FACULTY OF ARCHITECTURE RESEARCH UNIT
UNIVERSITY OF MORATUWA, SRI LANKA

FARU Journal
www.faru.lk

Dimensions of Space
June 2023

EFFECT OF RISK PERCEPTION AND VULNERABILITY ON ADAPTIVE ARCHITECTURE IN FLOOD RESILIENCE: A CASE FROM RATNAPURA, SRI LANKA

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Abstract: In the last few decades, the frequency and severity of floods in South Asia have vastly increased due to the increase in global surface temperature and change in rainfall patterns. The lack of risk perception, high vulnerability and lack of proper architectural adaptations have added to the negative consequences of disasters. This study discusses the effect of risk perception and vulnerability on flood resilient architecture. The research was conducted with 35 participants selected from the Mudduwa area in Rathnapura, Sri Lanka where the annual flood frequency and damage is very high. The collected data was analyzed using statistical software to calculate a composite mean score to each theoretical factor risk perception, vulnerability, and architectural adaptation. With assumptions, a non-parametric correlation test was carried out to identify the relationship between the three theoretical factors and their subsequent variables. The research findings concluded that risk perception has a positive correlation with architectural adaptation, but vulnerability demonstrates a negative correlation. According to the study, vulnerability acts as a resistance to the correlation between risk perception and architectural adaptation. In conclusion this study elaborates on the importance of a proper system of adaptation for vulnerable people living in flood prone areas.

Keywords: *Adaptive Architecture, Flood resilience, Risk Perception, Sri Lanka, Vulnerability,*

1. Introduction

With an increase in extreme weather events due to climate change, many coastal areas in particular will be more vulnerable, wiping off billions of national economies and human lives. Apart from the sea level rise, severe climate events like floods, extreme rainfall, heat increase, drought and water shortage have also increased, and it is expected to have a bigger impact on urban areas (Revi et al., 2014, as cited in Gran Castro & Ramos De Robles, 2019). With the monsoonal rains in Sri Lanka, the country is subjected to seasonal floods affecting a large number of the population every year. Most of these people have no choice but to relocate during this period, ultimately impacting and interrupting their lifestyles. The affected are left with severe damages to their properties and valuables, as well as the loss of human lives on some occasions. As floods are an annual catastrophe in Sri Lanka, the perception of risk towards flooding has changed in the human mind. Over time people have developed a greater tolerance to these disastrous events and are willing to accept its consequences. As a result, people tend to reside in these flood prone areas despite the obvious risk associated with it. Although people may be accustomed to flooding and their perceptions may have changed positively, natural disasters are becoming more frequent and severe every year due to the impact of climate change. As a result, the impact of flooding on human settlements will also worsen in the future. As it is important to build resilience through adaptation, adaptations alone will not suffice. Risk perception and vulnerability of a community should be studied as it also contributes and plays an important role in managing natural disasters.

2. Literature Review

According to Cannon (1994), Nature offers humans opportunities as well as risks, which are diversified greatly based on the geographical distributions. Opportunities are categorised as land, water, minerals, energy sources etc. with the risks being natural hazards in the form of floods, droughts, earthquakes etc. This unequal distribution of natural resources and unequal distribution of human social systems in terms of social class, poverty, ethnicity etc. ultimately contributes to the impact of the risk on a community. However, IFRC (2022) also states that disaster risk is ultimately a function of risk perception and vulnerability of a given community, thus these concepts should be studied.

2.1. RISK PERCEPTION

Risk perception is a vital adaptive practice in disaster management and mitigation since the way people perceive risks can influence risk management. Psychometric paradigm is used in quantitatively analyzing risk perception (Birkholz et al., 2014). When using the psychometric approach people tend to make quantitative judgements on the current and

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FARU Journal: Volume 10 Issue 1 DOI: https://doi.org/10.4038/faruj.v10i1.183

desired level of risk. According to Solvic et al.(1984 as cited in Raaijmakers et al., 2008). risk is characterized into voluntariness, dread and knowledge. When considering the risk associated with natural hazards, the terminology changes as, Dread is identified as worry, knowledge is characterized as awareness and control over a hazard is identified as preparedness.

2.1.1 Awareness

Awareness is the knowledge and the ideology about possible risks related to a particular hazard (Raaijmakers et al. 2008; Lui`s et al. 2016; as cited in Askman et al., 2018). Lindell and Hwang (2008) have proved through an empirical study that people who have faced a disaster in their life are more aware than anyone who has not. Furthermore, the frequency of the hazardous events have a direct impact on awareness.

2.1.2 Worry

The level of perceived awareness on the frequency of the occurrence of a disaster, will have a direct impact on one's worry towards such an occasion. The more the frequency and severity of a disaster, the more worried an individual becomes. Due to the awareness that people develop on the severity of the impact, they will tend to worry about their belongings, family, economic stability, health and their lives (Tapsell et al.,2002, as cited in Raaijmakers et al., 2008). According to Jaracz (2001, as cited in Lechowska, 2018) people are more sensitive and worried towards the probable loss rather than the frequency of the disaster.

2.1.3 Preparedness

Preparedness of an individual towards a flood event will depend on the one's perception towards that event. Preparedness can be categorized into two sections: pre flood preparation and preparedness to cope with post flood events (Lechowska, 2018). People should be prepared to face flood events in order to minimize the potential damage caused. In regard to risk perception, awareness, worry and preparedness are interlinked.

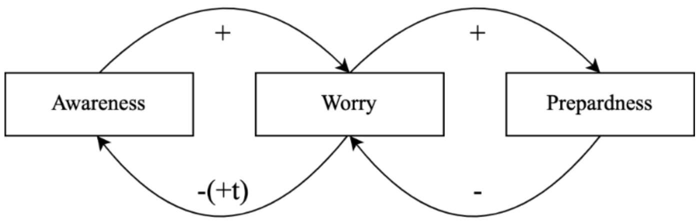

Figure 10: Relationship between Awareness, Worry and Preparedness. (Source: Raaijmakers et al., 2008)

Figure 1 explains the relationship between the three components awareness, worry and preparedness, in a community where the awareness about flooding is high, it leads to a higher level of worry which in turn will improve the preparedness (top rightward arrows with + signs confirm this). However, the more prepared a community is, the less worried they may become towards a flood event (the bottom leftward arrow explains this). Similarly, a community which is less worried will reduce the awareness over a longer period. (The bottom left ward arrows that is connected from 'worry' to 'awareness' with –(+t) confirms this).

2.2. VULNERABILITY

According to Wratten (1995; as cited in Pelling, 1997) vulnerability is more of a concept which has been used to describe a household's position relative to its economic stress and poverty. Sometimes the same disaster will affect different people at various different levels. According to Birkmann et al., (2006), there are two different ways of defining vulnerability. One is based on the core factors of vulnerability, the other is based on different thematic dimensions like social, economic, environmental and institutional factors. However, the majority of the definitions identify vulnerability as a function of exposure, susceptibility and lack of adaptive capacity which is also referred to as core factors of vulnerability (Birkmann et al., 2006.)

2.2.1. Exposure

Exposure describes the appearance of people and their livelihoods, their properties and belongings, infrastructure and other valuable things in an area that could be affected badly in a disastrous situation (IPCC, 2012,; as cited in Birkmann et al., 2006). According to Messner and Meyer (2006) there are different indicators that describe exposure of a certain community to a flood event. Indicators to describe the exposed elements give information about the land use, population density of the area, elevation from water level, distance from the river, frequency of occurrence. Indicators that give information about flood characteristics describes rainfall patterns and the frequency of flooding in a particular area, duration, inundation area, flood velocity, and inundation depth.

2.2.2 Susceptibility

In contrast to exposure, susceptibility explains the likelihood of a community to become affected and harmed in a hazardous situation. This is also termed as sensitivity or the fragility of a community towards a disaster. In other words, susceptibility defines the condition of the community that was exposed to the hazard (Birkmann et al., 2006).

This condition can be of either a social, economic, physical, institutional, or environmental setting. Some scholars argue that the lack of awareness and preparedness can cause susceptibility to increase in a given scenario (Huq et al., 2020).

2.2.3 Capacity

Capacity describes all the strengths, resources and attributes that a community possesses to mitigate and manage the risk of a hazardous event. Capacity, either coping or adaptive, based on the pre hazard and post hazard situations. Coping capacity is the capacity that a community should possess to respond and manage the risk to survive the situation. Adaptive capacity is considered as the ability of a community to identify the possible threat and adjust to its damage and thus take advantage of the opportunities in a positive manner (Jamshed et al., 2020). When the capacity increases whether its coping capacity or adaptive capacity, it helps to reduce the overall vulnerability of the community. The overall relationship between the three factors exposure, susceptibility and capacity can be represented as Figure 2. Exposure and susceptibility together define the potential impact of a disaster; however, vulnerability will be defined together with both potential impact and coping capacity. Potential impact can be reduced if the capacity is high. Hence the vulnerability can be reduced.

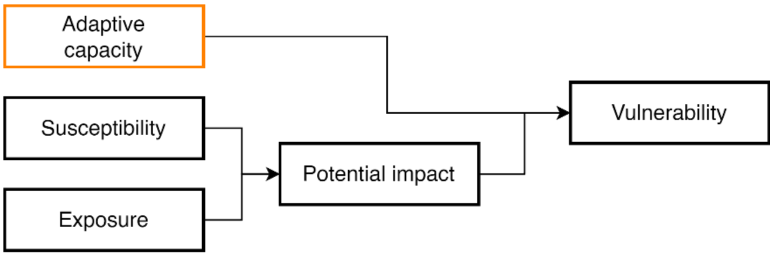

Figure 2: Relationship between exposure, susceptibility and adaptive capacity. (Source: Klein, 2004)

2.3 ARCHITECTURAL ADAPTATION

Risk perception and vulnerability have a physical component in relation to human life which connects with architecture. Having poor structural components and inadequate building techniques in a structure situated in a flood-prone area leaves residents more vulnerable to such flooding and its consequences. People around the world have identified the importance of architectural adaptation in flood resilience and discovered different innovative building typologies through trial and error. These architectural innovations can be categorised based on their similarities: 1) Terp dwellings, a typology made with artificially elevated earth fill. 2) Pile dwellings or stilt dwellings which is one of the oldest adaptive measures practised in Southern Asia where the buildings are raised above ground 8-15 feet using wooden or steel poles. 3) House boats and amphibious houses that use buoyant forces of water to float on water when there is a flood.

2.3.1 Site design and Orientation

Flood flow and flood direction should be identified which can determine the access and egress of a building to ensure easier evacuation. Furthermore, the landscape arrangement can reduce the debris and the speed of current (Federal Emergency & Management Agency, 2003). Whilst slowing down the speed of current, it is equally important to reduce the possible turbulence that is created. To further reduce flood impact on buildings, modifications can be incorporated including streamlining the corners of buildings, orienting buildings to reduce turbulence and structuring the building mass for minimum resistance.

2.3.2 Plan and sectional Configuration

Simple and symmetrical shapes are superior for buildings in flood prone areas. Specifically, circular shapes are most appropriate due to its smaller surface area and any irregular shapes such as L, H and U should be avoided as they increase surface area. Elongated shapes should be avoided too whilst also ensuring that the length of the building does not exceed three times of its width with the shorted side facing flow direction (Hazard Resilient Housing Construction Manual, 2015). Building a storied house (multi storied or split level) in these areas would be ideal as it will provide proper evacuation space for the residents (HFMSC, 2003, as cited in Dilhani & Jayaweera, 2016).

2.3.3 Substructure

Substructure is a key component in any building, and therefore there is no difference in this study where buildings should have strong foundations that are able to withstand floods. Since most of the flood mitigating solutions involve elevating the structure, this substructure plays an important role. Earth fill, use of wooden, concrete or steel posts to elevate the buildings, and pile foundation are identified as widely popular in the flood prone areas.

2.3.4 Superstructure

According to Dilhani & Jayaweera (2016), it is recommended to have RCC columns in building corners for better strength. Additionally, the vertical reinforcements in the columns should link with the foundation and the roof. To withstand the lateral forces exerted by the water column on the walls, it is advised to have a minimum thickness of

200mm. However, if the walls are only 100mm thick, they should not be done with hollow masonry work. Furthermore, fenestrations should be placed in an axial manner for flood water to travel through the building with minimal interruptions. Also, the roof level should be kept above the identified flood level of the area as it can be utilised as an evacuation point. It should be strong enough to withhold extra load and also kept flat in at least one area to be easily accessible for residents in flood situations. The roof angle is another key factor to consider in flood prone areas which should be maintained to avoid the uplift caused by high winds (Hazard Resilient Housing Construction Manual, 2015). For corrugated sheet double pitched roof, slope should be >10º and for tiled, double pitched roof, slope should be >20º. According to Dilhani & Jayaweera (2016) the rafters of the veranda roof and the rafters of the main roof should be separated because the roof strength will be affected. Furthermore, the rafters should be fixed to the wall plate and the reapers should be connected to the rafters with GI straps as this will enhance the strength for the roof in a flood situation (Hazard Resilient Housing Construction Manual, 2015).

2.3.5 Services

With respect to all electrical and telephone lines, these should be taken through the utility company's meter board and fixed above the flood level. If this is not possible it is important to ensure they are waterproof. Additionally, all the distribution panels and plug bases should be kept beyond the flood water level. Plumbing lines should be properly fixed and maintained, since flood water could contaminate drinking water from any leakages. It is very important to fix sewer systems with non-return valves in order to prevent discharge of effluent outside (Dilhani & Jayaweera, 2016).

3. Method of Study

A theoretical framework was developed to analyze the research objectives and the research question (Figure 3). Each theoretical factor, risk perception, vulnerability and architectural adaptation was evaluated separately to create an overall framework to assess the effect of risk perception and vulnerability on architectural adaptation.

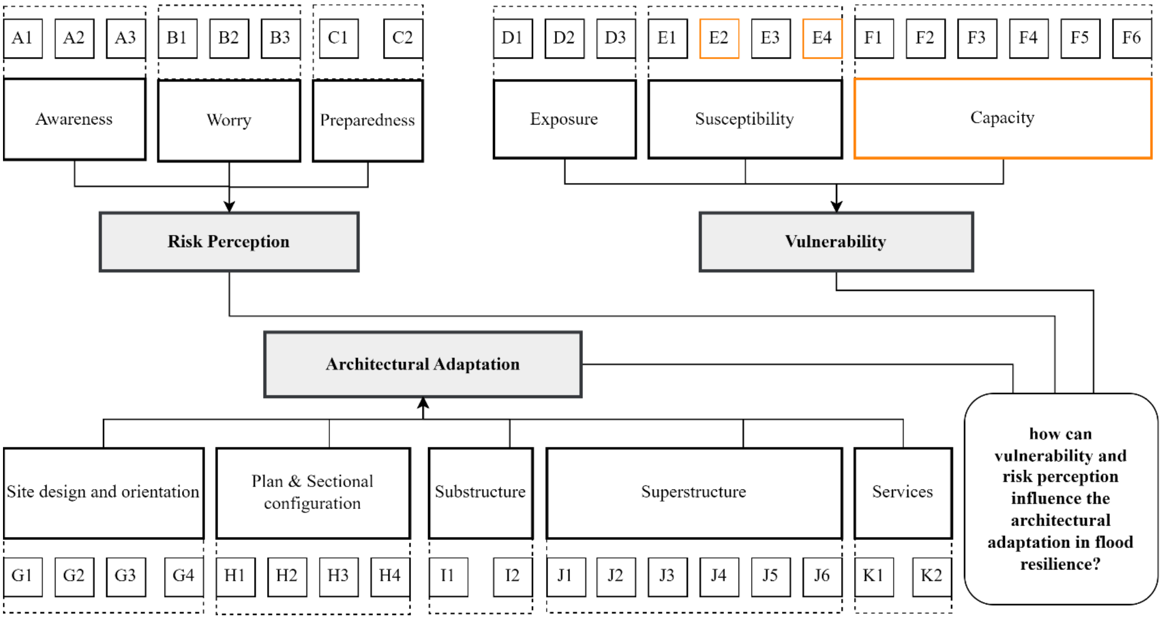

Figure 3: Theoretical framework

3.1 EVALUATION OF RISK PERCEPTION

Main variables of risk perception were identified as awareness, worry and preparedness. According to Raaijmakers et al. (2008) each of the above variables were assigned to a set of indicators based on previous literature to collect data(Table 1). (Rana et al., 2020),(Zabini et al., 2021)

Table 1: Risk perception variables and their indicators

Variable	Indicator No.	Indicator
Awareness	(A1)	Awareness about frequency of flooding
	(A2)	Awareness about evacuation routes
	(A3)	Awareness about possible risk of flooding
Worry	(B1)	Worry on safety of family and relatives
	(B2)	Worry on personal belongings
	(B3)	Worry on safety of neighbors
Preparedness	(C1)	Preparedness for sudden flood event
	(C2)	Experience in flood situations

3.2 EVALUATION OF VULNERABILITY

Acoording to Birkmann et al. (2006) there are three main factors affecting the vulnerability: exposure, susceptibility and capacity. According to Smit and Wandel, (2006), exposure and susceptibility have a positive impact on vulnerability while the variable capacity has a negative impact on vulnerability (Highlighted in Red in table 2). Majority of the indicators had a positive relationship with its subsequent variable however two indicators Monthly income and Number of stories of the dwelling (Highlighted in red in table 2) had a negative relationship with the variable susceptibility. Each of these variables were given indicators based on previous literature to collect data. (Bixler et al., 2021),(Lien, 2019)

Table 2: Vulnerability variables and their indicators

Variable	Indicator No.	Indicator
Exposure	(D1)	Distance to River
	(D2)	Frequency of flooding
	(D3)	Inundation Depth
Susceptibility	(E1)	Age
	(E2)	Monthly income
	(E3)	Health condition
	(E4)	Number of stories of the dwelling
Capacity	(F1)	Availability of evacuation centers
	(F2)	Access to pre warning signals
	(F3)	Availability of evacuation routes
	(F4)	Access to Emergency services
	(F5)	Having a flood insurance
	(F6)	Having any savings/ investmensts

3.3 EVALUATION ARCHITECTURAL ADAPTATION

Based on previous literature by Dilhani & Jayaweera (2016) five variables were selected to assess the architectural adaptation and these variables were then assigned indicators to assess the architectural adaptation level (Hazard Resilient Housing Construction Manual, 2015), (Federal Emergency & Management Agency, 2003). All these indicators had a positive relationship with its subsequent variable.

Table 3: Architectural adaptation variables and their indicators.

Variable	Indicator No.	Indicator
Site design and oreintation	(G1)	Practical location
	(G2)	Plot coverage
	(G3)	Building orientation
	(G4)	Availability of vegetation
Plan and sectional configuration	(H1)	Plan form (compact/complex)
	(H2)	Availability of storage/ evacuation attic
	(H3)	Availability of multiple stories
	(H4)	Availability of high ceiling/roof
Substructure	(I1)	Availability of raised plinth or erected on stills
	(I2)	Availability of plinth beams or structural bracing
Superstructure	(J1)	Availability of RCC columns
	(J2)	Wall thickness
	(J3)	Availability of additional structural support on roof
	(J4)	Availability of wall bracings/ continuos lintels
	(J5)	Axial placement of fenestrations
	(J6)	Height of the roof level
Services	(K1)	Availability of non return valves in swere lines
	(K2)	Location of electrical points

3.5 CASE STUDY SELECTION

The selection of the case study was based on three key factors: frequency of flood occurrence, number of affected people and the distribution of socio-economic levels of the area. According to Disaster Management Centre & United Nations Development Programme (2012) over the last decade out of all the districts in Sri Lanka, highest number of flood events, and highest number of affected families were recorded from Rathnapura district. According to the Urban Development Authority (2019), Social and Economic vulnerability of the people live in Mudduwa in Rathnapura Municipal boundary was high. Its close proximity to the Kalu River and Wey River resulted in frequent flooding which affected the people badly. Based on those factors Mudduwa in Rathnapura was selected to conduct the research.

3.6 DATA COLLECTION

To validate a relationship between three theoretical factors; risk perception, vulnerability and architectural adaptation, a questionnaire-based survey was conducted with 35 randomly selected villagers from Mudduwa. Due to the level of complexity of the questions and language communication issues among the villagers, the questionnaire was verbally presented, and their responses were noted.

3.7 DATA ANALYSIS

For analysis of collected data based on the questionnaire, SPSS statistical software was used. First, descriptive statistics of the data set were tested with mean, and standard deviation to check the normality of the data set. Then a composite mean score was calculated for each of the variable. In risk perception, awareness, preparedness and worry were measured using Likert scales, however in measuring vulnerability, a mix of several scales were used (Likert and dichotomous). Therefore, those scales were normalized to a scale ranging from 0-1 for reliable calculation. For normalization of the collected data, two arithmetical equations were used (Lien, 2019).

$$x_{ij} = \frac{X_{ij} - \min_i\{X_{ij}\}}{\max_i\{X_{ij}\} - \min_i\{X_{ij}\}} \quad (1)$$

Equation (1) was used in areas where there was a positive functional relationship between the indicator and variable (Lien, 2019).

$$y_{ij} = \frac{\max_i\{X_{ij}\} - X_{ij}}{\max_i\{X_{ij}\} - \min_i\{X_{ij}\}} \quad (2)$$

Equation (2) was used to normalize indicators which have a negative functional relationship with the variable. This was followed by a composite score which was given to each variable based on the mean values of its indicators. Under risk perception, for each awareness, preparedness and worry, individual scores were given in a normalized scale ranging from 0-1. Then the mean value of those three variables were calculated to give a composite score for the total risk perception. Similarly, this procedure was followed to get composite individual score values for both vulnerability and architectural adaptation and their respective variables. It was assumed that each variable represents equal weightages regardless of the variable (Lien, 2019).

Then to identify the relationship between architectural adaption score with other variables (awareness, worry, preparedness, exposure, susceptibility, and capacity) a non-parametric correlation test was carried out using the SPSS statistical software. Then a similar test was performed to identify the multiple collinearities between the three theoretical factors, risk perception, vulnerability, and architectural adaptation. A non-parametric correlation was calculated to avoid contradictions with non-parametric variable distributions in the questionnaire (Zabini et al., 2021). Finally, two scatter plot charts were developed using SPSS statistical software to graphically analyze and interpret the relationship between the variables.

3.8 SCOPE AND LIMITATIONS

The study was limited to one case study due to the time limitation and convenience in data collection and travelling. The questionnaire-based survey was limited to 35 respondents due to the time limitation. Indicators selected for the questionnaire were based only on previous literature, due to lack of expert personnel in the area. Equal weightages were given to indicators and variables in calculating the composite score due to the lack of expert opinion on the area of study.

4. Data Presentation and Analysis

Each variable under risk perception, vulnerability, and architectural adaptation, were given an individual score from 0-1 where, 0-was the lowest and 1-was the highest, based on the normalized mean values of their indicators. Table 4 shows each individual score calculated.

Table 4: Computed mean score value for each variable under risk perception, vulnerability and architectural adaptation.

		N	Mean	Std. Deviation
Risk perception	Awareness score	35	.6976	.19812
	Worry score	35	.7190	.16920
	Preparedness score	35	.7429	.19867
Vulnerability	Exposure score	35	.6000	.19259
	Susceptibility score	35	.4875	.18241
	Capacity score	35	.3810	.18774
Architectural Adaptation	Site design and Orientation	35	.6286	.23772
	Plan and sectional configuration	35	.6143	.22148
	Substructure	35	.5143	.30883
	Superstructure	35	.5762	.23689
	Services	35	.5000	.32084

According to the mean score values of variables under risk perception as shown in the Table 4, each variable had a mean score value near to 0.7. Out of the three variables, preparedness had the highest mean score value of 0.7429 and the least mean score was found in awareness at 0.6976. Therefore, it can be interpreted that the preparedness of the people in Mudduwa towards a flood event is good compared to their awareness. Although the awareness is small, people have managed to prepare for flood events. However, the scores obtained for the vulnerability variables range from 0.4875 to 0.6190. The highest score is shown by the adaptive capacity of 0.6190 and the least score was found in susceptibility at 0.4875. Here, it can also be stated that in the Mudduwa area, residents' adaptive capacity is higher compared to susceptibility, hence will result in lower vulnerability.

Based on the analyzed data shown in Table 4, each variable of the architectural adaptation section has a mean score value above the 0.5 level. It can be interpreted that people in the Mudduwa area have attempted architectural adaptation techniques to an average level. It was evident that out of the five variables under architectural adaptation, site design and orientation possessed a mean score value of 0.6286 which is the highest. The second highest score is found in the plan and sectional configuration of the buildings, which is at 0.6143. The least mean score value in architectural adaptation is shown by services. Therefore, it can be interpreted that most people in the Mudduwa area were not concerned about the arrangement of services when building in such a flood prone area.

The mean scores of each of the individual variables in Table 4, were computed to obtain a single mean score for all three theoretical factors, risk perception, vulnerability and architectural adaptation as shown in Table 5. Each score was classified from (Very low – Very High) using the obtained mean score values in table 05 to interpret the severity of each score value obtained (Table 06). Here, the overall score for risk perception of the respondents in the Mudduwa area was 0.7198 which can be categorized as high-risk perception (Table 06), and well above the average level. Overall, the vulnerability score of the 35 respondents in Mudduwa was 0.5688 (Table 05), which can be categorized as an average vulnerability score (Table 06). Finally, the total architectural adaptation score of 35 respondents was 0.5667 (Table 05), which also lies in the average range. (Table 06).

Table 5: Composite mean score value for each theoretical factor, risk perception, vulnerability, and architectural adaptation.

	N	Mean	Std. Deviation
Risk Perception score	35	.7198	.15380
Vulnerability score	35	.5688	.12138
Architectural Adaptation score	35	.5667	.18087

Table 6: Mean score value classification

	Risk perception score	**Vulnerability score**	**Architectural adaptation score**
$0 < x \leq 0.2$	Very Low risk perception	Very Low vulnerability	Very Low architectural adaptation
$0.2 < x \leq 0.4$	Low risk perception	Low vulnerability	Low architectural adaptation
$0.4 < x \leq 0.6$	Average risk perception	Average vulnerability	Average architectural adaptation
$0.6 < x \leq 0.8$	High risk perception	High vulnerability	High architectural adaptation
$0.8 < x \leq 1.0$	Very high-risk perception	Very high vulnerability	Very high architectural adaptation

4.1. CORRELATION ANALYSIS AND DISCUSSION

To compare and identify the relationship between each variable, a non-parametric correlation was carried out. The awareness, worry and preparedness scores of risk perception, and the exposure, susceptibility and adaptive capacity scores of vulnerability were compared with the overall architectural adaptation score (Table 7). Here the correlation coefficient (rs) varies from +1 to -1, where the +1 indicates a strong positive correlation between the two variables, and -1 indicates a strong negative correlation between the two variables. The significance of the correlation is represented with asterisk marks where (**.) represents the significance of correlation when the sig(2-tailed) or the p value is valued at 0.01 level, and the (*.) symbolizes the significance of correlation when the sig.(2-tailed) or the p value is valued at 0.05 level.

Table 7: Correlation analysis between Architectural adaptation score and six other variables.

	Architectural Adaptation score	**Awareness score**	**Worry score**	**Preparedness score**	**Exposure score**	**Susceptibility score**	**capacity score**

Architectural Adaptation score	Correlation Coefficient	1.000	.477**	.128	.376*	.017	-.492**	-.488**
	Sig. (2-tailed)	.	.004	.463	.026	.922	.003	.003
Awareness score	Correlation Coefficient	.477**	1.000	.340*	.677**	.414*	-.232	-.299
	Sig. (2-tailed)	.004	.	.046	.000	.014	.180	.081
Worry score	Correlation Coefficient	.128	.340*	1.000	.281	.056	.166	-.184
	Sig. (2-tailed)	.463	.046	.	.101	.751	.339	.289
Preparedness score	Correlation Coefficient	.376*	.677**	.281	1.000	.486**	-.348*	-.373*
	Sig. (2-tailed)	.026	.000	.101	.	.003	.040	.027
Exposure score	Correlation Coefficient	.017	.414*	.056	.486**	1.000	-.037	-.042
	Sig. (2-tailed)	.922	.014	.751	.003	.	.833	.810
Susceptibility score	Correlation Coefficient	-.492**	-.232	.166	-.348*	-.037	1.000	.535**
	Sig. (2-tailed)	.003	.180	.339	.040	.833	.	.001
capacity score	Correlation Coefficient	.488**	.299	.184	.373*	.042	-.535**	1.000
	Sig. (2-tailed)	.003	.081	.289	.027	.810	.001	.

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

When analyzing (Table 7) it was clear that awareness and architectural adaptation had a positive correlation (0.477**) and showed statistical significance. This can be interpreted as, when the awareness of a person is high, they will architecturally adapt to the situation in order to protect themselves. Similarly, preparedness and architectural adaptation showed a positive correlation (0.376*) with statistical significance. However, out of the six variables shown in Table 7, awareness had the highest positive correlation to architectural adaptation. According to the analyzed data, when people are more aware about a flood situation, they tend to take initiatives in terms of architectural adaptations. In regard to susceptibility and architectural adaptation, there was a negative correlation (-0.492**) between the two with statistical significance. This can be interpreted that when the architectural adaptation is greater, the susceptibility/ sensitivity of being affected from floods is reduced. This can be further studied and utilized when implementing flood mitigating projects. In contrast, when further analyzing the overall variable set, it was clear that highest correlation was shown by awareness and preparedness (0.677**) with statistical significance. When awareness is high, preparedness will also become high. According to Table 7, exposure and awareness showed a significant positive correlation (0.414*) which can be interpreted that when exposure to a flood event is high, the more awareness it builds. Similarly, exposure showed a significant positive correlation (0.486**) with preparedness, which is more significant and positive compared to exposure and awareness.

After analyzing the inter correlations between variables, a second non-parametric correlation test was carried out using the SPSS statistical software to test the relationship between the overall adaptation score with the overall risk perception score and vulnerability score (Table 8). According to the analysed data, it was evident that risk perception had a significant positive correlation (0.505**) with the architectural adaptation (Table 8). This can be interpreted as when the overall risk perception, in terms of the awareness, worry and preparedness is high, then the architectural interventions are also greater.

Table 8: Correlation analysis between risk perception score, vulnerability score and architectural adaptation score

		Architectural Adaptation score	**Risk Perception score**	**Vulnerability score**
Risk Perception score	Correlation Coefficient	.505**	1.000	-.117
	Sig. (2-tailed)	.002	.	.502
Vulnerability score	Correlation Coefficient	-.505**	-.117	1.000
	Sig. (2-tailed)	.002	.502	.
Architectural Adaptation score	Correlation Coefficient	1.000	.505**	-.505**
	Sig. (2-tailed)	.	.002	.002

**. Correlation is significant at the 0.01 level (2-tailed).

This relationship is graphically represented in Section A of Figure 4. People are found to put more effort and thought into incorporating architectural interventions to improve the adaptation of their residences when they have a good risk perception. On the other hand, vulnerability and architectural adaptation were found to have a significant negative correlation to one another (-0.505**). This can be interpreted that when the architectural adaptation is high towards a flood incident, it will lead the individual to become less vulnerable to its effects. Therefore, in order to reduce the vulnerability of a flood event, proper architectural adaptation methods can be used. Section B of Figure 4, shows the relationship between vulnerability and architectural adaptation.

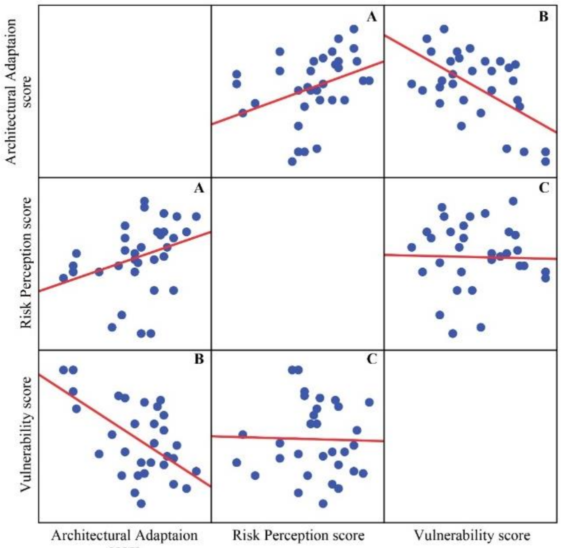

Figure 4: Scatterplot chart between Architectural adaptation score, risk perception score and vulnerability score.

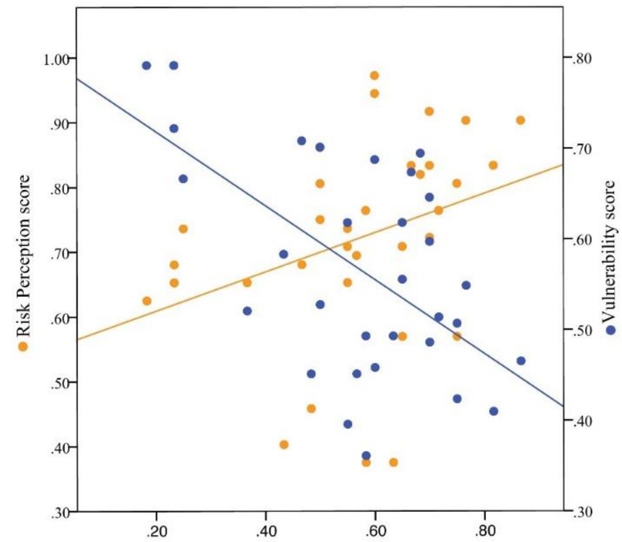

Figure 5: Variation of architectural adaptation with risk perception and vulnerability together.

According to the data shown in Table 8, risk perception and vulnerability showed a negative correlation, but this value is not statistically significant. Section C of Figure 4 confirms this relationship. However, when we elaborate this, it is quite clear that when the risk perception is high, people may act on it so that they can reduce their vulnerability. As the final discussion when we graphically represent the architectural adaptation score against the risk perception score and vulnerability score on the same plane Figure 5, the distribution of points with respect to architectural adaptation concentrates to the area where the two lines of best fit are crossing one another.This concentration of data towards one side can be different from one community to another. However, the main reason behind this explains the relationship between all three factors: risk perception, vulnerability and architectural adaptation. According to the analyzed data in Table 8., risk perception shows a positive correlation with architectural adaptation, therefore architectural adaptation measures should increase with higher risk perception. Involvement of the concept of vulnerability can be identified at this moment. Since vulnerability is a border concept that is bound with multiple thematic dimensions like social, economic, environmental etc. it will hinder people from pursuing proper architectural adaptations for flood resilience as per their need. People may compromise their requirements on architectural adaptations due to their vulnerability. Although we discussed how vulnerability can be reduced by improving architectural adaptation, to achieve this people need to overcome their vulnerability first. Following this barrier, they may improve on architectural adaptations in flood areas thus further reducing vulnerability,

5. Conclusion

This study was aimed at identifying effects of risk perception and vulnerability on architectural adaptation in flood resilience. Research was supported by literature to identify the key variables of risk perception (awareness, preparedness, worry) and key determinants of vulnerability (exposure, susceptibility, and capacity). Research was carried out in the Mudduwa area of Rathnapura with 35 respondents using a questionnaire-based survey. The collected data was analysed using the SPSS statistical software and according to the computed results, it was identified that the people of Mudduwa had a high-risk perception, whilst vulnerability and architectural adaptation were average. In correlation between variables the research identified that variables; awareness, preparedness, and capacity have a significant positive correlation to architectural adaptation. However, the variable susceptibility had a significant negative relationship with architectural adaptation. This means that the lack of architectural adaptation strategies can result in a house being more susceptible to flood events compared to others. In the non-parametric correlation analysis, it was evident that the relationship between risk perception and architectural adaptation is a positive correlation, where when risk perception increases so does architectural adaptations. In contrast, vulnerability indicated a negative correlation with architectural adaptation, thus when vulnerability increases, architectural adaptations decrease.

In conclusion, the overall relationship between the three variables, risk perception, vulnerability and architectural adaptation showed that when risk perception increases, architectural adaptation cannot increase as expected because vulnerability acts as a resistance. Ultimately this research and its findings serve an important cause when it comes to implementing flood adaptation projects. This study suggests flood resilient adaptations to overlook as a social and economically driven scenario rather than a physical solution.

6. References

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