Impact On Housing During 2018 Floods in Puthenvelikkara Panchayat

Lakshmy Kakkanatt U[1], Akhil Thilakan[2], Drisya Dinesh[3], D A Akhil Raj[4] ,Parvathy M H[5]

[1]Assistant Professor, Dept. of Civil Engineering, SNMIMT, Kerala, India
[2,3,4,5]Under Graduate Students, Dept. of Civil Engineering, SNMIMT, Kerala, India

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Abstract - *This paper aims with the impacts on housing that happened to Puthenvelikara panchayat during the 2018 floods. Puthenvelikkara is a village situated at Parvoor taluk of Ernakulum district and it is surrounded by the river Periyar, Chalakudy, and kottapuram lagoon, which is highly vulnerable to flood. Housing damage data of wards 15 & 16 of puthenvelikara grama panchayat are collected by means of field survey interacting with natives with the help of zoho app. Almost 323 houses were surveyed and distinguished damages are mapped using QGIS. Analyzing survey data, it is found that a multitude of factors are related to structure and conditioning the safety of building objects in floodplains. Damage to the building during floods can be the result not only of the direct action of the flood wave and surface water, but also different factors such as age of building, materials used for construction, height of foundation etc. The impact of such factors may be revealed later, after the floods cease. This study helps us to find out the assets at high risk and to deliver the right service at the time of emergency, thus minimizing the devastating effect of flood at Puthenvelikara.*

Key Words: **Kerala flood**, **Flood impact**, **Damage Analysis**, **QGIS**, **Participatory GIS**

1.INTRODUCTION

The Keralites will never forget the flood and it's aftereffects that occurred in 2018. Floods have enough potential to damage infrastructure. Damage can be minor, significant or complete damage. In the aftermath of such a disaster, it often calculates the initial damage assessment as in terms of injuries, loss of life, damage costs and damaged buildings. Therefore, in most cases, damage assessments are done after the floods as a means of recovery efforts, for example resettlement. There have been a number of studies related to the initial damage assessment of buildings after the flood. There are many ways to assess the damage after a natural disaster. There are also several guidelines for assessing the extent of structural damage prepared by government agencies, researchers, local authorities and non-governmental organizations (NGOs). The variety of damage levels depends upon the parameters affecting the housing damage and it may vary as building materials, age of the building and the nature of the flood disaster, etc . in different cases. So, the general surveys that determine the magnitude of flood-affected houses appear to be inconclusive to determine the impact of flooding on houses. `As a result, errors may arise in assessing the extent of housing damage .Therefore, this paper emphasizes an understanding of the extent of housing damage and recommends significant input to improve damage assessment.

2. MATERIALS AND METHODS

2.1 Study Area

Puthenvelikkara is a village located in Paravur Taluk in the Ernakulam district of Kerala, India. The Chalakkudy River meets the Periyar River at Elenthikara in the village of Puthenvelikkara. Puthenvelikkara is located on the banks of the Periyar River, Chalakudy and the port of Kottapuram. Provinces or wards such as Kurisingal, Kurumbathuruth, Thuruthipuram, Thuruthur, Panjipalla, ManancheriKunnu, Karottukara, VattekattuKunnu, Keezhuppadam, KodikuthiyaKunnu, Elanthikara, Malavana, Kanakkankadav, Cherukadappuramika, Kovidzhakka of Puthenvelikkara. Puthenvelikkara was famous for its many hills, but today it has been destroyed for production purposes in Paravur. The 15th ward of Puthenvelikara Gramapanchayat called Thuruthipuram and the 16th ward called Vellottupuram selected study area. Wards 15 and 16 have been affected by the floods since 15 August 2018 and the water level has dropped by one week. The area is 10 ° 10′0 ″ N 76 ° 15′0 ″

E.2.2 Methodology

2.2.1 Field Survey

Since details was available for flood damage, the best way to gather information is to conduct a post-flood survey. It was a difficult task to do because the damage caused by the floods disappeared during the flood reconstruction. Direct field survey is an effective way in which we can extract information from individuals and can be used to model flood events and learn about them. The questionnaire was prepared and uploaded to a mobile app called Zoho apps.

2.2.2 Questions for Data Collection

The questionnaire includes the following details.

Location Details: Latitude, Longitude.

Basic Details: Name, Address, Ward number, Building number, Contact.

Flood Details: Flood level, Flood duration, Debris accumulated and its scale.

Building details: Type of building, Number of stories of building, Year of construction, Has the building renovated, Area of building, Foundation material, Foundation height from ground, Roof type, Floor material, Wall material, Wall details.

Damage details: No damage, Damage to glass or locks in windows and doors, Damage to electrical systems (wires, fixtures, fitting),Damage to furniture and possession, Water leakage systems (pipes, tanks, pumps),Toilets and wash areas unusable, damage to floor and walls, damage to ceramic, ground tiles, decoration, damage to brick work and wall lining, structural damage related to beams, details of cracks(position, extend, nature) Partially or completely collapsed roof, Structural damage related to foundation, House completely damaged.

2.2.3 Zoho Forms App

List of questions uploaded to the zoho forms app. By using the zoho forms app we can do research. Zoho Forms is an open-source Android application available on the google play store that can replace general paper forms. It has the ability to collect a variety of queries with the help of institutions on a smart phone. It supports many types of forms and is designed to work effectively without network connection. This app also enables to store 10 survey data collected. The final data can be downloaded with a single excel file. Therefore, it was decided to form a team and conduct a survey using cell phones.

3. DAMAGE ASSESMENT

3.1 Categories of Damage to Housing

The damages happened to buildings can be distinguished into different categories [5] such as:

i. Category 1 unaffected -No flood damage, No structural damage.

ii. Category 2 (In additional to the previous category) Flood affected -Damage to glass or locks on windows and doors, Damage to electrical system, Damage to furniture and possessions, Fine cracks in plaster.

iii. Category 3(In additional to the previous category) Partially affected with minor structural damage Water leakage system, Toilets and wash areas unusable, Moderate damage to walls and floors, Moderate damage to ceramic, ground tiles, decorations.

iv. Category 4 (In additional to the previous category) Partially affected with major structural damage - Severe damage to brick work or wall lining, Severe damage to ceramic, ground tiles, decorations, any structural damage related to beams and columns.

v. Category 5(In additional to the previous category) Heavily or completely damaged - Partially or completely collapsed roof, Structural damage related to foundation, significantly more cracks in walls indicating foundation damage, House completely washed away.

3.2 Factors affecting damage to buildings

Floods are the cause of damage to buildings. But the intensity of the damage depends on a few other factors as well. The risk factors are:

i. Flood level: The height reached by the floodwaters caused by the overflow of the river above its normal limits. Also, the duration of floods and the force of floods cause damage to buildings.

ii. Age of building: As the building age increases the chances of damage also increase. The materials used in construction are getting old.

iii. Type of roof: Basically, the roof can be divided into concrete, tile, thatched roofs etc. The thatched-roof roof is often in danger of being damaged. Concrete roofs are often seen today due to their long durability.

iv. Debris and its scales: Garbage is all the rubbish that accumulates during floods in a house. The amount of rubbish can vary from house to house. Some may contain mud, stone particles, and may even pass-through metal, and even wood. By distinguishing between types of waste cleaning is also classified as minor, major and important cleaning.

v. Wall material: There is a large amount of wall material. Some of them are wood, brick, stone, concrete, sheet metal, glass, metal, plywood, bamboo etc. Here the most commonly used are concrete, bricks etc. Bamboo and mud are some of the oldest forms of wall used. Damage to wall work depends on its strength and durability. bricks and concrete last a long time.

vi. Wall details: This usually means wall details, i.e.; whether the wall is plastered or painted. Plastering will provide beauty and painting give aesthetic to the building. Painting does not depend on damage. But a painted building is something that gives the perfect feeling.

vii. Foundation materials: Concrete, stone, laterite, pile foundations are commonly used. Concrete, stone, laterite etc. are used in constructing shallow foundation . pile is used in constructing deep foundation.

viii. Foundation height: height of foundation from ground level. As the height of the foundation increases the chance of flooding into the house will decrease. Along with this the depth of the foundation below the level also plays a major role in avoiding settlement. Along with this there are several other factors such as incorrect construction, lack of care, Natural

Disasters that cause severe damage to the building.

4. RESULTS AND DISCUSSION

The survey method used was very effective in identifying the damages. Water entered directly from river to the area through the streams and canals, it was observed that low lying lands was severely flood affected. A total of 323 buildings were surveyed among these 322 buildings are affected by flood Surveyed buildings includes one religious building, two educational buildings, one Industrial building and 319 residential buildings.

4.1 Damage Assessment

Table -1: Damage Categorization

SL NO	CATEGORY	NO OF HOUSES
1	Category 1	1
2	Category 2	44
3	Category 3	159
4	Category 4	24
5	Category 5	71

323 houses surveyed were distinguished on the basis of damages. Most number of houses in the study area comes under category 3. Ie; partially affected with minor structural damage. On the other hand, 71 houses are heavily or completely damaged.

4.2 Factors Affecting Damages

Table -2: Roof Type

SL NO	ROOF TYPE	NO OF HOUSES
1	Thatched	6
2	Tiled	23
3	Concrete	263

Based on the survey, there are 3 types of roofs are noticed. They are Concrete, Tiled, Thatched. Out of 323 houses, about 264 houses are found to be concrete roof type. Only 23 Houses are found to be Tiled section and about 6 in Thatched section. So, we conclude that the most used roof type is concrete.

Table -3: Foundation Material

SL NO	FOUNDATION MATERIAL	NO OF HOUSES
1	Laterite	95
2	Concrete	25
3	Pillar	2
4	Stone	177

Mainly four types of foundation materials were observed during the survey namely Laterite, Stone Concrete and Pillar. Most number of houses used stone as their Foundation material.

Table -4: Foundation Height

SL NO	FOUNDATION HEIGHT (CM)	NO OF HOUSES
1	0-20	11
2	20-40	104
3	40-60	125
4	60-80	22
5	80-100	20
6	100-120	11
7	120-140	1
8	140-160	1

Table -5: Wall Details

SL NO	WALL DETAILS	NO OF HOUSES
1	Non- Plastered	8
2	Plastered	21
3	Plastered and painted	263

Checking on the wall details, we observed three stages. It was observed that, only 8 number of houses had non-plastered wall, while there were 21 number of houses that was plastered but had not been painted, the greatest number of houses i.e., 263 houses were both plastered and painted. So, we came across a conclusion that about 81% houses in our study area has been both plastered and painted.

Table -6: Wall Material

SL NO	WALL MATERIAL	NO OF HOUSES
1	Brick	105
2	Cement Block	85

3	Stone	3
4	Hollow Brick	1
5	Laterite	102

In case of wall materials we analysed 5 categories .Here most of the houses used Brick and laterite as their wall material, which includes 105 in brick and 102 in lateritic. And in case of Cement Block there are 85 such houses, where Stone and Hollow have the least number of houses.

Table -7: Age of Building

SL NO	AGE OF BUILDING (YEARS)	NO OF HOUSES
1	0-25	111
2	25-50	130
3	50-75	66
4	75-100	33
5	100-125	11
6	125-150	3
7	Above 150	2

From the 323 buildings surveyed it is found that the age of buildings ranged from 3 to 175 years. Therefore, the categorization on the age of building was done at an interval of 25 years. Overall, we can conclude that most of the buildings were constructed around 50 years ago.

Table -8: Flood Level

SL NO	Flood Level(cm)	NO OF HOUSES
1	0-50	2
2	50-100	9
3	100-150	18
4	150-200	166
5	200-250	85
6	Above 250	15

Measurement from the ground level was marked in all the buildings that have been surveyed. From the survey, the flood level ranged between 0 and 300cm in height. It is observed that, most of the houses had a flood level of 150-200cm.

There is one house in the unaffected category. House no.1 of ward 15 belongs to this. By analysing the factors affecting damages we can understand that the house is constructed in 2018 after the flood that is why it is unaffected.

A total of 44 houses are there in the category 2, i.e.flood affected. This category includes slightly damaged houses. By analysing the factors affecting damages, we can understand that these houses are plastered and painted. Most of the houses fall under a flood level of below 200cm and age span between 20 to 60 years. Most have stone as foundation material. Bricks, cement block, laterite are used as wall material. One house (House No 457 of ward 15) used stone as wall material and 1 house (House No 210 of ward 15) used hollow bricks. Houses in this category has foundation height of 40-60cm. 1 house (House No 388 of ward 16) has foundation height between 100-120cm.15 houses are in the category 20- 40cm foundation height. All houses in this category are concrete roofed houses.

Category 3 is termed as partially affected with minor structural damage. A total of 159 buildings belonged to this category. Here most of the houses fall under 150 - 200cm flood level. House number 230 of ward 16 marked about 205cm of height of flood from ground level. Majority of the buildings were plastered and painted. From the ward 16 house number 214 and 261 were non-plastered. When it comes to type of roof of the houses mostly seen were concrete roofs. Only 2 houses had thatched roofs- House number 256 of ward 15 and house number 67 of ward 16. Height of foundation of the houses of this category have mostly 20-60 cm height from ground level. House number 207 of ward 15 and 487 of ward 16 measured 15 cm of foundation height. House number 100 of ward 16 measured 120cm height which was the highest foundation height observed. No houses were recorded having foundation height above 120 cm in this category. Wall materials of the houses seen in this category was brick, cement block and laterite. Only single house was made of hollow brick-house number 210 of ward 15. Material used for foundation was categorized as stone, laterite, concrete, piller. Majority of the houses that came under category 3 was stone preceded by laterites. Only 2 houses were found that used piller and both of them were in ward 15. Mostly the houses in this category have their age ranging from 0-50 years. It was also observed that only 3 houses have their age above 100 years.

A total of 24 houses are there in category 4. Among these 20 houses have concrete roof and 4 houses have tiled roof (302,403 of ward 15 and 112,187 of ward 16).Most have foundation material as stone and some have laterite in this category.1 house (493 of ward 15) have foundation height between 20cm and 6 houses have foundation height between 20-40 cm.1 house (47 of ward 16) have foundation height between 80-100cm and 1 house (488 of ward 15) have foundation height between 100- 120cm. All others have 40-60 cm foundation height. Most of the houses have wall material as brick and cement block. 1 house(457 of ward 15) have stone as wall material. House no.187 of ward 16 have non plastered wall. Wall of house no.47 and 112 of ward 16 of this category are plastered only. All others are both plastered and painted. House no.491 of ward 16 of this category have age span between 100-125 years. House no.488 of ward 16 have age between 75-100years. 3 houses have age between 50-75 years and 7 houses have age below 25 years. All others have age between 25-50 years. Taking flood level into consideration 1 house (107 of ward 16) have flood level between 50-100cm. House no. 146 of ward 16 have flood level above 250 cm. All others have flood level between 150- 200cm.

Heavily or completely damaged Concrete roofed houses mostly constitutes in category 5. 4 thatched and 7 tiled roofed houses also were included. Houses under category 5 used wall materials were brick, cement block and laterites. Laterites and stone were the most common foundation material found in category 5. It also included concrete foundation houses. Most of the houses included were plastered and painted. Only 1 house under this category was non-plastered- house number 348 of ward 16. Foundation height of houses coming under category 5 were 4 houses from 0 -20cms, 14 and 16cm, 20- 40cm and 40-60cms respectively. 17 houses were found to have the foundation height in the range of 80-100cms. House number 501 of ward 15 has the highest foundation height of 160cm among all the houses. Least height of foundation was for house number 263 of ward 16. Flood level measured in this category of houses mainly ranged from 150cm to 30 250cm. 6 houses were flooded at a height of above 250cm and 3 houses between 0 -50cm height. 17 houses included in this category have an age between 25 - 50 years and 9 and 8 from the range of 0-25 and 50-75 yrs.

4.2.1 Debris and its scale

In most houses debris are accumulated along with flood water. Significant scale of debris is accumulated and houses are inaccessible before cleaning. A major cleaning was required. This resulted in taking place of contamination damages to structure.

4.5 Damage Mapping

The impact on housing during 2018 flood in ward 15 and 16 of Puthenvelikkara Panchayat are distinguished into five categories and are plotted in a map in QGIS software as shown in figure.

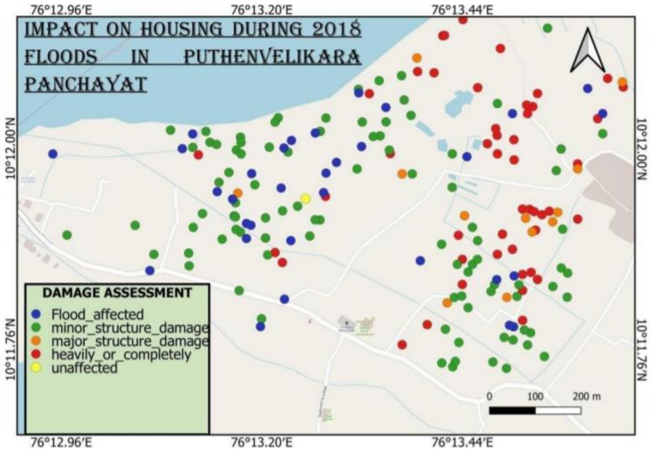

Fig 1: Damage mapping of wards 15 & 16

5. DESIGN RECOMMENDATIONS

From the Guidelines Improving Flood Resistance of Housing (2010), Building Materials & Technology Promotion Council, Ministry of Housing & Urban Poverty Alleviation, Government of India, in order to build buildings in flood-prone areas, the following basic needs must be taken into account:

- Preparation and Maintenance of large maps (1: 10,000 or 1: 15,000) in flood-prone area at a time of 0.3 m or 0.5 m
- Designation of areas that should be flooded by rain or flood waves, say once every two, five, ten or twenty years.
- Markings of areas that may be submerged in different phases of floods or stormwater runoff on these maps.

5.1 Bye- Laws for buildings in flood prone areas

The following provisions need to be incorporated into the Local Council building regulations for buildings located in flood-prone areas.

- Plinth levels of all buildings should be 0.6 m above the water / water levels below the mean annual floods.
- All buildings must be two or more storey.
- In single-storey buildings, roof stairs should be provided. Roof should be flat so that it can be used as temporary shelters during flood time.
- The roof levels of single-storey buildings and the first-floor level of two-storey buildings must be constructed above 100 years of flood level.

5.2 Recommendation for Construction of Houses in Flood Prone Areas

5.2.1 Site Soil Conditions

i. Floods occurring in alluvial plains of rivers or costal deltas cause the following effects on the ground soil. Soil carrying capacity is reduced and heavy material structures can sink and be damaged due to differential settlements.
ii. Soil can erode under the action of flowing water and erosion can occur around and under the foundations leading to the breaking of simple poles or immersion and tilt of heavier foundations.
iii. Soil erosion can occur near buildings where floodwaters run down the area.
iv. The act of soil liquefaction can occur during earthquakes with a strong or moderate earthquake if it occurs during floods.

5.2. 2 Foundation

Taking into consideration the alluvial nature of the soil which normally has low bearing capacity, reduction in bearing capacity due to rising of water table and liquefaction potential of the water bearing soil under postulated earthquake intensity occurrences, three types of foundation designs may be considered, the choice of which will be based on the soil conditions met at the site. These are:

I. Where stiff soil is available at a depth of about 60-90 cm below ground level which may not be eroded under flowing flood water nor subject to liquefaction, the strip foundation which is normally used by the people could be adopted.
II. If a stiff soil is available at a depth of upto 2.0 m, brick pedestals may be used at spacing of 1.5 to 2.0 m with a plinth level RCC beam at the top to support the superstructure walls .
III. In the situation where soft alluvial soil is met to larger depths, a deeper RC pile foundation has to be used with an appropriate bulb at the foundation. In such a situation ordinarily a depth of 3 m may be adopted. Such piles will also have to carry a reinforced concrete beam at the plinth level to support the super structure.

5.2.3 Treatment at Plinth Level

The plinth level should be chosen at least 45 cm above the ground level, to provide security for inmates under the most common flood conditions and above the drainage level. In the case of the load bearing strip foundation, the foundation masonry must be raised upto plinth level on top of which a damp-proof course must be provided. In the case of brick pedestal or RC pile foundation, the pedestal and the piles will be raised sufficiently to provide a RC plinth beam on top. Such a beam will also serve as the damp proof course. The gap between the ground level and the plinth beam will have to be suitably filled with a curtain wall constructed using low strength brick, block, stone or plain concrete.

5.2.4 Super Structure Walls

There may be a number of wall construction options such as solid brick walls (230 mm thick.), solid concrete block (200 mm thick.), stabilized compressed earth block (200 mm thick.) and hollow concrete blocks of 200 mm width etc. In consideration of reduction in cost and reduction of weight on the foundations, a system of 230 x 230 brick columns with 115 mm thick. brick wall built simultaneously with the columns may be used. In place of this arrangement, Rat-trap brick wall of 230 mm may also be adopted which will increase the weight on the foundation to some extent. These wall systems will provide full support to the roof slab without requiring any beams there.

5.2.5 Roof

Reinforced concrete slab or filler type slab with a thickness of 100 mm with appropriate reinforcement provided. This should be a place of refuge for residents under flood conditions. The roof should provide a low parapet of at least 150 mm height to provide a sense of security for people climbing the roof. A bamboo fence could be placed over a fence where you like.

6. CONCLUSIONS

One of the major problems caused by natural disasters is loss of housing. The floods washed away fields, houses and their valuables. This paper has opened the way for the detection of flood damage caused to the houses of Puthenvelikara gramapanchayat and preparation of damage indicating map. This map will facilitate future use in disaster preparedness and land use planning.Also it helps using most of the floodplains in a effective way and helps in emergency rescue during flood risk time. The participatory survey conducted was very successful in collecting the required data and strengthened public participation in decision-making.the information collected during the survey can be used for resettlement and planning , execution ofthe rescue process. A look at the study site helped to identify the actual condition of the affected house and the analysis of the study. It is estimated that several landfills occur in low-lying areas and in agricultural areas for housing, and commercial areas. This non-scientific method of landfill will increase the risk of flooding. The main causes of flood damage to buildings are the following: foundation scouring & settlement and subsequent wall collapse under hydro-dynamic loads, Wall collapse, either due to inadequate bearing capacity caused by saturation under heavy rain or due to inundation (combined effect of saturation, buoyancy and mortar becoming mud), which leads to the collapse of the roof as well. Floating of the roof due to flooding, which leads to damage to the wall as well.Other types of less severe damage are wall erosion, cracks and bulging, plaster delamination and floor settlement apart from damage to services like water supply, sanitation and electrical systems. Damage to the building during floods can be the result of not only the direct action of floods and surface water, but also various factors such as the age of construction, materials used in construction, the height of the foundation etc. The study helped to identify high-risk goods and provide appropriate services during emergencies, thus reducing the devastating effect of floods on Puthenvelikara panchayat.

REFERENCES

[1] Alexander Fekete (2019),"Critical infrastructure and flood resilience Cascading effects beyond water ", Wiley Interdisciplinary Reviews: Water,1-13.

[2] Jean Joy, Shruti Kanga and Suraj Kumar Singh (2019),"Kerala Flood 2018: Flood Mapping by Participatory GIS approach, MeloorPanchayat", International Journal on Emerging Technologies,10,197-205.

[3] R. Pant, S.Thacker, J.W. Hall, D. Aldersonand S. Barr(2018)"Critical infrastructure impact assessment due to flood exposure"J Flood Risk Management, 11,22-33..

[4] AimiliaPistrika and S.N. Jonkman(2010),"Damage to residential buildings due to flooding of New Orleans after hurricaneKatrina",Nat Hazards ,54,413434.

[5] Thuraiyamohd, Mohamad Haizam Mohamed Saraf ,Siti Fairuz Che Pin, MohdNasurudinHasbullah,TajulEdrusNordin and Dzulkarnaen Ismail(2016),"The degree of housing damage model for a flood affected area",MATEC Web of Conferences 66,1- 9.

[6] Guidelines Improving Flood Resistance of Housing (2010),Building Materials & Technology Promotion Council, Ministry of Housing & Urban Poverty Alleviation, Government of India, New Delhi.

[7] Thomas Naumann,JohannesNikolowski, Sebastian Golz(2009),"Synthetic depth-damage functions a detailed tool for analysing flood resilience of building types "

[8] Krzysztof Wilk (2018),"Hazards for buildings and ssssstructures caused by flood conditions"E3S Web of Conferences ,45,1-8.