Appraising the need for disaster mitigation in existing planning documents of Municipal Corporations of Kerala in the event of past disasters

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Abstract. The state of Kerala has a long history of natural disasters, of which the most recent disasters happen to be the floods and subsequent landslides in 2018 and 2019. Comparatively, the floods of 2018 and 2019 have claimed many lives, destroyed houses and have affected the normalcy and livelihood of many people than the earlier disasters that have occurred in Kerala. Apart from the floods, disasters like cyclones, earthquakes and droughts have also affected Kerala in the past. Understanding the vulnerability of Kerala to disasters, it is a requisite to address the same in the planning documents of every each district of Kerala. In many cases of disaster, it has been observed that the predicted susceptible area has drastically differed from the actual affected area. So as to signify the need of an in-depth disaster mitigation intervention in all the districts of Kerala, this paper intends to recommend a few suggestions and modifications to the existing planning documents of Municipal Corporations of Kerala through a condensed study on the impact of various disasters on different sectors of all the six Municipal Corporations of Kerala.

1. Introduction:
Kerala, a state with a population of 3.48Cr (as per the census of India 2011), is one of the physically linear states of India, bounded by the Arabian Sea to its West. Looking into the disasters that have affected the state of Kerala, it could be inferred that floods and landslides due to rainfall have been one of the most impactful. This paper intends to discuss the impacts of climate change due to urbanisation and other factors, which passively lead to disasters, primarily floods. To efficiently study the impact of the disaster across the state, the master plans, disaster management plans and other relevant planning documents of all the six Municipal Corporations of Kerala have been considered. The six municipal corporations of Kerala are namely Thiruvananthapuram, Kollam, Ernakulam, Thrissur, Kozhikode and Kannur. The geographical locations of these Municipal Corporations are such that the study covers the entire area of Kerala along its vertical axis as Thiruvananthapuram happens to be in the bottommost of the state with Kannur at the topmost.
The urban people of Kerala have enlisted a gigantic growth throughout the last decade as the number of towns in the state expanded more than three times during the period. The fact is Kerala has experienced a drastic transition from a rural entity to a ‘rurban’ entity within a short period of time. This transition has had its impact on the micro-climate of a particular region, as a result of which Kerala has started witnessing the climate change [1]. Because of this drastic climate change, Kerala is very much vulnerably against catastrophic events and the changing climatic dynamics, given its location along the sea coast and steep inclination along the slants of the Western Ghats.

Table 1. Area and population vulnerable to hazards in Kerala [2]

| Hazards       | Susceptible area (km²) | Population exposed |
|---------------|------------------------|--------------------|
| Landslides    | 5619.7                 | 2799482            |
| Floods        | 6789.5                 | 7795816            |
| Coastal Hazards | 289.70                | 3132205            |
2. Hazard profile of Kerala:
Kerala is vulnerable in varying degrees to a large number of natural as well as manmade disasters that result in loss of life, livelihoods, infrastructure and property, and subsequently cause extreme hardships to the affected population, alongside resulting in disruption of economic activity. Kerala positions first among the Indian states in the SDG files with remarkable accomplishments in human advancement equivalent to developed economies [3]. The state holds three Ramsar sites, i.e., wetlands of international importance. The Western Ghats are one of the major environmental hotspots in the world, wealthy in its biodiversity, yet profoundly under danger. Kerala’s proximity to the sea with a coastline of nearly 600 km, presence of numerous rivers, lakes, backwaters and estuaries, and a considerable proportion of the total land area makes the state vulnerable to floods and landslides. More than half of the coastal zones of the state are susceptible to sea erosion according to the state disaster management plan. About 14% of Kerala’s land area is susceptible to landslides. To a minor level, Kerala also experiences drought due to human interventions. The state is also vulnerable to cyclones as well as Tsunami. Thus, Kerala is frequently ravaged by the disastrous consequences of numerous hazards and hence it is a multi-hazard prone state.

2.1. Major Natural Disasters that occurred in Kerala:
In the year 1924, ‘the great flood of 99’ devastated Travancore, Kochi and Malabar. Following which, in the year 1961, floods and destruction hit with 56% above normal rainfall. Later in 2001, landslides in Amboori claimed 38 lives. In 2004, the coastal districts of Kerala got hit by the ravaging Tsunami. It was Idukki in 2013 that faced floods and landslides, spreading havoc. Four years later, in 2017, Cyclone Ockhi took a toll on the lives of the fishermen. The 2018 floods and landslides paralysed the entire state of Kerala. Subsequently, in 2019, Northern Kerala was left shattered by the floods and landslides. However, by analysing the various disasters that occurred, those that affected the state the most are the floods, landslides and coastal erosions.

| Hazard type     | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Flood           |     |     |     |     |     |     |     |     |     |     |     |     |
| Landslide       |     |     |     |     |     |     |     |     |     |     |     |     |
| Drought         |     |     |     |     |     |     |     |     |     |     |     |     |
| Heat-wave       |     |     |     |     |     |     |     |     |     |     |     |     |
| Coastal erosion |     |     |     |     |     |     |     |     |     |     |     |     |
| Wind damages    |     |     |     |     |     |     |     |     |     |     |     |     |
| Lightning       |     |     |     |     |     |     |     |     |     |     |     |     |
| Epidemics       |     |     |     |     |     |     |     |     |     |     |     |     |
| Earthquakes     |     |     |     |     |     |     |     |     |     |     |     |     |
| Tsunami         |     |     |     |     |     |     |     |     |     |     |     |     |

3. Impact of floods on the Municipal Corporations of Kerala
Despite the state-wide outrageous rainfall in Kerala in August 2018, likely causes (substantial downpour and reservoir operations) of floods have been critically discussed. The catchments upstream of the major reservoirs experienced enormous rainfall in the long stretch of August in 2018 in the whole record of 117 years [4] This resulted in severe flooding in 13 out of 14 districts in the state.
Table 3. Table depicting the amount of rainfall district wise during June 2018- August 2018 [5]

| District   | Normal Rainfall/mm | Actual Rainfall/mm | Quantity of rainfall |
|------------|--------------------|--------------------|----------------------|
| Alappuzha  | 1380.6             | 1784               | Excess               |
| Kannur     | 2333.2             | 2573.3             | Normal               |
| Ernakulam  | 1680.4             | 2477.8             | Excess               |
| Idukki     | 1851.1             | 3555.5             | Large Excess         |
| Kasaragod  | 2609.8             | 2287.1             | Normal               |
| Kollam     | 1038.9             | 1579.3             | Excess               |
| Kottayam   | 1531.1             | 2307               | Excess               |
| Kozhikode  | 2250.4             | 2898               | Excess               |
| Malappuram | 1761.9             | 2637.2             | Excess               |
| Palakkad   | 1321.7             | 2285.6             | Large Excess         |
| Pathanamthitta | 1357.5   | 1968               | Excess               |
| Thiruvananthapuram | 672.1     | 966.7              | Excess               |
| Thrissur   | 1824.2             | 2077.6             | Normal               |
| Wayanad    | 2281.3             | 2884.5             | Excess               |

Floods are the most common of natural hazards that affect people, infrastructure and natural environment in Kerala [6]. Reclamation and settlement in floodplain areas is a major cause of flood damage in Kerala. Frequency and magnitude of floods in the state seem to be on the rise. Factors contributing to the increase in the magnitude of floods are reclamation of wetlands and water bodies, increase in the impermeable built-up area, increase in the roads with impervious surfaces, deforestation in the upper catchments etc. Urban flooding is also very common in most of the urban centres of the State [7]. The major cities that frequently experience urban flooding are Thiruvananthapuram, Kochi and Kozhikode. Encroachment of river banks and infilling of paddy lands as well as wetlands are the major cause of an increase in the susceptibility to floods.

3.1. Thiruvananthapuram:
Urban flooding in the city is an annual event indicating the inadequate maintenance and management of sewerage systems and storm water drains. The 2018 floods claimed around 11 lives within 30 days of heavy downpour. 1356.96 hectares of agriculture land had been damaged. Close to 111 houses were fully damaged and 2940 houses were severely damaged in Thiruvananthapuram district.

3.2. Kollam:
All the coastal villages in the locale are areas vulnerable to floods. High intensity of rainfall during the monsoons causes severe floods. The 2018 floods affected the district, though not with much severe intensity [7].

3.3. Ernakulam:
Kochi corporation area is subjected to floods during monsoon since it is a flat land adjacent to the coast. In addition to this, water logging is one of the major problems in Kochi. Based on the history of such floods, the worst affected areas in the Kochi city can be divided into two major sectors, namely East and West sectors. South Railway Station, Kaloor, North Town Hall, Palarivattom in the east sector and Thamaraparambu and Palluruthy in the west sector are additionally exposed to serious flooding [8].
3.4. Thrissur: 
The municipal corporation area of Thrissur experienced intermediate floods in the regions of Cheroor, Daya, Shoranur road and Kurinjnakkal. Chalakuddy had adverse flood effects owing to the river. However, areas of Chetuvadid not witness flood because of the large mangrove cover.

3.5. Kozhikode: 
All the highly vulnerable areas of the flood are adjacent to water bodies. Unprecedented heavy rainfall occurred during the months of June and July 2018 in Kozhikode. 58% of normal rainfall in the district occurred from 8th to 14th June 2018. It also led to a landslide that occurred at Karinchola, Kattipara Grama Panchayat.

3.6. Kannur: 
The ascent of the water level upstream of the Valapattanam stream caused worry that the flood circumstance in the influenced zones would deteriorate. Low-lying zones on the banks of the stream at Kakkathuruthi close to Kattampally, Chengalayi and Kambil were flooded. The parts most awfully affected by the flooding are in Iritty Taluk.

4. Impact of Coastal Erosions on the Municipal Corporations of Kerala: 
Coastal erosion becomes a hazard where human activity is threatened by a temporary or permanent hold back of the shoreline. Coastal accretion is the opposite, where the shoreline builds over time. The loss (erosion) and the (gain) of coastal land is a visible result of the way shorelines are reshaped in the face of these dynamic conditions [9].

4.1. Thiruvananthapuram: 
In view of systematic field review directed by National Centre for Earth Science Studies, 6.5 km of the 27.4 km of Thiruvananthapuram City's coastline is inclined to high rates of coastal erosion.

4.2. Kollam: 
Kulathupadam, Thanni and Kakkathoppu areas in Eravipuram Village of Kollam Taluk were affected during sea erosion that occurred in 2012. Alappad is one of the villages rich in minerals affected by Tsunami. For minerals, mining activities of Sea sand has made life impossible in the coastal regions of Alappad village as it has shrunk from 87.5 Sq.Km to 8.7 Sq.Km within a span of 50 years.

4.3. Kozhikode: 
The coastal road, which connects Koyilandy to the popular tourist destination, Kappad, caved in the 2019 coastal erosion. The incident occurred when road development works were in progress at another stretch. The sea wall in the area too fell to the attacking waves, which are very strong due to the monsoon. During the past 12 years in Kozhikode district, almost 1510 people have been affected due to the coastal erosion. 28.7 hectares of land loss has been reported of which 14.1 hectares happened to be agricultural land.

5. Impact of landslides on the Municipal Corporations of Kerala: 
Debris flow is the most frequent and common type of landslides that happen in the highlands of Kerala. The initiation of most of the landslides was in typical hollows generally having degraded natural vegetation. The characteristic pattern of this phenomenon is the swift and sudden downslope movement of highly water saturated overburden containing a varied assemblage of debris material ranging in size from soil particles to boulders, destroying and carrying with it everything that is lying in its path.
5.1. Kannur:
Thaliparamba Taluk of Kannur district was extremely affected by landslides in 2018. The hilly regions of Kannur are subjected to excavation, cut and fill process for the various infrastructure development processes which add as one of the reasons for the occurrences of landslides.

5.2. Kozhikode:
In the landslide at Karinchola in June 2018 an area of 6.2313 ha was affected, thereby displacing 1,24,626 tonnes of the landmass. 4 houses were completely buried. 14 lives were lost and 8 people were severely injured. Later in August, landslide affected the regions of Mattikunnu, Puthupadi of Thamarassery Taluk. Tentatively, the landslides resulted in the destruction of 15 houses completely and 98 houses partially.

6. Suggestions and strategies towards mitigation of natural disasters:
Alongside the study of impacts of disasters in various municipal corporations of Kerala, the impact of the disasters on various sectors of the municipal corporations, like governance, economy, physical and social infrastructure, drainage and solid waste management have also been analysed.

Table 4. Analysis of various disasters that affected various sectors in the Municipal Corporations.

| Municipal Corporation | Disasters occurred | Sectors affected                                      | Inference                                                                 | Suggestions                                                                 |
|-----------------------|--------------------|-------------------------------------------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Trivandrum            | Flood, Tsunami,   | Agricultural sector, Housing sector,                   | Presence of a large no of backward fishers (4.4% of population) increases the vulnerability of the area. | Second phase of Operation Anantha needs to be carried out. Maintaining the city drains and block the unauthorized construction on sensitive areas. Waste Management awareness programs are required. |
|                       | Coastal erosion   | transportation, Economic base, Connectivity, Housing sector, Economic base Land area | Operation Accumulation of waste prevents the flow of water into the canal and this led to the flooding in the low lying areas like East fort and Thampanoor. |                                                                            |
| Kollam                | Tsunami, flood,   | Housing, environment, social infrastructure, Tourism  | Coastal villages were mainly affected. Major impact on livelihood of people of coastal communities. | Protect water resources which act as natural drain; promote sustainable livelihood options. Enforce regulations to prevent fire disasters. |
|                       | fire accident.    |                                                        |                                                                            |                                                                            |
| Ernakulam             | Flood, Drought    | Traffic, Rail, Metro, Airport Connectivity, Economic Base – agriculture, livestock, Water Supply, Buildings, Physical & Social Infrastructure. | Disasters caused huge losses to the region. More Coordination required between Disaster Management Authority and Municipal Corporation to handle the disaster. | Comprehensive Water Management Strategy and Drainage Plan to be implemented. Revised Disaster Management Plan considering recent disasters and the vulnerable areas. Integrate this with Development Plan. |
| Sector   | Disasters | Housing, Connectivity, Water supply, Environment | Unplanned conversion of wetlands into urban developed areas overloads the existing canals and result in flooding and water logging in certain areas of the city. | Develop wetland management conversion for better drainage. A citywide comprehensive drainage study and objectives with a proposed solution KSUDB could be addressed with the district master plan. |
|----------|-----------|-------------------------------------------------|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Thrissur | Flood, landslide | Housing sector, Connectivity, Water supply, Environment | Most affected areas are the houses located in the steep areas and those are close to water bodies. | No building activities in red-alert zone of the flood plain, landslide area. Better construction techniques need to be adopted. |
| Kozhikode | Flood, Landslide, Tsunami, Lightning, Coastal Erosion | Housing, Transport, Agriculture, Tourism, Water, Electricity, Education | The hilly regions of Kannur are subject to excavation/cut & fill/ flattening. | Construction activities should be based on the geo-hazard map so as to avoid infrastructure developments in landslide prone areas. Construction of flood resistant houses may be promoted. |
| Kannur   | Flood and Landslide, Drought | Housing, Transportation-Road, Rail, Physical infrastructure. Housing, Agriculture, Livestock. | This has been the reason for the occurrence of landslides. | |

Based on the inferences from the study of these sectors, a few strategies for disaster preparedness and recovery that could be applied to the planning approaches and to modify the existing planning documents of the municipal urban areas of Kerala are envisaged.

- Identify the most viable social buildings in the disaster-prone areas in the event of each disaster and equip them with necessary provisions and other emergency amenities.
- Drainage improvement shall be integrated into the Master Plan for water management in the urban areas with a specific focus on flood control [7].
- Analysis between the flood susceptibility map and detailed drainage map be done periodically and recorded to estimate the kinds of interventions required.
- Removal of debris soon after the impact of a flood is highly essential as it could affect water bodies; destroy public properties, buildings, roads, etc.
- The high flood line mapping and the vulnerability regions have to be published in public platforms and efficiently communicated to the people to build awareness.
- Flood reduction in the most affected and forecasted areas are to be done by upstream interventions such as reforestation, protection of vegetation, clearing of obstructions from streams, regular de-silting of major reservoirs and water holding structures, conservation of ponds and lakes etc.
- The development of new infrastructure and settlements in coastal areas shall be strictly regulated as per the CRZ Notification.
• Services like fire force, ambulance, etc. should be made available within the circumference of disaster-prone areas during monsoon.

7. Conclusion:
Understanding the adverse effects of various disasters in different sectors of Kerala, it is significant that preparedness measures are to be included as a part of the planning documents, preferably the master plan of each municipal corporation. In the 2018 and 2019 floods, landslides occurred in contrary to the susceptibility maps and predictions in the northern part of Kerala. Hence, it is important that provisions for frequent analysis and scrutiny of climatic behaviour be made.

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