon perceptions could do little to reduce damages to such assets.

The variable, ADULT (the number of adult members in the family), and COMTY (the level of community sprit) in the town appear to have the tendency to have a positive impact on the avoided damages (to contents). For example, the per household damage avoided estimates as TK 11763 for those with larger than 3 adult members, as against TK 6358 for those having up to 2 adult members (r=.29*). That is, as expected, the more adult members in the households, the greater is the households' capability to undertake damage-reducing measures resulting in more damages avoided. Similarly, the more frequently the community came forward to help, the more it was possible for the victims to carry out damage-reducing activities. This relationship, however, has not been established in the case of proportions of avoided damages (to potential damages). This relationship is also not established in the case of damages to structure and, possibly, other assets, presumably because measures to avoid such damages are limited, if at all.

Unexpectedly, however, the frequency of flooding used as a measure of past experience appears not to have shown any significant negative impact on avoided damages to inventories. Nonetheless, the proportions of avoided damages (to potential damages) are found to have the expected inverse relationship with frequency of flooding; however, the relationship is not found to be statistically significant.

That the frequency of flooding or past experience is not found to have significant negative impact on damages is somewhat disturbing[4]. This is disturbing because, frequency of flooding vis-a-vis personal experience of the flood victims is expected to be positively related to the levels of perception power, which is, in turn, expected to be negatively related to damages. Nonetheless, one can put forward several explanations for the failure to support the hypothesis in the present analysis. First, the case study town is a moderately flood prone location. The distribution of the sample over the variable, frequency of flooding, is highly skewed towards the frequency of one or two; over and above, it has not demonstrated any wide variations. Second, the damage variations, considered over the whole sample, varied

[4] Parker (1976) found strong evidence that frequency and recency of personal experience are positively related to flood hazard perception. In other words, frequency is likely to be inversely related to flood losses.

immensely and widely[5]. Third, the possibility of incorrect recall of the past floods (except for the recent devastating ones) by the respondents, some of whom are not the head of the households and are relatively young, cannot be totally ruled out.

The flash flood

In the case of the flash flood area (Bahubal), as already mentioned, a formal warning was given in the late hours of night and a short while before the occurrence. Only a few people had trust in the message of the warning[6]. Table 2-B presents the results for the flash flood. The flood was a local flood believed to have occurred as result of combined effect of incessant rains in the hilly areas and the breach created at the river embankment[7].

The Table 2-B reveals that in the case of the flash flood, an average household moved about 32% of their possessions to safer places, resulting in per household avoided damage of TK 1943. The avoided damage as a percentage of the total potential damages amounted to about 30%. As is evident from the Table, warning has a direct and positive impact on damage reduction. On an average, those who believed the warning have moved about 45% of their contents, as against 26% for those who did not. Similarly, those who believed have avoided an average damage to the extent of TK 7906, as compared to TK 1714, for those who did not believe. Although very few people believed the warning message and its distribution is rather skewed, it appears that warning has a positive impact on the damages to structures and other assets as well[8]. However, lead time of the warning is not found to be directly related to structural damages. Nevertheless, lead time has the tendency to have a positive impact on inventory damages. For example, the percentage of inventories moved to safer places ($r=.20$), and the damages avoided ($r=.18$), as expected, appear to have shown increases with the increase in LEAD hours; however, neither of the correlation coefficients, $r=.20$ and $r=.18$, are found to be statistically significant.

Nevertheless, it is demonstrated that generally the damages are inversely related to the level of perceptions, the levels measured in terms of length of time of perception. It is evident that the percentage of inventories moved to a safer place, and thus the damages avoided, as expected, systematically increases with the increase in PERLEAD. The relationship with

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[5] For example, in the case of inventories, the highest damage (TK 27650) is more than 300 times the lowest damage (TK 80).

[6] About 13% of the households believed the message of warning.

[7] The breach on the embankment of river Khoai, was widely reported as man-made, executed by the upper-stream inhabitants of Habiganj town, which was under tremendous threat of inundation at that time.

[8] This is contrary to the finding obtained in the case of river flood for PERLEAD hours;the skewness of the sample towards non-believers of warning and the scant information on the details of measures against structural and other damages(especially because of inability of the survey to administer all the set questions, as the respondents were stressed at the time of the survey) have made it difficult to interpret this finding.

Table 2-B: Damage as a function of warning, perception and social variables

Flood type 2 : flash flood

Variables	% of Content moved	Per HH inventory damage avoided (92/93TK)	Inventory damage avoided as % of potential damage	Struct. damage as % of value of building	Damage to other assets as % of value
WARN : Warning					
- No response	18.9	637	26	25	71
- Not certain	22.4	766	24	32	63
- Didn't believe	26.4	1714	32	25	65
- Believed	44.6	7906	52	3	52
LEAD : Lead time					
- LT 1 hr	29.9	1120	27	26	65
- 1-2 hrs	28.5	1982	30	26	64
- 2 hrs	35.1	2403	33	25	61
PERLEAD: Perceived flood hrs before					
-1 hr before	24.5	1301	29	20	61
-1-2 hrs	33.1	1487	29	42	68
-2 + hrs	42.3	4771	39	23	63
ENTER:Hrs between water entering into town and property					
- 0.5 hr	29.2	1323	29	29	65
- 0.5-1.0 hr	31.0	2190	29	28	63
- 1.0 + hrs	35.3	2898	35	12	60
FREQ : Frequency of flooding					
- 2	31.9	1940	32	34	63
- 2-3	32.1	2046	29	18	62
- 3+	12.9	560	26	47	74
ADULT:Adult members in household					
- 2	16.7	404	23	30	67
- 3	28.7	1043	27	33	62
- 3+	33.5	2821	34	21	62
COMTY: Community spirit					
- Lessened	32.4	1789	33	21	65
- Same	34.0	6325	31	14	58
- Heightened	24.2	1207	24	40	59
All households	31.7	1943	30	26	63

HH = Household; Taka (TK) = Bangladesh currency

ENTER, however, is not confirmed. For example, per household damages avoided, for those who perceived 1 hour before the actual occurrence, is in the range of TK 1301, as compared to TK 4771 for those who realised the possibility of flood more than 2 hours before. Pearson's correlation coefficient of the avoided damage with the variables, PERLEAD and ENTER, are estimated as r= .34* and r= .13 respectively, the former coefficient beinghighly significant. Similarly, the avoided damage as a percentage of potential damages is also found to be directly related to the variable, PERLEAD, with the proportions systematically increasing with the increase in the length of perceptions (r= .28*). The relationship with ENTER is only tentative, as the coefficient, r=.11 is not statistically significant.

Although structural and other damages have a tendency to decrease with the increase of LEAD time and ENTER time, these relationships are not found to be statistically significant. This leads to conclude that damage-reducing actions, if any, in respect of damages to structures or other assets, based upon perceptions are not considerable.

As regards social variables, the variable, ADULT (the number of adult members in the family), emerges as an influential variable in the reduction of the potential damages, both in absolute and proportional terms. However, the variable COMTY (the community sprit) appears to show no such systematic relationship. One possible explanation can be in that when the total community is flooded in such a small urban area it is possible that very few local people could come forward to help each other[9].

As in the river flood, unexpectedly, personal experience, measured in terms of the frequency of flooding, appears to have little bearing on damages. One explanation could be that some households in the area had been flooded three times in the past two months. Such victims were deliberately excluded from the survey in order to obtain damage estimates attributable exclusively to a single flood. Thus, the frequency of flooding variable was possibly not represented adequately.

The tidal flood

Table 2-C presents the results of the case of the tidal flood (Khatunganj area), the flood which was accompanied by strong cyclone and storm. Despite a 37-hour pre-landfall specific warning given, unfortunately, few householders (2%) believed the message when it was given. However, about 14% of the residents realised the risk within the last hour when it was too late to take any action. Thus, the results need to be treated with caution in that the distribution of samples over the relevant variables is extremely skewed. The average lead time according to sample respondents (measured from the individuals time of receiving) was about 32 hours.

Table 2-C reveals that in the case of the tidal flood, an average household moved 7.5% of their inventories to safer places; this resulted in an average damage avoided of TK 1795. The avoided damages as a percentage of the total potential damages amounted to only about

[9] It may be mentioned that in this analysis community refers to population of local neighbourhood, not anybody from outside.

Table 2-C : Damage as a function of warning, perception and social variables

Flood type 3 : tidal flood

	% of Content moved	Per HH inventory damage avoided (92/93TK)	Inventory damage avoided as % of potential damage	Struct. damage as % of value of building	Damage to other assets as % of value
WARN : Warning					
- No response	-	-	-	-	-
- Not certain	3.6	662	2	50	37
- Didn't believe	5.4	1363	5	46	42
- Believed	25.6	41814	39	3	45
LEAD : Lead time					
- LT 24 hrs	5.2	1033	3	47	43
- 24-36 hrs	2.7	555	3	50	36
- 36 + hrs	16.1	5965	8	43	33
PERLEAD: Perceived flood hrs before					
- 0 hr before	0.4	157	1	51	39
- 0-0.25 hrs	12.7	6534	21	18	32
- 0.25 + hrs	26.3	20472	36	22	42
ENTER:Hrs between water entering into town and property					
- 0 hr	5.6	1045	4	47	38
- 0 + hr	10.4	3543	4	50	41
FREQ: Frequency of flooding					
- 1	6.1	1795	15	23	29
- 2	1.7	341	1	62	45
- 2+	3.4	736	2	38	35
ADULT:Adult members in household					
- 2	5.5	1140	5	73	55
- 3	4.3	1394	4	59	51
- 3 +	7.9	1926	4	43	35
COMTY: Community spirit					
- Lessened	2.5	507	1	52	24
- Same	14.3	3509	11	33	16
- Heightened	16.0	6088	11	36	22
All households	7.5	1795	4	47	38

HH = Household; Taka (TK) = Bangladesh currency

4%[10]. Nevertheless, it is evident that warning has some direct damage-reducing effects. Not surprisingly, those who believed the message were able to reduce considerable inventory damages (TK 41814, on average), compared to those who did not believe the message (TK 1363), or who were uncertain about the event (TK 662). Surprisingly, however, unlike in the river flood for PERLEAD variable, this is true even for structural damages, as the percentage of structural damages (to value) was only 3% for those who believed, as compared to 46% for those who did not. As the storm was the major damage variable, and the lead time was quite long, some of those (particularly of low-cost houses) who believed the warning could possibly adopt some prompt precautionary measures against the storm.

It is apparent, as expected, that the percentage of contents moved (and thus the value of damages avoided) tend to increase with the increase in LEAD, PERLEAD and ENTER hours. Nevertheless, the correlation coefficient of the avoided damage with only the variable PERLEAD (r=.41*) is found to be significant at an acceptable level of confidence.

Of the social variables, as is the case with other flood types, the variable, ADULT appears to emerge as a determining variable in the reduction of the potential damages. For example, the correlation coefficient of the avoided damage with the variable ADULT estimates as .68*, which is highly significant. The relationship of the variable ADULT with the proportional damages (by value) for both inventory and structure are found to be inverse, as expected. However, only for the proportional damage to structure is the coefficient (r= -.28*) found to be statistically significant. The relationship of ADULT with the proportional damage to inventory is estimated as r=-.23, which is not found to be significant at an acceptable level. Likewise, the variable, COMTY (the level of community spirit, measured in ordinal scale) has a negative influence on damages, both in absolute and proportional terms. Like in other flood types, unexpectedly, again, the variable, FREQ-frequency of flooding, appears not to have generally shown any negative impact on damages.

6 Conclusion

The analysis reveals that individual perception and human factors are important to the hazard preparedness process. The analysis suggests that the level of flood perception among flood plain users in Bangladesh is quite high, which has a positive bearing on the resilience-building or the vulnerability-reduction process. Although, generally, warning has damage-reducing effects, formal warning systems in Bangladesh often do not perform satisfactorily. The investigation reveals that few people in the study areas have trust in the warning message. Following the lack of effective warning systems, however, the local knowledge process and informal warning systems, essentially developed through flood plain occupants' own perceptions and judgements, appear to play an important role in the damage-reduction decision making process. This is especially true in the case of river floods. Community cohesion along with family kinship and household structure also play a significant role in the positive response to flood hazard.

[10] A few occupants reported that they could hardly take any measures mainly due to the infrastructural adversities, following, among others, the power failure, the lack of transport and the traffic congestion in an already congested area.

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