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RESEARCH ARTICLE

A Multi-Approach Investigation of Tlawng River Flood Hazard in Sairang, Mizoram

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Abstract

Objectives: Sairang, a town in Aizawl District, drained by the longest river in Mizoram-Tlawng River has been re-currently affected by floods since time immemorial. A study was conducted to determine the causative factor, impacts and possible risks associated with the flood. **Methods:** Data were collected from several government offices. An open-ended interview was conducted with NGO leaders. Daily rainfall data of Aizawl for the period of 2007-2021 were considered to evaluate how intensity, frequency and duration of rainfall influenced flood events. The date of the flood event in a flooding year was correlated with the amount of rainfall in a particular day which is represented in the graph chart. An experimental survey using Total Station and Differential Global Positioning System was carried out at times when the flood was at an alarming rate. The survey was conducted so as to detect and determine the river line and land cover area during floods. Contour and 3D maps were generated in Arc GIS 10.8. **Findings:** Tlawng river and the river system provide a lot of benefits and highly support the economic condition of the population. But unfortunately, on the contrary, deteriorate and terminate in times of flood. Hundreds of farmlands were damaged, sand miners could no longer perform their job- consequently freezing one's income- further escalating the misery. The frequency and return period of flood depicts enormous alterations and fluctuations; disregarding indigenous knowledge which maximizes the flood risk. Flood has been the most widespread and costliest disaster in Mizoram in terms of economics. Sairang Police Station's records have shown that 50% of drowning accident in the Sairang Tlawng river occurs during the month of the flood period. The amount of rainfall in a day greatly influences the situation of flood in the study area. The topography has highly governed the magnitude of rising and receding water levels of the river. The imprint of Flood and land cover could be detected in the absence of a River gauge and subsequently from an inaccessible point of the area. Risk is maximized due to lack and gaps in building Community-based Disaster Management strategies which could encompass the farmers and the local community as well. **Novelty:** As the study employed

multi-approach investigation, emphasis was laid in several aspects and various dimensions. Examination and investigation were conducted covering both the scientific approach and societal approach. Measures and strategies adopted at different levels were also considered.

Keywords: Sairang; Flood; ArcGIS; DGPS; Total Station

1 I ntroduction

The river Tlawng is one of the most important rivers and the main source of water supply in the state. Despite its significance, number of flood hazards and flood-induced disasters were experienced during the past decades [(1)]. Flood of the Tlawng river has been one of the most massive and destructive calamities in terms of socio- economic and ecological threat in Mizoram. According to the Department of Disaster Management & Rehabilitation (DM & R), Govt. of Mizoram, during 2007- 2019, hundreds of villages experienced floods of different intensities; claiming 37 lives and seriously harmed 61 persons. Sairang, a town in the Aizawl district has been among the flood high-risk zone and is one of the worst affected areas [(2)]. Over 1/3 the Tlawng river watershed areas in Sairang are situated in very high and high hazard zones [(3)].

Disaster studies require multiple examinations of a particular phenomenon from different dimensions to achieve an ample management measure. Factors affecting the occurrence of flood hazard and the indicators for flood study could vary from the geographical and climatic condition of a particular area [(4)]. Furthermore, the area of inundation in a specific flooding should also be taken into an account [(5)]. Tracing the historical evidence, its frequency and magnitude and the curse it posed on the society and environment help in understanding the risk. Accumulating the possible causative factors enhanced the mitigation process which could largely contribute to building a Disaster resilient [(6)]. This study aims to achieve an overview of the Tlawng river flood hazard by considering the causes and impact it poses within Sairang town, which could enrich strategies for mitigation and management process thereof. The employment of Total station and Differential Global Positioning System in flood study is one of a kind approach in the study area.

1.1 Study Area

Sairang is a notified town in the Aizawl district located in the north-western part of Mizoram. It extends between 23°48'0" N latitude and 92°40'12" E longitude. With 14 kilometres distance, it is the nearest town with a river from the capital city- Aizawl. The town with a total population of 5,950 (2011 census) has a total administration of over 1,308 houses. The river serves as the lifeline for Aizawl city by providing a water supply. The town has a good connectivity through National highways and other internal roads [(7)]. The river Tlawng is stretching along the western part of the entire town [Figure 1].

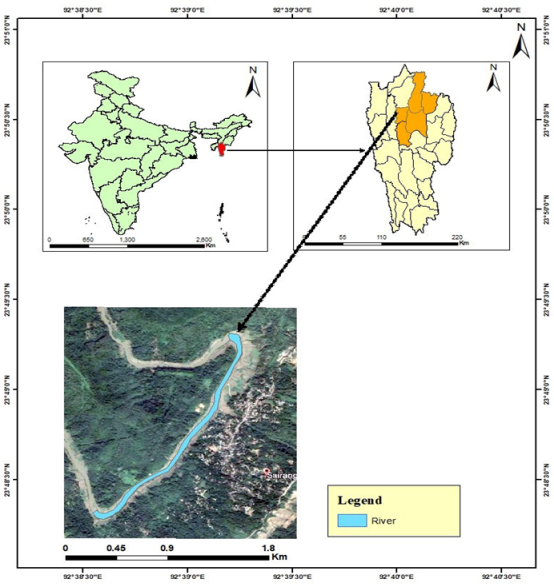

Fig 1. Location map of the study area

2 Methodology

Flood Reports of Mizoram were collected from the Department of Disaster Management and Rehabilitation (DM&R), Government of Mizoram. Daily Rainfall and Temperature of Aizawl District for the year 2007- 2021 was collected from the State Meteorological Centre, Directorate of Science and Technology, Government of Mizoram. Records of Drowning Incidence in Sairang Tlawng River were acquired from Sairang Police Station. A semi- structured interview using purposive sampling techniques was conducted where leaders and senior prominent adviser of the Young Mizo Association (YMA), Sairang Branch. The history of flood in Sairang, impact of 2017 flood which is hitherto known the most destructive calamity and the community perception towards flood and its management were acquired from the interviews. An experimental survey was carried out to determine the possibility of river line detection in the absence of a river gauge. The survey was performed using Total Station and Differential Global Positioning System (DGPS). The flood elevation and current river line from several points were successfully accessed.

To determine the causes of flood-i) amount of rainfall and recent flood events were considered which is presented in a graphical chart by sorting out the highest rainfall record in each year from 2007- 2021 correlated with the flooding events acquired through interview responses. ii) Contour map and 3D map of the study area is generated in Arc GIS 10.8.2 by extracting desired locations from Google Earth imagery.

Using descriptive analysis techniques, the consequences and impact of 2017 flood was drawn from the interview responses by interpreting the historical flood events supported by comparison picture image captured by the authors. Records of drowning accidents for 10 years i.e 2010-2020 was collected from Sairang Police Station which was analysed using trend analysis technique. The month-wisely value was put in percentile which is presented in pie-chart.

During the flood in the year 2022, the right bank of the river line was detected using Differential Global Positioning System (DGPS). The left bank was inaccessible due to high level of flood. Owing to that problem, Total Station was employed to perform the same as the right bank. A total of 31 longitudinal points indicating the coordinates and elevation were taken along the current river line and the edge during the highest flood level [(8)].

3 3. Results and Discussion

3.1 Causes of Flood

Mizoram, situated in the north-eastern part of India is drained by numerous rivers and streams flowing in either the north or south direction, conforming to the north-south trending ridges [8]. Of all the possibilities, the main causes of flood hazards in the study area are mainly heavy precipitation during the summer monsoon and the topography.

3.1.1 ***Heavy Precipitation***

The climatic condition during monsoon is crucial to consider in evaluation of susceptibility to flood hazard [9]. The increasing rate of extreme rainfall intensity and frequency results in changes in flood pattern thus escalating the cursed [10].

The particular days that the community were wrecked by the flood in 2017 and 2018 was exactly the highest rainfall record for the certain years and also the entire decade i.e 13th June and 12th June respectively. On 7th December 2021, an unprecedented flood was experienced in Sairang town. This flood marks the only flood event that the locals have so far experienced in such time of a season or month of the year. However, the highest amount of rainfall in 2021 eventually falls on the same date i.e 7th December [Figure 2].

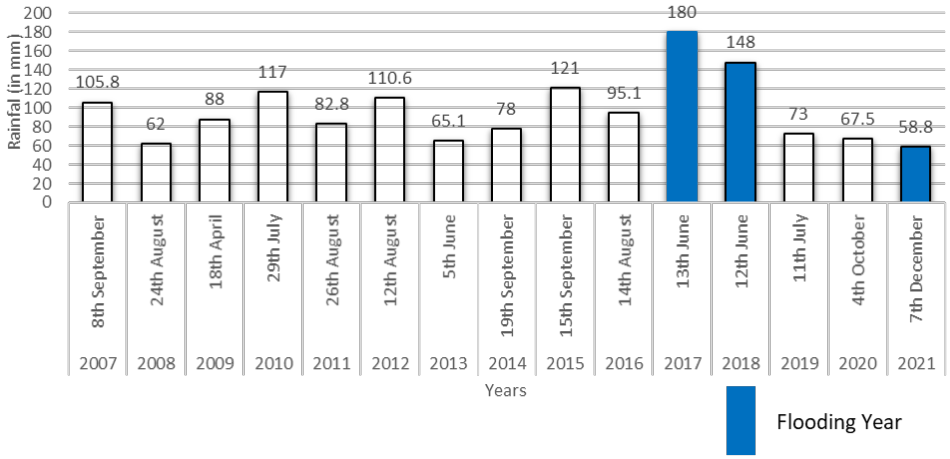

Fig 2. Highest Rainfall Record for each year during 2007- 2021 with flooding years

Under the direct influence of South- West Monsoon, Mizoram receives an adequate amount of rainfall during the summer monsoon. According to Agriculture Statistics, 2020, Mizoram received an annual rainfall of 1693.5 mm. and the heaviest rainfall was recorded in the month of July. It is evident that the amount of single-day extreme rainfall largely determines the events of flood in the study area. Since the amount of rainfall in a day rather than duration of rain days, has greatly influenced the event, the riverine flood of this river resembles the natures and activities of flash flood.

3.1.2 ***Topography***

It is obvious that water normally flows from higher to lower elevations. As a consequence of which the lower the elevation, greater is the degree of susceptibility [11]. When precipitation occurs, the velocity of surface runoff greatly depends on the steepness of the watershed area [12].

Based on the contour map, 320m contour line depicts the highest elevation within the study area while 80m falls on the water body [Figure 3]. The rate of run-off is greater than the rate of infiltration which eventually increases the speed of water entering the river catchment area. The study area is quite steep where the elevation increases towards the east. Fortunately, majority of the settlements are confined to the eastern bank of the river. However, due to the heavy congestion owing to growing population, the lower elevation is continuously colonized descending as low as Flood mark monument. A large area of both the east and

west bank were deforested and modified into cultivated land thus loosening the soil thereby increasing the rate of erosion. Besides the steep physical features, settlements growing near the flood plain results in sealing the surface [13] which speed up the velocity of run-off draining into the river.

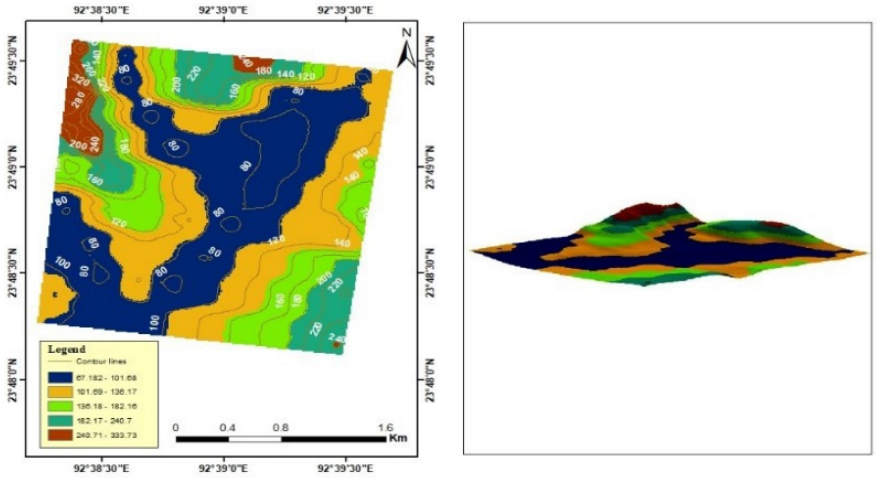

Fig 3. Contour and 3D map of Tlawng River, Sairang

3.2 Consequences of Flood in Sairang town

3.2.1 ***History of the Tlawng River Flood***

Floods with great intensity hit the town in 1929, 1993, 2017 and 2018. The 1929 flood was claimed to be the most massive. The flood reached up to an elevation of 320 feet inundating the present National Highway- 6. For once since time immemorial, the flood was experienced in the consecutive years of 2017 and 2018. The 2017 flood happens to be the worst affected that flood caused the town.

One of the greatest challenges faced in the present study is the lack of information on historical flood data in the study area. Although the recurrent prevalence of flood event is obvious, a detail profile could only be accessed through the local community and the records of an NGO i.e Young Mizo Association, Sairang Branch. However, while taking into account, the mitigation measures- it is equally important to consider the impact that it could or had been caused [6].

3.2.2 ***Impact of 2017 Flood***

Studies have shown that the town was severely cursed by flooding in several past years. The growth in socio-economic development and population increases the flood risk [14]. Developing and under- developed countries are more vulnerable to climate induced disaster like flood [15]. The nature and characteristics of flood and the available resources for mitigation largely determines the severity of the cursed that flood could cause [16].

Relying on the fertile soil produced by the river, there were over 700 farmers practicing subsistence and commercial farming along the river banks in Sairang town. Owing to the flood in the year 2007, it was estimated that loss to the agriculture sector ranges between ₹35,000- ₹2,50,000. Benefiting the deposition of sand, sand mining has emerged to be one of the mean sources of income amongst the locals. The 2017 flood badly cursed the daily salary of around 500 sand miners. The workers had missed out ₹1250-1800 per day.

As settlements were clustered in close proximity to the river, several houses were inundated where 15 houses were evacuated. Since water seep into the earth, cracks were developed in most inundated houses. Meanwhile, the flood prone must be restricted for settlement [17] and other several constructions to minimize the loss and destruction. However, regardless of the vulnerability, those houses were normally occupied again soon after. The reason to these circumstances are absence of restriction and land-use regulations and too; low economic status to quest and rebuild a new dwelling.

Fig 4. 2017 Flood innundated house, Sairang

Fig 5. Same house scene in January, 2022

3.2.3 ***Drowning Accidents during 2010- 2020***

Despite the least consideration for curtailing the events, emergency of drowning incidence mostly and frequently took place in the river system [18]. It is crucial to identify the nature, patterns and factors leading to drowning accidents in an effort to design and implement mitigation plans and actions [19]. Accumulating the past records supports delineation of the individual's identity and helps in determining the risk and vulnerable groups [20].

In view of determining the vulnerability and risk of the community, lives lost due to drowning in the river over the period of ten years were attained from Police records. As per records of Sairang Police Station, 20 people had drowned to death, out of which 19 were from outside the locality. 50% of cases occurred during the month of the flood period i.e June- September. However, the winter months of December- February shows nil cases [Figure 7].

As the Tlawng river in Sairang is in close proximity to Aizawl city. During summer a large number of people from the city headed towards the river to look way for cool down. The study finds out that 56% of the individual drowning were the residence from Aizawl. Entertaining purpose while unaware of the flow and depth of the river are the chief distributors of the drowning cases.

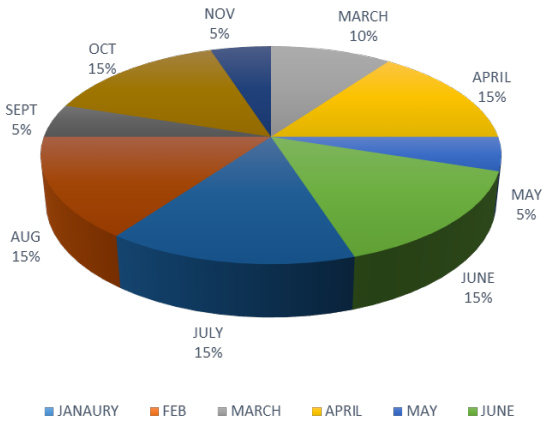

Fig 6. Drowning Incident in Sairang Tlawng river

3.3 The 2022 Flood

On 18th June, the river Tlawng was flooded at an alarming rate and two houses were evacuated. An experimental survey was conducted on 22nd June using Total Station and Differential Global Positioning System. The utilization of total station has become efficient and convenient in study of hydrological process [8,21]. Collecting points of desirable location can be performed through DGPS survey [22] and river line survey using Total Station [8,22].

Table 1. Coordinates and Elevation of points using Total Station

Point no.	Latitude	Longitude	Point code	Elevation (m)
1	23°48'49.61"N	92°39'7.44"E	OP	93
2	23°48'49.10"N	92°39'7.88"E	BS	98
3	23°48'50.48"N	92°39'3.91"E	FS1	97
4	23°48'50.12"N	92°39'3.52"E	FS2	99
5	23°48'49.68"N	92°39'3.10"E	FS3	101
6	23°48'49.19"N	92°39'2.72"E	FS4	102
7	23°48'48.70"N	92°39'2.32"E	FS5	104
8	23°48'48.15"N	92°39'1.93"E	FS6	103
9	23°48'47.60"N	92°39'1.43"E	FS7	102
10	23°48'47.09"N	92°39'1.06"E	FS8	100

OP= Occupied Point, BS= Back sight point, FS= Front Sight point

Table 2. Coordinates and Elevation of Points using DGPS

Point no.	Latitude	Longitude	Elevation (m)
1	23.813904 N	92.65206E	68.589
2	23.81411N	92.65213E	65.649
3	23.81416N	92.65219E	64.551
4	23.81424N	92.65221E	63.451
5	23.81429N	92.65222E	62.667
6	23.81433N	92.65223E	62.103
7	23.81436N	92.65224E	61.426
8	23.81375N	92.65215E	71.208
9	23.813718N	92.65224E	72.207
10	23.81378N	92.65247E	76.12
11	23.81373N	92.65247E	75.752

Continued on next page

Table 2 continued

12	23.81369N	92.65235E	73.731
13	23.81366N	92.65215E	71.861
14	23.81403N	92.65206E	66.716
15	23.81394N	92.65212E	67.758
16	23.81391N	92.65203E	67.831
17	23.81364N	92.65268E	78.443
18	23.8133N	92.65298E	84.629
19	23.81322N	92.653E	85.834
20	23.81305N	92.65295E	86.807
21	23.81306N	92.65261E	81.566
22	23.81304N	92.65203E	79.353
23	23.81287N	92.65152E	73.907
24	23.81283N	92.65131E	68.562
25	23.81285N	92.65123E	66.427
26	23.81293N	92.65115E	63.011
27	23.81297N	92.65128E	65.521
28	23.81316N	92.65124E	60.79
29	23.8139N	92.65206E	68.589

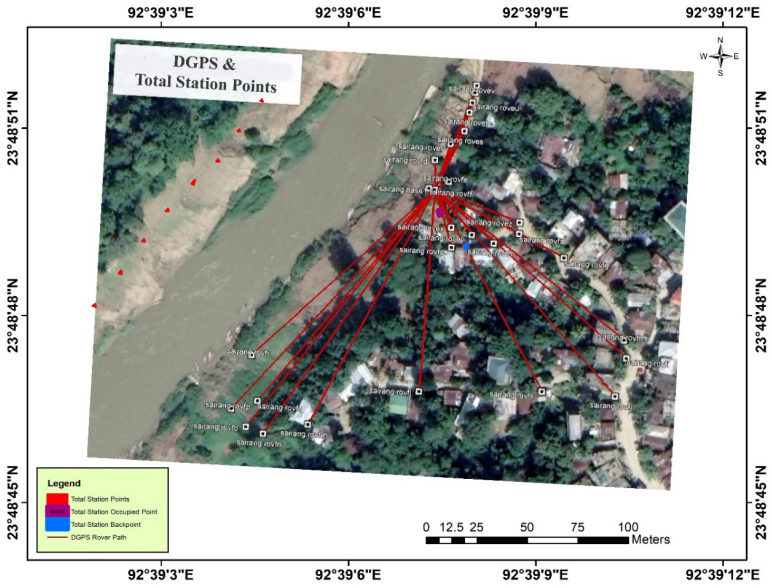

Fig 7. DGPS and Total Station points

The current river line on the right bank of the river was observed using DGPS. The left bank was inaccessible due to flood, where Total Station survey was performed effectively in collection of point along the imprint line of flood elevation. The flood has reached up to an elevation of 104m on 18th June 2022. It was detected that water has receded from 104m to 61m from 18th-22nd June 2022. The decrease amount of rainfall in the area being the chief reason which has led to the speedy receding of the flood level.

4 Conclusion

From scientific investigation to social examination provides and complete the nature and scope of the so called 'Disaster Management'. Likewise, when it comes to flood studies a multi-disciplinary studies provide a set of handful findings which otherwise is crucial to design compact solutions.

It is evident from the study that proper land-use regulation in the flood prone area could minimize the destruction of houses and agriculture. Restriction and caution notice would be an effective preventive measures by reducing drowning cases. Community awareness campaign and training were strongly suggested for personal safety and so as to rendered timely intellectual needs.

The utilization of DGPS and Total station for flood studies is rarely to never been performed in the study area. The distinctive successful experimental survey is an urge for further and future studies of the alike subject. Besides river line survey, with the same instruments employed, it is possible to perform river cross section and preparation of topographic map for a specific area. The potential of accurate monitoring and acquisition were being among the various advantages of the employed instruments.

5 Declaration

Presented in 4th Mizoram Science Congress (MSC 2022) during 20th & 21st October 2022, organized by Mizoram Science, Technology and Innovation Council (MISTIC), Directorate of Science and Technology (DST) Mizoram, Govt. of Mizoram in collaboration with science NGOs in Mizoram such as Mizo Academy of Sciences (MAS), Mizoram Science Society (MSS), Science Teachers' Association, Mizoram (STAM), Geological Society of Mizoram (GSM), Mizoram Mathematics Society (MMS), Biodiversity and Nature ConservationNetwork (BIOCONE) and Mizoram Information & Technology Society (MITS). The Organizers claim the peer review responsibility.

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