Social Science Asia, Volume 7 Number 4, 2021, p: 50-64 DOI : 10.14456/ssa.2021.30

LIVING WITH FLOODS: PROFESSIONAL ADVOCACY *vis-à-vis* TRADITIONAL WISDOM IN RATHNAPURA CITY, SRI LANKA

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Abstract

Rathnapura city is located in a deep valley where two rivers converge. It experiences serious flooding during the monsoon period. The city center and most of the suburbs succumb to flooding at least twice a year. During early 1980s, the new town of Rathnapura was established 5 km away from the old city center in an attempt to relocate the city at a safer place. People were advised to relocate their houses and businesses in the new town. Although most of the government establishments were relocated there during the last 40 years, the new town lacks life and character due to the lack of a residential population. People prefer to live in their traditional homelands in the old city instead of relocating in the new town. They do not mind the recurrent flooding problem due to several reasons. The most prominent among them is the cultural practices and livelihoods that are deep rooted in specific places of the old city. They do not like to abandon these customary places and relocate in new places for the sake of safety. Due to the social resistance, the local government has reluctantly adapted the "living with floods" policy for development planning in Rathnapura. This paper inquires the tussle between traditional wisdom and professional advocacy when dealing with the urban development agenda of Rathnapura City. It also examines the traditionally practiced and professionally advocated building construction methods in the study area. Stakeholder consultation survey and a field survey were conducted by the first authour's team as a prelude to develop an urban design scheme and building construction strategy for the core areas of the city. This scheme recognizes people's place making process and adapts an enabling role despite shortcomings on the safety front. This stance may go well with the local people but not necessarily with the project proponents, financiers and urban managers.

Keywords: Professional advocacy, Indigenous practices, Traditional wisdom, Flood mitigation, Resilient buildings

1. INTRODUCTION

Rathnapura is the capital city of Sabaragamuwa Province of Sri Lanka. It is a unique city because it is the epicentre of the Sri Lankan gem industry. It is situated in the South-western part of Sri Lanka where Kalu Ganga (Black River) and Wey Ganga (a tributary of Black River) meet. It is located approximately 100 km (63 miles) away from the national capital city, Colombo. Rathnapura City is located in the wet zone of Sri Lanka, at an elevation of 21m (69 ft) above the mean sea level. The surrounding of Rathnapura City features a tropical rainforest climate according to the Köppen climate classification (Hasaan, 2020). The city receives rainfall mainly during the south-western monsoon (May to September). During the remaining months of the year, there is also considerable precipitation due to convective rains. The annual precipitation is in the range of 4,000 to 5,000 mm. The temperature varies between 24 °C - 35 °C. Rathnapura also experiences very

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Received: 2/09/2020; Revised: 27/10/2020; Accepted: 15/12/2020

high humidity throughout the year. The least humid month is February with 74.2% and the most humid month is November with 84.3% relative humidity (UDA, 2019).

The name 'Rathnapura' means "city of gems". This name is derived from the Sanskrit words ‘pura’ (town) and ‘rathna’ (gemstones). The types of gemstones found in the region are Rubies, Blue Sapphires, Aquamarines, Tourmalines, Topaz, Garnets, Cat’s Eyes, and Amethysts. Rathnapura region has produced two of the world’s largest blue sapphires, including the “Blue Belle of Asia” (which adorned the British crown), and the ‘Star of India’, displayed at the New York Museum of Natural History (www.ceylonbluesapphires.com).

Although there are several gem mining areas in the country (see Fig.1), Rathnapura City has become the epicentre of the gem industry and gem business over time. It is the hub of a network of smaller trading towns. Traditional lapidary works (i.e., gem cutting, and polishing) once located in the city have declined due to the lack of local craftsmen and availability of modern technology elsewhere. However, the mining industry services are still supplied by the establishments located in the city. Most of these trading, processing and service activities are located in the old city centre of Rathnapura. They are the anchoring economic activities of the city.

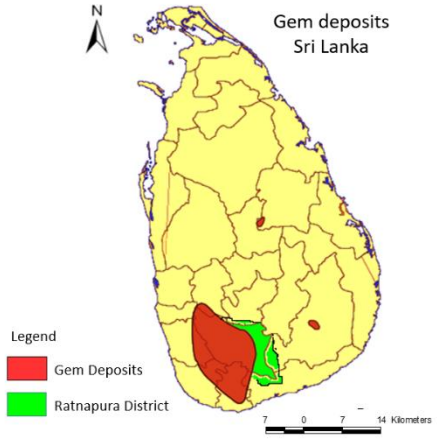

Figure 1: Map of Sri Lanka showing major gem mining areas
(Source: UDA, 2019)

Many people’s livelihoods are directly or indirectly related to the gem mining industry, gem & jewellery business and mining services. Others engage in livelihoods related to cash-crop trading (tea, rubber, agricultural produce), forest-based produce (herbs, spices, palm sugar, timber), and various services including tourism. The old city centre portrays characteristics of mixed land-use due to those livelihood activities. There is a significant residential population in the city centre and its hinterlands. In 1900, Rathnapura was a small town with around 4,000 people. Most of them were engaged in gem related livelihoods. When Rathnapura gradually grew to be the regional economic centre it became a city with a population of 49,000 by year 2000. It has increased to the level of 56,000 by 2020 as estimated by UDA, (2019). The share of this population living in the new town is very small.

2. PROBLEM STATEMENT

The old city centre of Rathnapura is located at a valley where the aforementioned two rivers converge. The city is surrounded by hills. When it rains heavily in the hills, water rushes down the hill slopes and creates flash floods in the valley. Flood water overflows the river banks and submerge a substantial part of the city (see Fig.2). There are no major dams constructed upstream on either river for hydro-electric, irrigation or flood control purposes. Therefore, management of the flash flood phenomenon and its impacts are quite difficult. Historically, Rathnapura has been affected by three levels of flood hazards, namely: Critical, Major and Minor flood events (UDA, 2019).

Rathnapura is prone to flooding between May and June, and October and November. In May 2003, the city encountered one of the biggest floods in history. It was 1 in 10-year type critical flood event. It caused significant impacts on lives and property. Most recent critical flooding occurred in 2017. During this flood event, approximately 80% of the land area of the city was inundated for five days. According to the records of Rathnapura Municipality, 620 houses were damaged, 25,491 people were affected and 337 people were evacuated to IDP camps during that flood (as Quoted by Hasan, 2019). As the Disaster Management Centre (DMC, 2012) estimates, the average number of families and people

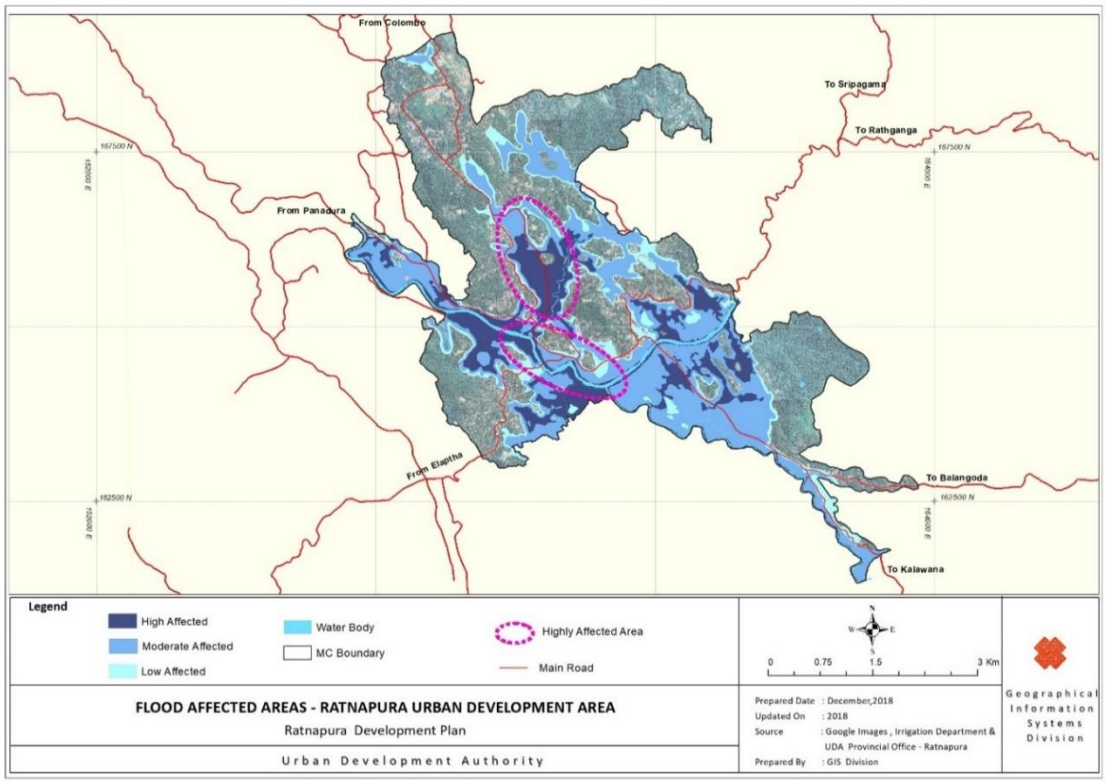

Figure 2: Flooding Scenario within the boundaries of Rathnapura City (Source: UDA, 2019)

affected by annual floods in Rathnapura are 200 and 1,200 respectively. The annual flood scenario causes direct impacts on over 80% of businesses in Rathnapura, and around 70,000 individuals living in the city and its periphery. About 9 km stretch of Colombo-Batticaloa Highway (AA4 Road) runs through the City centre of Rathnapura. Out of this length 4km get inundated during the floods. This is a serious problem that affects the access and connectivity of the local communities at a time of disaster.

In early 1980s, there was a plan to relocate the city centre to a safer location. Land was acquired from a rubber plantation and sub-divided for various purposes. Although it was just a land sub-division scheme without a proper urban plan and an urban design, it was called Rathnapura New Town. Public Institutions and business establishments located in the flood-prone areas of the city were requested to relocate to the new town (UDA,2019). It was also expected that people will follow suit by constructing houses and moving there subsequently. Four decades have passed since then and only the public institutions have moved there. Some public institutions such as Divisional Police Headquarter and City Police Station, Divisional Postal Headquarter and City Post Office, Rathnapura Municipal Council, National Gem & Jewellery Museum, Rathnapura National Museum and Bus Terminal are still located in the flood-prone areas of the city. This means some of the critical public establishments are yet to be relocated in the new town. The major economic and civic activities also continue to function in the old city centre. On the other hand, the flooding problem and the vulnerability of the city is exacerbated due to the continued reclamation of low land for urban development around the old city centre, climate change phenomena and some other reasons like poor drainage and land erosion (Cuny, 1991, Khailani & Perera, 2013).

Successive urban development plans have attempted to persuade commercial, transport, service and civic functions to relocate in the New Town. Infrastructure mains and serviced land were provided to persuade them to relocate, yet the New Town remains as an administrative area. There is no significant residential population and commercial activities in the New Town. People go there during the day time mainly for official

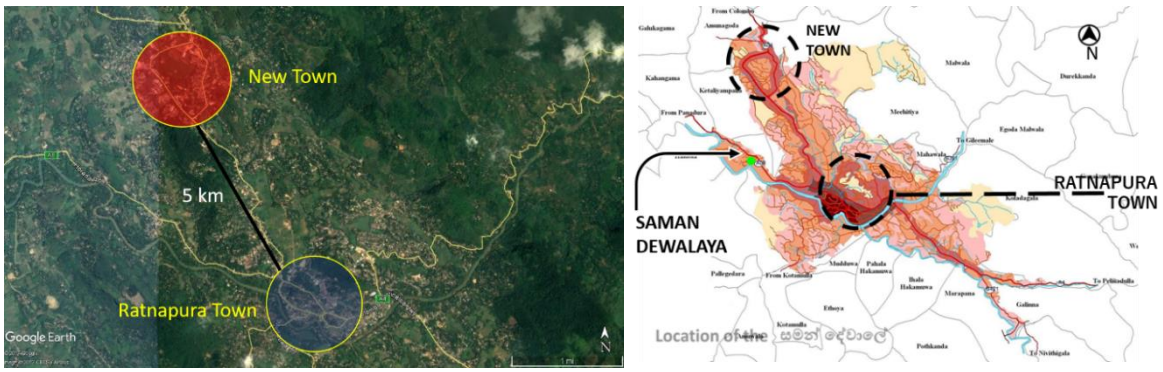

Figure 3: Dual centre structure of Rathnapura City (Source: UDA, 2019)

purposes. It looks scarcely populated at the night time.

Why do people prefer to function in the old city centre despite its vulnerability to annual floods?

Why do people disregard professional advice to relocate to the safer environment of the new town?

How do people maintain/increase resilience of their buildings and property against recurrent floods?

3. METHOD OF STUDY

While finding answers to the above questions, this study inquires the conflict of traditional wisdom and professional advocacy when dealing with the urban development agenda of Rathnapura City. It also examines the traditionally practiced building construction methods in the study area. For this purpose, stakeholder consultation surveys and a field survey were conducted. Stakeholder consultation surveys were conducted by the author's team as a prelude to formulate an urban design scheme for the old city centre and new town of Rathnapura. These surveys involved following stakeholder groups.

- Senior officers from state departments and organizations
- Senior officers from law enforcement and emergency response units
- Political leaders and senior officers from local government (municipal council)
- Members of the gem traders' association
- Members of civic/community organizations
- Members of Non-government organizations
- Principals of public schools
- Representatives of the transport sector

Some major stakeholders like gem traders were consulted separately because they are culturally, geographically and spatially deep routed in the city for a very long time. Besides that, the city's economy is anchored on their business activities.

Field surveys involved measuring and documenting some selected houses/ buildings where traditional wisdom of flood resistance is demonstrated. They were purposively selected depending on their suitability for the study.

4. STAKEHOLDERS' PERSPECTIVE

Many residents and entrepreneurs argue that they are not in favour of relocating at a safe site because they are affected by floods for not more than 5 days per year. They argue that they can function normally for the other 360 days of the year. Annual floods are part of their lives and they are used to coping with even critical floods. They do not see why they have to abandon their traditional homelands and relocate to safer grounds just for the sake of safety during couple of days. Although people can be evacuated to safer places using an effective flood warning system, safeguarding building and other property is not that easy. Physical harm related to flash floods can range from damage to infrastructure, and building structures, destruction of farmland, disruption of accessibility to critical services such as busses, hospitals, public markets, post offices and schools. Although the municipal council

and police station that provide emergency services become inaccessible during a flood, they also prefer to stay at current locations instead of relocating to the New Town. This means it is not only the people and business entrepreneurs who are reluctant to relocate to the New Town but also the state authorities that provide emergency responses and essential services. Table 1 provides the main points that surfaced during stakeholder consultations.

Table 1: Summary of Stakeholder Consultations

Stakeholder Group	State (status)	Impact (main)	Response (current)	Remark
1. Government departments, and state organizations such as Law courts, Provincial council (PC), General hospital (teaching), Urban Development Authority.	• Most of them are already relocated in the new town and safe from floods	• Accessibility problems for people who use public transport	• Encourage transport service providers to run via new town.	• Not effective due to lack of transport in the new town
	• Regional Police HQ, Gem authority, Public library and Post office are still in the old town	• Although in safer locations/levels, access to them cut off when flooding	• They are willing to relocate in the new town if land is provided	• Even relocated, some have to maintain units in the old town
2. Law enforcement and emergency response units	• City Police station is located in the flood-prone area	• Access to the police station is cut off during flooding	• It has to be kept in its central place to maintain law and order	• Flood resilience of the police station has to be improved
	• Emergency response units and vehicles of LG and PC are located at safer places	• Effectiveness is limited due to limited capacity	• Planning to establish better equipped and coordinated units	• Strengthen the line of command between state, province and local authorities
	• Major Health care services are located at safer places	• Accessibility problems for people who use public transport	• Elevate and improve access to emergency services	• Need a shuttle transport facility along a service loop
3. Local government (LG)	• Most municipal services are located in a centralized building and in the high flood zone	• Although most floors of the municipality are at safer levels, access is cut-off during flooding	• Municipal Council is a landmark building; hence LG is reluctant to relocate to the new town	• Flood resilience of municipal council buildings need to be improved
4. Gem traders' association	• Itinerant traders move from place to place during the day. These places are flood-prone.	• There are not many physical facilities. Hence impact is only for a few days.	• The places are historically and culturally rooted. Hence, they do not want to relocate.	• Consolidate these places and provide better identity and resilience
	• Most of the well-established traders have shops in the gem streets. Some parts of the streets are flood-prone.	• Businessmen are used to moving to safer places during flooding, hence the impact is felt only for few days.	• Businessmen strongly resist relocation since the gem streets are historically and culturally well grounded.	• Highlight the gem street and provide better identity and resilience. Articulate with a trading hub.
5. Civil society/ Community organizations	• A large number of communities are affected by floods. They are not only inundated but are also cut off from the critical facilities.	• Life & livelihoods are disrupted during flooding. People rely on familiar coping mechanisms and support networks.	• Many people resist the idea of relocation to the new town because they know how to cope with annual flooding.	• Improved infrastructure can increase the resilience of people. Accessibility is also most critical.

Stakeholder Group	State (status)	Impact (main)	Response (current)	Remark
6. School authorities (principals)	• Most of the public schools in the city are located to safer grounds. However, parts of the premises and access roads get inundated.	• Schools have to be closed during a flood. Some schools are used as flood shelters that disrupt school functions.	• Schools are centrally located and accessible by public transport. Relocation will affect people in the catchment areas.	• Safer access networks from public transport nodes and communities are desirable.
7. Transport service providers (Public and private sector)	• The transport center is not inundated but some access roads are affected.	• Accessibility problems for people who use public transport services.	• They resist the idea of relocation in the new town because riders are mostly in the old town.	• A feeder node at new town and connected with a transport center may resolve issues.

The above table indicates that only the state organizations are in favour of relocating on safer grounds in the new town provided that they are given land, building and other facilities. Most other stakeholders prefer to be in the flood-prone old town and its vicinity and due to reasons like centrality, easy accessibility (except during 3-5 days of flooding) convenience, cultural attachment and other sentimental reasons. As Wijegunawardena et al. (2018), highlights relocation will have negative consequences like loss of livelihoods, interruption of socio-economic networks and disruption of routines. Bi-polar city is the result of difference of opinion between the state sector and the local people during last four decades. It looks like the mutually agreed upon and acceptable status for most of the stakeholders. Therefore, the state has no option other than going with the stakeholder sentiments and agree on a "Living with floods policy". Living with flood policy requires acceptable conditions in terms of safety of individuals and communities. Two critical variables that affect people's acceptance of living with flood condition are depth and velocity of flood water. These two variables determine whether living with floods policy can be implemented without compromising the safety of people and communities (Permana & Petchasasithon, 2021).

5. PROFESSIONAL ADVOCACY

While promoting the "Living with floods" policy, the Rathnapura Development Plan 2019-2030 (UDA, 2019), continues to promote the New Town as the safer location and the potential location for economic development activities. In this document we can also identify the measures taken to allow building in flood-prone areas since the authorities cannot go against the wishes of the stakeholders in the old city as discussed above. The planning document proposes two actions:

Action 01: Introduce Regulations for Disaster Prone Areas

Preparation of hazard mapping has been followed by the of detailing flood plain zoning maps and land use controls. Three kinds of zones have been delineated as; (1) prohibited zones, (2) restricted zones, and (3) warning zones. These zones have been delineated in accordance with the three flood categories viz., critical floods, major floods, and minor floods. Accordingly, the following restrictions are imposed in the respective zones;

Prohibited zones (Areas Highly Vulnerable for critical floods)

- No further development is allowed.
- Relocation of highly vulnerable settlements in the new town.

Restricted zones (Areas Moderately Vulnerable for major floods)

- Existing Settlements should strictly follow the prescribed methods for building consolidation.
- New constructions are allowed only if they follow the prescribed building regulations.

Action 02: Introduce Regulations for Living with Floods

Accepting the wish of stakeholders' who are not so severely affected and not willing to relocate elsewhere, the plan has offered them some advocacy to improve the resilience of their settlements and buildings. They are;

- Introduce general guidelines for construction or consolidation of buildings in restricted and warning zones.
- Introduce regulations to restrict boundary walls that separate home gardens (to allow smooth water flow in disaster situations)

These professional advocacies indicate that the authorities have more or less accepted the stakeholders' stand- point and attempt to minimize damage and improve resilience through regulatory measures. They expect stakeholders to implement adaptation/ resilience measures within a fairly flexible regulatory framework. It is a direct result of stakeholder consultation during the planning process.

6. INDIGENOUS RESPONSE

Vernacular Architecture of the Rathnapura area has evolved while incorporating the flood risk. Traditionally, religious places and civic buildings such as schools and community centres are located on high ground. They act as places for evacuation and temporary shelter during floods. They are usually not so affected by floods in a direct manner but in an indirect manner such as curtailed accessibility by land transport modes. Religious leaders and people who are not so affected by flooding incidents look after people who are evacuated to buildings like preaching halls, community centres and schools. It is an integral aspect of social value systems in the disaster-prone areas of Sri Lanka.

In contrast, residential and commercial buildings are usually located in the valleys and in close proximity to places of livelihood such as agricultural fields and trading centres including gem trading places. Vernacular architecture of such buildings and places have adapted to seasonal floods. People understand that vernacular architecture should be serving the peoples' livelihood interests while maintaining some resilience from the flood threat. They traditionally adapt such resilient construction techniques so that they can get on with their usual activities with little repair work when flood water recedes.

As there is a growing concern regarding increased vulnerability to floods due to climate change and continued urbanization in low-lying areas, contemporary architectural practices should draw inspiration from vernacular methods and adapt to the impeding situation. Some of the flood mitigation strategies used in vernacular architecture are studied below referring to some selected examples. These selections are limited to domestic buildings because there is no big difference between the strategies adapted by domestic buildings and commercial buildings. These examples amply demonstrate the indigenous knowledge on building construction in flood prone communities in Rathnapura. The versatility and effectiveness of these practices give confidence to people from generation to generation to be willing to live with floods, instead of following professional advocacy and relocating to safer places.

6.1 Method of Exploration

Primary data collection on vernacular domestic architecture in the Rathnapura area was conducted during the first quarter of 2020. Peoples' impressions and experiences were collected and documented through key informant meetings involving some residents, village headmen, and community leaders. A short and structured questionnaire was used for key informant meetings. Selected dwellings (cases) represent the typology of vernacular residential buildings in Rathnapura area. They include houses built in the 19th and 20th centuries. The exploration covered physical, social, economic, and cultural aspects of vernacular residential architecture. However, this paper presents only some findings on

physical features (attributes) of the dwellings such as; (1) Location, (2) Plan, (3) Substructure, and (4) Superstructure. These attributes are explored from the perspective of flood mitigation and resilience.

6.2 Indigenous Mitigation Practices Depicted in Vernacular Architecture

Case 1 – A single story house with a small attic

This particular dwelling is built on a 1.5-meter high mound bordering a local road. It is accessed by a flight of steps. It can be affected by a critical flood. The house is built anticipating invading water coming from the roadside. Floor plan of the house is arranged in such a way to allow flood water to enter from the front side and exit from the rear. Rooms are arranged on either side of a relatively free space in the middle. This arrangement helps to minimize damage from flowing water. The house consists of an attic. This is used to safe keep valuable belongings and as a refuge during an emergency.

A mix of Laterite rocks and rubble have been used for the foundations and walls. The roof is built at a height of 4.5 meters. This helps to create the attic space and ensure the safety of the roof during floods. The attic is not spacious to use as a utility area during normal times. The columns of the front verandah also help to reduce the direct impact of flowing water on walls and the roof.

Case 2 – A single story house with a large attic

This house is also located on a 2m high earthen mound, but it is not safe from floods. It is accessed from the road via a flight of steps. Foundations and walls are made out of rubble, laterite blocks and cement mortar. Flood water can enter from the roadside and exit from rear side of the house. Verandah, living room and dining room are built as relatively undivided spaces, anticipating the flood water to flow through. This house has a large attic space accessed through the living room. This is used as a living area and an area where people and property can be kept in relative safety. The ridge height is almost 6 meters. This has allowed enough space, head room and clear story windows to make the attic a pleasant place to live. The large attic made out of hard wood act as a good brace for the high walls.

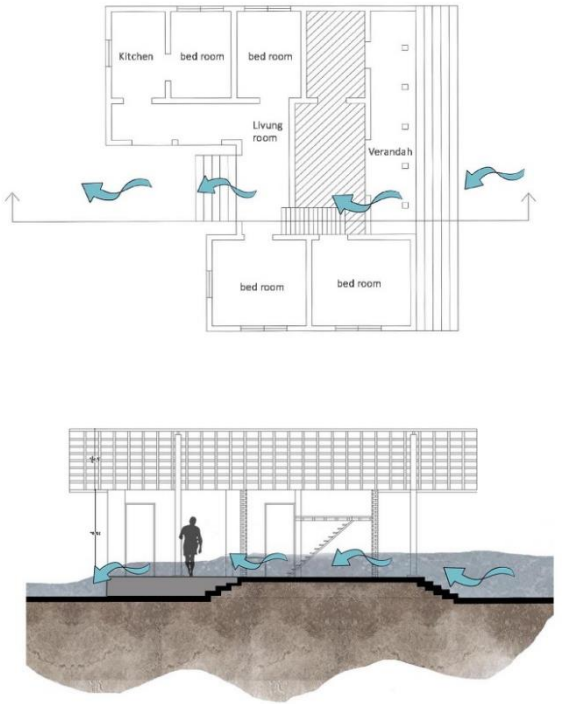

Figure 4: Floor Plan and Cross Section showing movement of flood water and level of inundation in Case 1
(Source: Henarangoda, 2020)

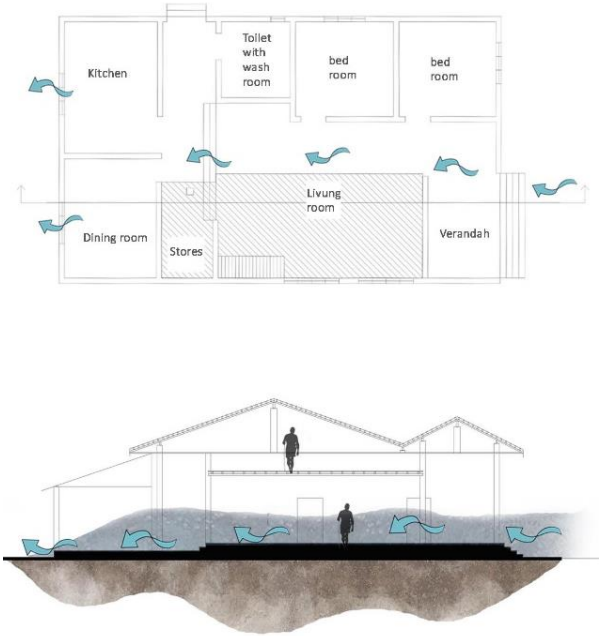

Figure 5: Floor Plan and Cross Section showing movement of flood water and level of inundation in Case 2
(Source: Henarangoda, 2020)

Case 3 – A single story house with an elevated floor and a small attic

Compared to the first two cases, this house depicts a further mitigation measure in the form of a raised floor. The house faces the direction of oncoming flood water. Since it is directly on the flood way the floor plan is arranged in such a way to allow flood water to enter from the front and exit from the rear of the house. The floor of the house is elevated 1500mm from the access road level. Rubble in mud mortar has been used to construct the foundation. The mud plaster of the high plinth

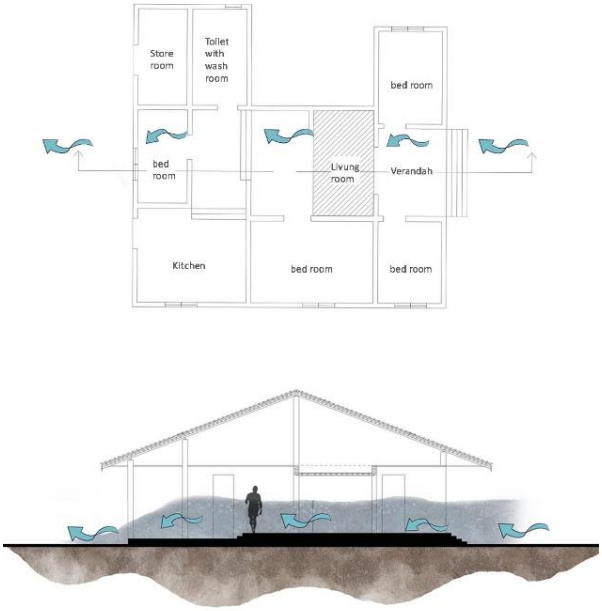

Figure 6: Floor Plan and Cross Section showing movement of flood water and level of inundation in Case 3
(Source: Henarangoda, 2020)

has been replaced by a thick cement plaster to protect the foundation and plinth. The walls are 500mm thick and constructed out of laterite blocks in order to give rigidity to the superstructure.

During a flood event the occupants can shift belongings to the attic and move to a safer place. Although quite small in size, the hard wood attic braces the walls. The cross arrangement of the walls also provides a bracing effect. Perfect crosses are normally not used to build traditional housing because it is considered as a bad practice. Off centered cross joints are not a problem.

Case 4 – A house with a partially elevated floor

Case 4 is a single-story house located at a high elevation. It is built 4 meters above the road level and accessed by a flight of steps. The house is not generally affected by flood water unless in a critical flood situation. The rear part of the house is raised by 500mm as a precautionary measure. This is a later addition to the house. The foundation is constructed out of rubble and mud mortar and the plinth is heavily plastered in cement mortar. That indicates damage during critical flood events. Walls are 560mm thick and made out of laterite blocks in mud mortar.

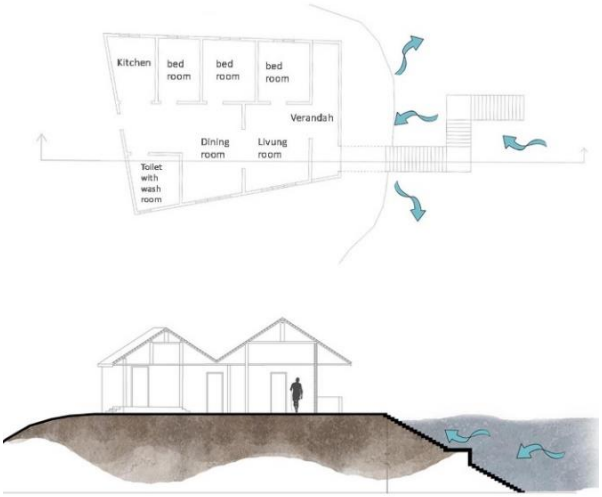

Figure 7: Floor Plan and Cross Section showing movement of flood water and level of inundation in Case 4
(Source: Henarangoda, 2020)

The long side of the house is arranged parallel to the direction of water flow so that water pressure on the walls is kept to a minimum. Water can easily enter the house from the semi-open front side and exit from the rear side.

Case 5 – A single story house with a substantially elevated floor

The strategy used by this house to keep away flood water is to raise the floor level within the house. The occupant said that they are not much disturbed by flood water due to this arrangement although their compound usually gets inundated. The floor plan has kept the rooms on either side of a small space so that

water can pass through the house in an event of a critical flood. The original house is built on a rubble foundation. The addition to the house on left side is strengthened by a concrete plinth beam made on top of a rubble foundation. Walls construction is not uniform because of different construction times. They are made out of bricks, and cement blocks in the old section and new section respectively. Wall plate of the roof is kept at 4-meter level. As a result, the roof of the house is quite high and has no risk of inundation.

Case No. 1 to 5 are all single-story houses. They are the most vulnerable type of houses in Rathnapura depending on their location in the flood plain. The selected cases for study are located on elevated places. They have been constructed at a time when the selection of a building site was not as difficult as at present. As older houses in the city, they demonstrate the use of material available and popularly used during that time. Common flood mitigation strategies are seen in these houses. They are (1) Selection of a high place to construct the house sacrificing ease of access, (2) Unusually high plinth levels compared to other areas with no flood threat, (3) Rooms arranged on one or two sides of a free space that allows water to flow through, (4) A fully or partially raised ground floor, and (5) Inclusion of an attic space to be used as a safe storage space. The next set of cases examine houses with more than one floor.

Case 6 – A House with two floors

This house is a further development of the single story, attic house typology. With the wide availability of cement and concrete in the 19th century, people could easily build multi-story houses. Scarcity of cheaper material like rubble and laterite was a reason to shift to industrially produced building materials. This house is constructed on a 5-meter-high earthen mound and accessed from the road via a flight of steps. The mound is partly natural and partly constructed (cut and fill site).

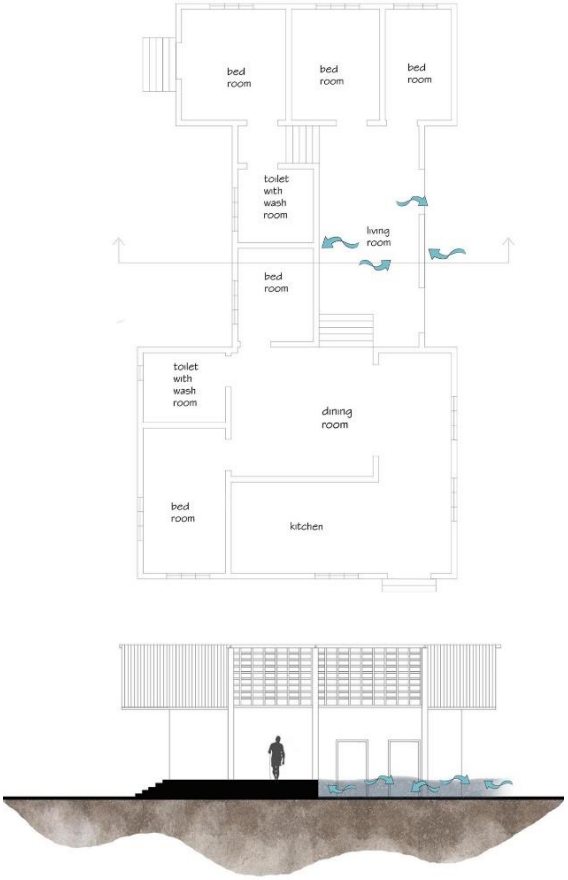

Figure 8: Floor Plan and Cross Section showing movement of flood water and level of inundation in Case 5
(Source: Henarangoda, 2020)

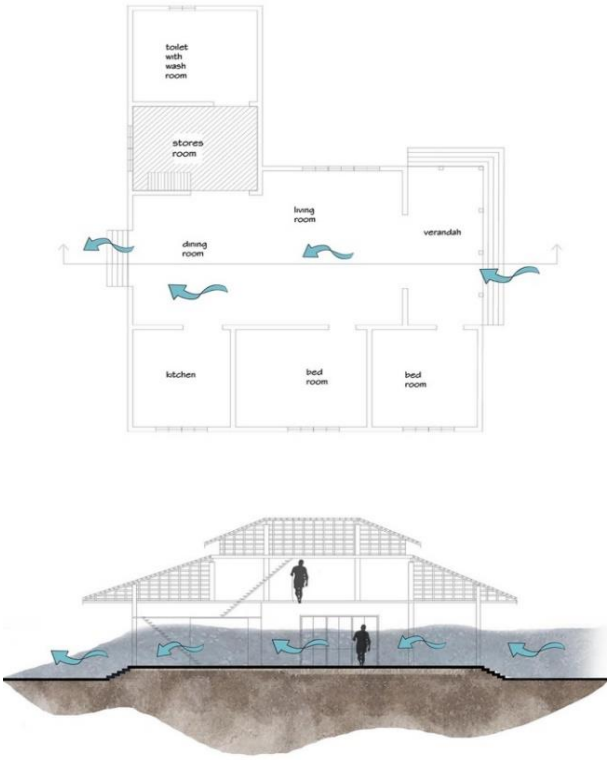

Figure 9: Floor Plan and Cross Section showing movement of flood water and level of inundation in Case 6
(Source: Henarangoda, 2020)

The foundation is made out of rubble and cement mortar and the walls out of 225 mm thick brick masonry. Concrete columns placed at corners and wall intersections have strengthened the structure. The higher roof is supported by reinforced concrete columns. The ground floor is arranged in such a way as to allow flood water to pass through the central space. The double roof arrangement has allowed the creation of an upper floor with good light and ventilation aided by clear height windows. The upper floor is placed at 4 meters above the ground floor. It is a habitable space and also a safer place to keep belongings during a flood. The upper floor also braces the central structure of the house.

Case 7 – A Compact House with an upper floor

This is a quite small house compared to previously discussed cases. It is a house belonging to a medium-income family. The very vulnerable location of the land has forced the dwellers to construct a two-story house, although it is not an affordable construction method for them. The dwellers have tried to raise the ground floor level by increasing the plinth level to 450 mm above ground level. However, it is not an adequate strategy to keep away flood water.

The superstructure made out of brick walls and reinforced concrete columns provide strength to the structure. The central part of the house has an upper floor space above. Although it doesn't have good light and ventilation, it provides safety for their belongings during a flood. The ground floor arrangement is similar to most of the previous cases. Rooms are arranged on two sides of a free space. Flood water can easily pass through this undisturbed space.

Cases No.1 to 7 are all constructed on land located at the level of an access road or at a higher level. This is a typical situation in the city where topography consists of land gently sloping from the low-lying flood plain. When the valley is flooded and the flood level rises along sloping land, many houses constructed along the valley next to the agricultural fields experience inundation. Land bordering the valley and higher elevations are mostly occupied. As a result, many people have no choice other than to construct their homes on the flood plain. Rathnapura has many houses and buildings constructed even at depressions.

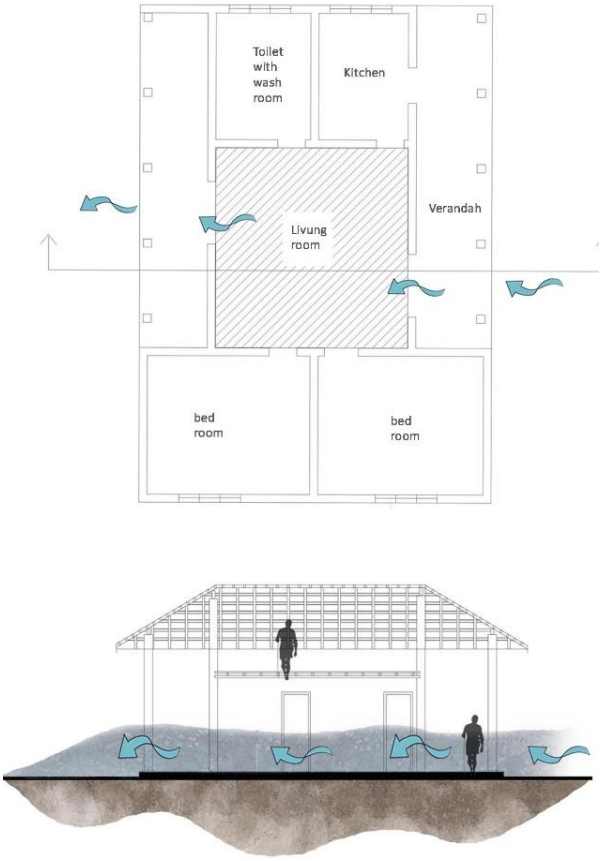

Figure 10: Floor Plan and Cross Section showing movement of flood water and level of inundation in Case 7
(Source: Henarangoda, 2020)

Case 8 – A Compact House built at a depression.

This house is constructed on a land that can easily get inundated. Therefore, the dwellers had to construct the house on a platform (floor slab) raised on reinforced concrete columns. Although building houses on columns/pillars is quite common in South Asian countries, it is a practice largely confined to Buddhist religious places in Sri Lanka. Therefore, houses constructed on columns with an almost empty ground floor is quite peculiar. This is the only strategy available for people living in flood prone valleys in Rathnapura. People are gradually

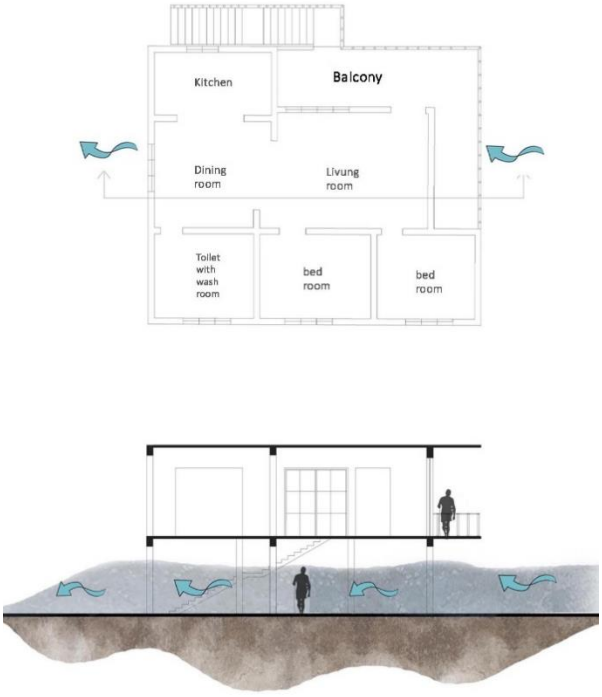

Figure 11: (a): Floor Plan and Cross Section showing movement of flood water and level of inundation in Case 8
(Source: Henarangoda, 2020)

getting accustomed to building on depressions and live above the ground. Case No. 8 is constructed on reinforced concrete column footings and 6m high columns placed on a 3m x 3m grid. The floor of the house is kept at a fairly safe level. The ground level is not even properly finished. It is used for mundane purposes. The owner of this house usually lives there even during the floods although accessibility is limited.

Case 9 – Multi-story house built at a depression.

Case 9 is somewhat similar to Case 8. The difference is it is a two-story house constructed on a raised floor slab. The house actually has three levels. It is constructed at a depression using 4 meters high reinforced concrete columns. These columns are constructed on individual footings placed at an irregular grid. Footings are connected by plinth beams to give additional strength to the structure. Even if

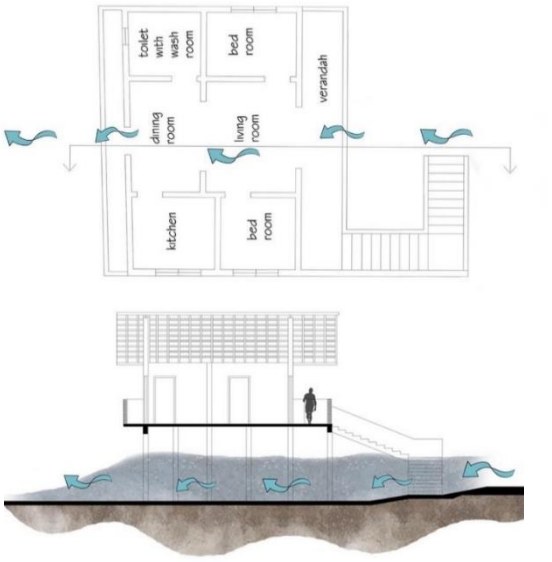

Figure 12: Floor Plan and Cross Section showing movement of flood water and level of inundation in Case 9
(Source: Henarangoda, 2020)

there is ground erosion during floods, the integrated structure is relatively safe unless there are serious erosion underneath column footings. Although it is a vernacular building it depicts contemporary building practices. The two floors of the house are not vulnerable to flooding even at a critical flood. Therefore, the dwellers can continue to live there safely during a flood incident. The owners use a pedal boat for access during flooding. The ground floor is partially finished and used for ordinary purposes like parking and storage. With continued urbanization of Rathnapura, more buildings of this nature will continue to appear in low-lying areas.

The following table presents a comparative analysis of the 9 cases. It attempts to identify indigenous knowledge on flood mitigation and coping strategies integrated in building practices in Rathnapura. There seems to be an indigenous wisdom among people about how to construct buildings in flood risk areas. Table 2 shows that there are common coping strategies between the typology of vernacular houses in Rathnapura.

Table 2: Comparative analysis of cases

Case	Typology	Substructure	Superstructure	Floor Plan	Coping Strategies
1	Single story house on elevated ground	Masonry foundations with very high plinths	High masonry walls and high roof with a wooden attic space	Usual house layout plan with provision of letting flood water through. Rooms with walls arranged on one or two sides of a free-flowing central space.	• High plinth to keep flood water away as much as possible. • Thickly plastered plinth to prevent damage to foundation and plinth. • Very thick masonry walls that provide stability against lateral water pressure • Provisions to let flood water through the house and minimize damage. • Inclusion of an attic as a safer place for belongings
2					
3					
4					
5					
6	Two story house on elevated ground	Masonry foundations with high plinth and essential column footings (RCC)	Masonry walls and sloping tile roof. Bracing provided by RCC beam and floor slab		• Plinth level of the whole house or part of house raised so that the floor is not completely inundated. • Very thick masonry walls that provide stability against lateral forces • Provisions to let flood water through the house and minimize damage. • Safer upper floor
7					
8	Two story houses on depressed ground	RCC column footings connected by plinth beams	RCC columns and masonry walls with flat/sloping roof		• Minimized the risk of substructure by eroding soil. • Structurally integrated superstructure • Utility floors well-kept above the high flood level
9					

The above comparative analysis indicates that coping strategies are more or less the same irrespective of the housing typology. That means the indigenous knowledge on flood mitigation and resilience improvement is widespread among ordinary house builders.

7. CONSTRUCTION STRATEGIES ADVOCATED FOR NEW BUILDINGS

The Disaster Management Centre (DMC) and National Building Research Organization (NBRO) are the main state organizations that provide advocacy for builders. They have prepared manuals for house builders. Some of their recommendations are outlined below (DMC, 2012b; NBRO, 2015).

Substructure, Layout plan & Cross Section

- Foundations should be very well anchored to the ground & protected from getting washed away.
- Strip foundations and individual column footings are recommended for small buildings depending on the quality of ground.
- Use compact layout plans to minimize horizontal pressure from flood water.
- Rectangular layouts provide better resistance than L, U and H shaped layouts.
- Layouts with width to length ratio less than 1:2 to be avoided.
- Long side walls placed parallel to the direction of the flood flow to minimize direct impact on structure.
- Raise at least part of the ground floor by raising the plinth level. Protect the plinth from getting washed away.
- Construct an attic space in single story buildings to use as a safe storage place.

- Use gable roof over the walls so that light and ventilation can be given in the attic.
- Use the joists of the attic to brace walls from collapsing.
- Use the ground floor for flexible purposes and upper floor for functional purposes in two story houses.
- Build at least two rooms above the high flood level.

Superstructure

- Construct the superstructure on well secured high plinth/base.
- Use earth filled mounds or raised plinths to construct the superstructure.
- Use plinth beams to integrate foundation and the superstructure.
- Use tie beams on top of walls/columns to integrate the roof.
- Construction of two-story houses are advised. Ground floor to have a solid structure preferably using RCC, and upper floor can have a lightweight structure.
- Masonry walls should have a thickness of 200mm or more.
- Do not use thin hollow block walls at the ground level.
- Walls longer than 6 meters should be stiffened by built in RCC columns.
- Place doors and windows in such a way the flood water can easily exit if entered.
- Doors and windows should be placed perpendicular to the flood flow as much as possible.
- Openings on a wall should be less than 50% of its surface area.
- Keep the wall plate level above the high flood level.
- Roof should be kept at a height well above the high flood level. It is recommended not to build houses on land that cannot fulfil this condition.
- It is recommended to have at least part of the house with RCC flat roof.

The above strategies and recommendations indicate that they are very much in line with the indigenous building practices. There are only very few ideas not known to the local builders. They are recommended for flood-prone areas of the country and not limited to Rathnapura area. They have been prepared by consulting local stakeholders and observing local building practices.

8. CONCLUDING REMARKS

Floods can cause structural damage to dwellings and other buildings The flow of flood water and water stagnating around a building can exert lateral forces strong enough to cause serious damage like washing away foundations and collapsing the walls. Buildings with lighter structures can even be carried away in a flood when the forces of flowing water are significantly ferocious. Water filling up around a building can exert uplifting forces on the floor that is enough to cause damage to the foundations. Erosion underneath the foundation and ground floor can cause failure of the upper floor slabs. Moreover, foundations can undergo settlement or total collapse due to loss of strength caused by saturation or liquefaction of the subsoil. Unsuitable or poor-quality materials such as unburnt clay bricks and poorly bonded masonry work and poorly constructed foundations can easily give way during a flood. Indigenous knowledge and building practices have more or less covered almost all these aspects. In other words, what vernacular builders in Rathnapura have done is not so different from what the professionals advocate. Therefore, it is seen that people already know how to live with floods and it will not be difficult for state authorities to implement the “living with floods” policy. The study also indicated that planning measures such as relocation at safer place alone is inadequate to mitigate disaster impacts. There should be technological measures to improve the resilience of buildings and infrastructure that continue to exist in flood-prone areas. Moreover, the post flood recovery measures such as repair, rebuilding, relocation should be integral parts of a flood mitigation plan.

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