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A study of flood risk mitigation strategies in vernacular dwellings of Rathnapura, Sri Lanka

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Abstract

This study examines the flood mitigation strategies in vernacular dwellings in the high flood risk district of Rathnupra, Sri Lanka. In order to mitigate flood risks, local communities have devised successful flood risk mitigation strategies especially in relation to construction of dwellings. However the adaptive capacity of the local people is not well understood as limited research has been conducted on their ability to mitigate flood risk.

This study consists of 15 case studies in three flood risk zonal categories of Rathnapura. The time period of construction of these dwellings span from 1800 to 2005, allowing the authors to conduct a chronological analysis of development of materials and construction practices in mitigating flood risk in Rathnapura. The study takes the new guidelines for flood risk mitigation in Rathnapura as a framework to analyze the vernacular knowledge demonstrated in the case studies. The planning, spatial configuration, and construction methods were documented for the 15 case studies. The study concludes that the single-storey dwelling constructed in the 1800 and early 1900 demonstrate many of the flood mitigation features required by modern guidelines. The study also emphasizes the lack of attention to services such as plumbing and electricity in the case studies as well as in the modern guidelines.

Key words: flood risk mitigation, vernacular dwellings, Rathnapura

Introduction

Rathnapura city is located along the banks of Kalu River in the windward side of the central hill lands receiving an annual rain fall between 3000mm-4000mm (UN Habitat, 2013) and has a population of approximately 120,000(Department of Census and Statistics, 2012). The Rathnapura district is severally affected by floods and landslides due high rainfall and it's location in the flood plains of Kalu River. The highest number of flood events in the country from 1999-2011 was recorded in the Rathnapura district (Disaster Mitigation Center (DMC), 2012). A vulnerability & disaster risk assessment for Rathnapura MC area identifies that based on the DMC hazard impact records and the stakeholder judgments of the study, flood hazard is the most prominent in the area which is hundred and five (105) times severe than strong wind and twenty one (21) times sever than landslide presence in the Rathnapura area (Project Consultancy Unit, University of Moratuwa (PCUUoM, 2013b). As population and density rises in vulnerable areas, the associated damage from floods can be expected to rise (Loster, 2000). Loster, 2000 further establishes a trend in increase in flood disasters globally.

Locally, even though, it could not be clearly identified in the available data, there is a possibility of an increasing trend of flood disasters (DMC,2012).

Therefore there is a growing concern on how the city of Rathnapura can adapt to increasing flood risk. Physical damage associated with flood risk range from infrastructure, buildings, loss of farm land, injuries and loss of lives. In the city of Rathnapura, flood events have affected 49,144 people from 1999-2011 (PCUUoM, 2013b). As a city that has been exposed to disasters from historic times, many forms of resilient actions to flood risk are present in local community. The flood risk mitigation strategies in vernacular dwellings of Rathnapura are a key factor in demonstrating these actions. Hence this study focuses on the documenting and analysing of flood risk mitigations strategies in vernacular dwellings in an effort to appreciate the extensive indigenous knowledge of the local community.

According to the Charter on the built vernacular heritage, 1999:

"Vernacular building is the traditional and natural way by which communities house themselves. It is a continuing process including necessary changes and continuous adaptation as a response to social and environmental constraints."

Based on the above notion of vernacular, buildings demonstrate a response to environmental constraints. In the case of Rathnapura, would be the reactionary measures to flood risk through modifications to the traditional ways of planning and construction of dwellings. This study aims to identify these flood risk mitigation strategies in the planning and construction systems of the vernacular dwellings in respect to a framework developed by using modern guidelines.

Method

Attributes of flood risk mitigation strategies in dwellings

Five broad parameters were identified to develop the framework for analysis based on a literature survey for flood risk mitigation strategies for riverine or flash floods. These parameters are (1) Location and orientation, (2) Plan configuration (3) Substructure (4) Superstructure, and (5) Services.

(i) Location

Ideally, building on the highest practical location on the flood plain reduces the chances of flooding and the period of inundation. Building sites should be away from natural drainage paths (Sri Lanka urban multi-hazard disaster mitigation project (SLUMDMP), 2003; Disaster Management Center (DMC), 2012). This may also increase warning time to allow some preparation before the flood.
Plot usage and coverage as per Planning & Building Regulations Made Easy by Urban Development Authority of Sri Lanka 2005 (Project Consultancy Unit, University of Moratuwa (PCUUoM, 2013a), states that dwelling units are to have a maximum plot coverage of 66 2/3 %. Therefore the minimum open space at the ground level required is 33 1/3 % of an open space around the dwelling and this contributes to the speed of the return period. However, the extent of open spaces is dependent on a number of factors such as the character of the terrain, geographical location, and height of the building and the scale of the buildings among others.

(ii) Substructure

Raising the plinth above from the flooding surface is the best way to protect a building in flood prone areas. This can be done by either raising the whole building on an earth mound, high plinth or on strong stilts with the area under the building filled or with openings to allow flood waters to flow under the building. If the house is raised eight feet, the lower area can be used for a garage or for storage of items not subject to flood damage or which can be easily moved above inundation levels (SLUMDMP, 2003).

The height of the plinth is decided on exceeding the highest known flood level. It is suggested that the best way to protect a dwelling from surface flooding is to raise it at least one foot above the 100 year regulatory flood level [4]. If it is not possible to raise the entire building above the flood level, it is recommended that the floor of one room shall be raised and the room shall be used as flood shelter during inundation (SLUMDMP, 2003; DMC, 2012)

The depth of the footing system is dependent on a number of factors including foundation materials and flood flow velocity, whether the footing system sits on fill or undisturbed soil, slope of land and potential for landslip, so the construction activities should be in accordance with the above factors (PCUUoM, 2013a). Irrespective of the materials used, the foundations should be deep enough (at least 600mm or 2 feet below the ground) to prevent undermining. The plinth portion of the foundation should be high enough to prevent flood water coming into the buildings. The plinth should be well plastered against erosion (DMC, 2012).

(iii) Building form and orientation

Spatial planning and the orientation of the building with regard to a flood are important factors to consider in the case of flood mitigation. A compact building can withstand horizontal loading. L, H and U shapes are to be avoided. In the case where there is high velocity, it is recommended that long and narrow designs with the ratio of the sides is less than 1:2 are avoided [6]. Buildings with long walls are more fragile and susceptible to flood water loading and vulnerability to debris loading is maximized (Haekesbury-nepean Floodplain Management Steering Committee (HFMSC), 2006). Therefore longer walls should ideally be parallel to the water flow.

The building sectional form can also aid in flood risk mitigation. In a single-storey dwelling, a storage attic could provide a safe evacuation space for the building occupants. When the occupants are evacuating the building, the attic can be employed to store furniture, electrical equipment and other valuable items prone to damage. To obtain a useful attic space, a gable roof is recommended with minimum pitch of 21.5 degree. The roof structure requires heavier ceiling joists and basic flooring. The access stair to the attic should be wide and straight (HFMSC, 2006)

Many of the new constructions in flood risk zones employ a two-storey house construction or a split level house (HFMSC, 2006). Constructing storied buildings can reduce damage to property and life in times of inundation. Since it is costly to construct upper floors, low cost upper floors will be more acceptable by local communities (PCUUoM, 2013a). For storied dwellings, the ground floor walls can be constructed of concrete blocks and the floor could be concrete with tiled finish. The upper floors can be constructed of a lightweight clad frame.

The functional design of a house can be arranged so that the habitable rooms and most valuable and vulnerable goods are located at the highest level. The rooms on the lower floors can be used for the more basic purposes (e.g. garages, second bathrooms) then the opportunity exists to make the lower levels much more flood resistant. In areas of flood risk, buildings must be constructed with more than one floor located higher than the regular maximum flood level (HFMSC, 2006; PCUUoM, 2013a).

(iv) Superstructure

In new constructions as per guidelines, the building structure should have the corner posts in RCC if possible and fixed to strong and deep foundations. Vertical reinforcement in columns should link foundations to top of the superstructure walls and the roof. If all the columns in the dwelling cannot be in RCC then at least the intermediate columns should be in RCC and the free height of unbraced timber columns should not be more than 2250mm (DMC, 2012 b).

It is recommended that if it is not possible to raise the whole building, at least one room should rise above flood waters (SLUMDMP, 2003; DMC, 2012 b; PCUUoM, 2013a) Damage to dwellings from floods can be a result of strong lateral pressures on walls causing walls to collapse or be damaged. In addition, debris carried by the waters can cause damage to property and life. The minimum thickness of external and load bearing walls are recommended to be 200mm. If 100mm walls are constructed, they should be built of solid (not hollow) masonry units. A stiffener column is to be used to support the apex of the gable wall. Unsupported wall lengths exceeding 6m should be provided with intermediate columns. In addition, bracing of the adjacent posts diagonally using securely fixed wires or wood strips should be done in order to keep the house from leaning. Also wall construction should be braced by columns cross walls or continuous lintels (DMC, 2012 b).

Openings on walls should be strategically placed to minimize the damage due to the velocity of flood waters. Windows and openings ideally should be positioned axially to allow the out flow of flood waters through the dwelling (SLUMDMP, 2003; DMC, 2012 b). The aggregate width of all openings in walls should not exceed 50% of wall length in dwellings. Openings for doors and windows in walls are required to be kept at a minimum of 600mm from the corners of walls from each other (DMC,2012 b). Windows should be kept open during a flood.

Floods are usually accompanied by strong winds especially during the monsoon seasons which can pose an additional threat. The level of the roof should be kept above the high flood level. Houses should not be constructed in sites where this is not possible. As the roof should be strong enough to carry the load of the occupants, it is recommended that at least part of the roof is made as a flat roof. Therefore the roof system needs to be safe from rising waters as well as strong winds. The roof structure needs to be designed carefully to minimize or avoid the possible uplift due to cyclones and strong winds. A hipped tiled or sheet roof (min. slope 28 degrees) is recommended for high risk areas. Rafters at verandahs are required to be independent of rafters of the main roof of the building, so that the strength of the main roof is not compromised. Avoid wide verandahs that face prevailing wind. Circular pre-fabricated water tanks placed in roofs shall be anchored effectively to prevent them getting displaced or causing harm. Wall plates and rafters must be anchored adequately to the main construction frame. Mortar restrain bands shall be provided at 1.2m intervals at roof edges and 1.5m intervals elsewhere (DMC 2012 b).

(v) Infrastructure

The driveway to the site should provide easy access to and from the dwelling. The driveway from the house should be as high as possible along its full length to provide the longest period for evacuation. Links to safe flood free locations offer greater security for safe evacuation in flood events. Access to basic services such as plumbing and electricity has to be strategically planned to minimize damage to the system in times of floods. In Sri Lanka there is no separate drainage for waste and storm water in many of the flood prone areas. Sewerage systems in areas of flood risk should be fitted with non-return valves in order to prevent foul water backing up into properties (PCUUoM, 2013a).

Selection of Case studies

According to the Charter of the built vernacular Heritage, 1999 examples of vernacular may be recognized by:

- A manner of building shared by the community
- A recognizable local or regional character responsive to the environment, coherence of style form and appearance,
- Or the use of traditionally established building types: traditional expertise in design and construction which is transmitted informally
- An effective response to functional social and environmental constrains

As the intention of the study is to document and analyse the flood risk mitigation strategies of vernacular dwellings, case studies were selected adhering to the above criteria in areas that have high to moderate flood risk.

Flood risk in Rathnapura district is classified by (i) flood most likely to occur, (ii) flood can be expected, (iii) moderate level of flood hazard exists and (iv) flood not likely to occur (UN Habitat,2013). This study takes 15 vernacular dwellings constructed in the above mentioned high flood risk zones as case studies. Four case studies were selected from the flood risk zones in the Grama Niladhari (Village Officer) divisions (GN) of Batugedara (A1,A2,A3,A4), 2 from Angammana (C1,C2,) 4 from Thiriwanikatiya (D1,D2,D3,D4) and 5 from Mudduwa East (B1,B2,B3,B4,B5).

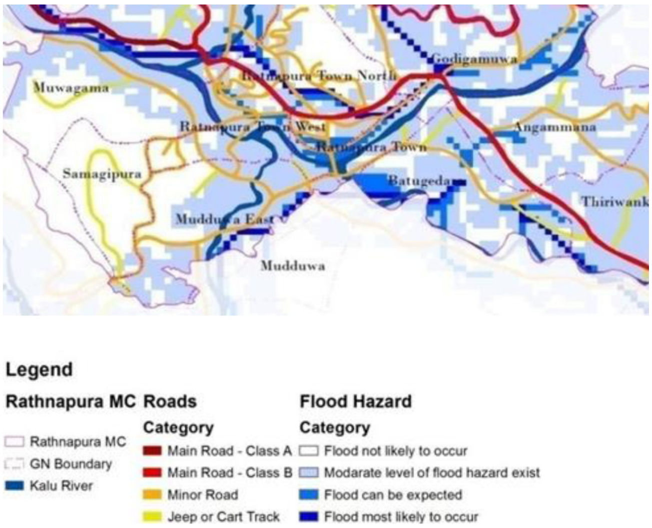


Fig.1: A section from the flood hazard map of Rathnapura
(Source: UN-HABITAT)

Table 1: Year of construction of the dwellings

Area	Given house code	Year of construction(approx.)
Batugedara	A1	1850's
	A2	1880's
	A3	1850-1900
	A4	2010
Mudduwa east	B1	1970
	B2	1900's
	B3	1850
	B4	1925
	B5	2010
Angamana	C1	1947
	C2	1900's
Thiriwanikatiya	D1	1850-1900
	D2	1992
	D3	1952
	D4	1975

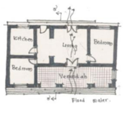
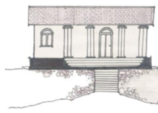
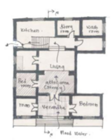
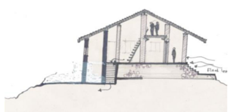
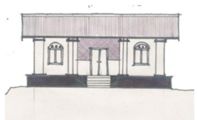
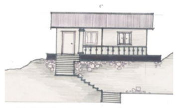
A field study was conducted to collect data on planning and configuration of the dwellings, materials and the construction methods. A semi-structured interview was conducted in Sinhala with the occupants of the dwellings to obtain information on the location, substructure, building form and orientation, superstructure and infrastructure. After collecting data measured drawings of the dwellings were developed for analysis.

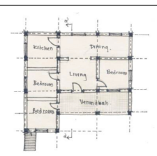
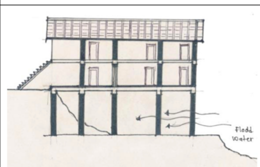
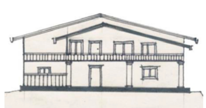
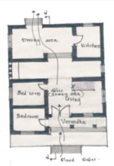
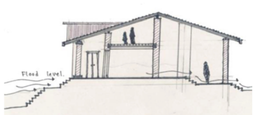
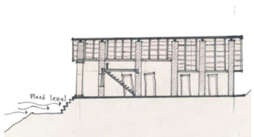
Limitations of the Study

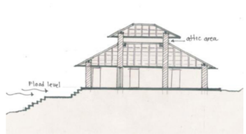
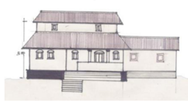
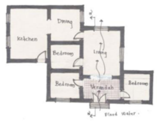
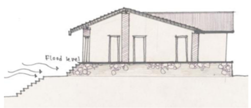
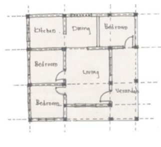
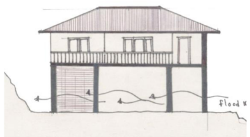
The reduction of damage and threat to human lives due to flood risk mitgiation strategeis in vernacluar dwellings is not fully assesd in this study. The study only focuses the physcial featrues of the dwelling that correspond to the given framewrok based on existing gudielines. The study does not assess the socio-economimc aspects of the households that would have given a clearer picture of reasons behind the communtiy's resillence to flood risk and their contiued willingess to live in the flood plains generation after generation. During an intial survey the autohrs did look in to flood risk mitigation of dwellings in other flood prone areas of the country, however it was observed that the dwellings in Rathnapura area had to most comprehensive response to flood risk.

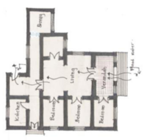
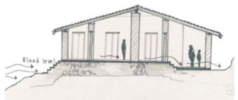
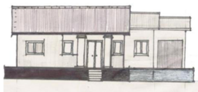
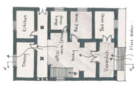
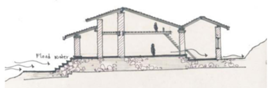
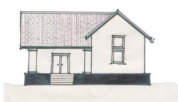
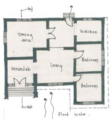
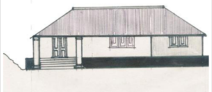
Flood risk mitigation strategies in vernacular dwellings in Rathnapura

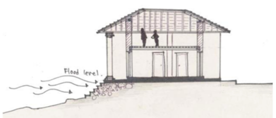
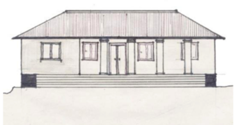
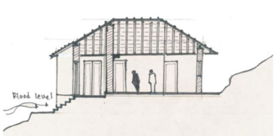
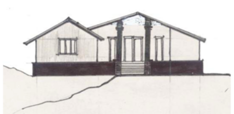
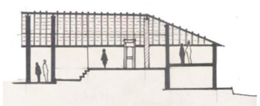
The traditional dwellings in Rathnapura have distinctive responses to flood risk which has gone predominantly unnoticed in exiting literature. In the following tables, 15 case studies are evaluated in 4 main flood risk zones in Rathnapura in the GN divisons of Batugedara, Mudduwa, Angamana and Thirwanikatiya based on the attributes in section 4.

	PLAN	CROSS SECTION	FRONT ELEVATION	FLOOD MITIGATION STRATEGIES
A1				The dwelling is constructed on a raised foundation (rubble and laterite rock) that has been further elevated from the existing road level by a high retaining wall. Walls are 56cm thick made of mud and laterite rock. The axial location of the front and the back doors facilitate the out flow of inundation. The dwelling has a compact form. The high ceiling of 3m prevents damage to the ceiling and the roof height is 5m. During the times of the flood the occupants use the roof for safety. The arch construction provides additional structural support for the roof.
A2				Constructed in the early 19th century this single storey dwelling is raised 5m from the existing road level. The foundation is constructed of rubble and laterite rock. The small attic constructed out of hardwood is used for storing and safety from inundation. Water flow is directed through the living room to the outlets from the kitchen, storage room. Double columns have been used to provide additional support to the superstructure and roof. Walls construct of laterite rock consists of a thickness of 50cm.
A3				This single storey dwelling is constructed 5m above the road level. The rear section of the dwelling is elevated from the living room areas. The walls of the house are 56 cm thick and constructed of mud and laterite rock. The long sides of the walls are parallel to flood flow. However there is no clearly defined outlet for flood waters. The roof height is 3m. The roof is used for evacuation in times of inundation.

	PLAN	CROSS SECTION	ELEVATION	FLOOD MITIGATION STRATEGIES
A4				A recent construction this dwelling is supported by a RCC column grid. The ground floor is 4m above the ground level. The dwelling is two storied and raised on pillars to avoid inundation reaching the habitable floor spaces. This house has been constructed in the flood risk plan as a result of urbanization and scarcity of land in the area. The dwelling is designed to prevent flood from entering the habitable spaces therefore the plan does not facilitate inundation out flow.
B1				This dwelling is elevated 4.5m above the existing road level. Similar to houses constructed in that era the rubble and laterite rock foundation is 1.5m in height above the existing ground. The dwelling is compact and facilitates the outflow of flooded waters through an opening from the dining room. The height to the roof is 4.5.m The house also consists of an attic constructed out of hardwood flooring for use during floods. The attic is accessible from the living room. The walls are 50cm thick made of laterite rock.
B2				This house is built on the highest point of the locality. It has a foundation height of 1.5m. The attic constructed out of wood is used to mitigate damage from flood waters to goods as well contribute to the safety of the occupants. The roof height is 4.5m The house also has several opening operating as outlets for inundation during a flood. The walls are constructed of a mixture of laterite rock and clay. The rubble adds strength to the walls which in other circumstances would be made of a mixture of clay only. The front colonnade provides support to the roofing structure.

	PLAN	CROSS SECTION	ELEVATION	FLOOD MITIGATION STRATEGIES
B3				This dwelling has an appearance of a two storey house due to attic being located above the roof level of the main dwelling. The foundation is raised 2m from the ground level and 5.7m from the road level. The spatial planning indicates a direct out flow of flood waters through the dining area windows into a rear open area. The attic is elevated 5m from the ground floor, which is a very safe height from flood waters. The angle of the roofs exceeds 28 degrees providing protection from the strong winds.
B4				This three bed room dwelling is constructed on a raised foundation of 2m from the ground level. There are 16 steps from road level to the dwelling. It is not compact in form, but has adequate openings to facilitate movement of flood waters out of the dwelling. The walls (50 cm thick) are constructed out of laterite and a clay, cement mix.
B5				A recent construction this dwelling is raised 6m on RCC pillars. The area under the ground floor is used as shops and as a temporary storage for the family. The column grid is 3mx3m which provides additional support in times of inundation. As the house is designed to avoid flood waters entering the dwelling provision has not been kept for adaptation. The walls are constructed without any additional bracing.

	PLAN	CROSS SECTION	ELEVATION	FLOOD MITIGATION STRATEGIES
C1				This single storey dwelling, with an extensive floor plan has had extensions added to the original during its life time. The house is built on a raised foundation (2m). The plinth is constructed out of cement and rock. There is a axial path for outflow of flood waters through the dwelling. The front columns are 28cm in diameter and provide the structural support for the front part of the roof during inundation. The walls (50cm thick) are constructed of clay cement and laterite.
C2				This is a small compact dwelling. There is a level difference between the kitchen and dining room and the other areas on the ground floor .The ground floor is on a raised foundation of 1.5m. The attic constructed of hardwood is accessible from the living room is more spacious than in other dwellings. There is direct flow path for flood waters. The verandah has a detached roof. The columns in front are constructed of bricks and cement mortar and are 25cm in dia.
D1				This compact dwelling was renovated several times by the occupants without compromising the early flood risk mitigation strategies. The house is constructed in the highest elevation of that area. The house is raised 1m above the existing ground level and 1.5.m above the road level. The axially positioned openings and the level difference of the ground floor facilitates flood outflow

	PLAN	CROSS SECTION	ELEVATION	FLOOD MITIGATION STRATEGIES
D2				The flood enters through the front verandah of this compact dwelling and the outflow is through the axially located openings as well as through openings from the bedroom. The house is raised 2m from the existing ground level. There is 3m wide rear space to facilitate outflow. There is also a spacious attic which is accessible from the bedroom. The roof height is 4.5m and allows sufficient headroom for occupying the attic. The front colonnade is constructed out of clay, cement and laterite rock and a column has a dia. Of 28cm.
D3				A dwelling has two large columns at the entrance supporting the high roof which is 6m from (ground level)at the highest point. The foundation constructed from cement, clay and rock is raised 2m form the ground level. The walls (50cm thick) are constructed of rubble, laterite and clay. The axially located openings accommodate flood water flow through the dwelling. Adequate rear space is allocated in this dwelling to accommodate the rate of flow.
D4				This dwelling is constructed on 3 split levels. The main entrance to the house is at the ground level. A part of the house is constructed on a RCC grid. The space under the ground floor is for temporary use by the occupants.

Discussion

The location of the dwelling in the traditional houses were more apt for flood risk mitigation as they were located on sizable plots on high ground (A1, A3,B2, B3, B4, B5, C2, D2, D4). The dwellings were located from 2m-5m above the road level with steps leading to the entrance verandah. However in the recent constructions, due to limitations of land in the area, plot sizes have become reduced.

In many of the older dwellings (A1, A2, B1, B2, B3, B4, C1, C2, D1, D2, D3), the building plan was configured for the flood to enter the dwelling and exist from the openings at which were generally axially located. The dwellings also have compact plans in many cases and several inundated flood outlets. These dwellings have stood the test of time in high risk flood zones with minimal structural damage. With the introduction of new construction materials; especially reinforced concrete, the design of dwellings have changed. In dwellings constructed in the 2000s all efforts have been taken to avoid floods entering the interior of the building (A4, B5, D4) by constructing two stories and allowing the ground floor level to be unused when flooded.

The substructures in all the case studies have been designed to mitigate flood using a number of different construction methods. In the older case studies, rubble and laterite rock were used to create a strong raised plinth on a high earth mound (A1, A2, B1, B2, B3, B4, C1, C2, D1, D2, D3). The plinth height varies from 1m to 2m. In the more recent constructions, dwellings (A4, B5, and D4) have been constructed on concrete pillars.

The roofs in all the dwellings had an angle of more than 28 degrees to avoid uplift due to strong winds which usually accompany floods. Case studies A1, A2, A3, B1, B2, and B4 have been able to withstand flood risk due to proper orientation, plan configuration and adequate roof height of the superstructure. The walls constructed of laterite rock and clay is around 56cm thick in the case studies and there is evidence of the use of double columns (A1, D2, and B2) for additional structural support. Columns are generally constructed out of rubble or laterite rock measuring up 30cm. in diameter. In houses A1 and D1, the flooring is in granite stones to provide durability. The roof height is about 5m in many of the cases studies. Unlike in the vernacular dwellings observed in other areas of the country, many case studies have an attic (A2, B1, B2, B3, C2 and D2) for safety in the event of a flood. The construction of a well-configured single-storey dwelling with an attic can mitigate flood effectively as identified in this study. In two-storey dwellings some of the features that are vital for mitigating floods such as axial location of opening, compact plan etc., becomes irrelevant as flood waters do not enter the inhabited upper floor level.

Conclusions

The adaptive capacity of the vernacular dwellings is high based on the several flood risk mitigation strategies identified by the study (Appendix 1). This study has identified that even in the absence of modern materials and professional knowledge, the vernacular dwellings comply with modern guidelines satisfactorily.

However the cases studies as well as the guidelines have not managed to provide solutions for dwelling services. The plumbing and electrical services in many of the case studies were in a very poor condition and none of the guidelines addressed this issue effectively. Further research has to be conducted in this area in order to develop good design solutions to improve the services of dwellings constructed in flood prone areas.

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Annexure 1 -A summary of flood mitigation strategies in vernacular dwellings of Rathnapura

Flood risk mitigation strategy	House code														
	A1	A2	A3	A4	B1	B2	B3	B4	B5	C1	C2	D1	D2	D3	D4
Location															
On the highest practical location	●		●		●	●	●	●	●		●	●	●	●	●
Within the req. maximum plot coverage	●		●		●		●	●	●		●	●	●		
adequate open space	●		●		●		●	●	●		●	●	●	●	●
Substructure															
Raising the plinth above the flooding surface	●	●			●	●	●	●		●	●	●	●	●	●
Raised on stilts				●					●						●
Building form and Orientation															
A compact building form	●		●		●						●	●	●		●
Longer wall parallel to flood flow		●	●		●	●					●				●
Storage and evacuation attic		●			●	●	●				●		●		
Two-storey house with the ground floor susceptible inundation				●					●						
Split level house			●								●	●		●	●
High ceiling/roof	●	●	●		●	●	●				●		●	●	●
Superstructure															
Corner posts in RCC fixed to strong deep foundations				●					●						
Min. thickness of wall more than 200mm	●		●		●	●	●	●		●	●	●	●	●	●
Additional structural support for the roof	●					●							●	●	
Walls braced by cross walls or continuous lintels															
Axial positioning of openings	●	●			●	●	●	●		●	●	●	●	●	●
Level of roof above flood level	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Independent rafters to support verandahs											●				