7.2. Risk Assessment

Risk is the probability or severity of occurrence of a harmful consequence due to hazards.

Hazard is a situation that poses a level of threat to life, health or environment.

Disaster is a natural or man-made hazard resulting in an event of substantial extent causing significant physical damage or destruction, loss of life or drastic change in environment.

Risk Assessment: Qualitative and quantitative measurement of the potential loss of life, personal injury, economic injury, and property damage resulting from hazards.

Risk assessment involves the following:

- Hazard Identification
- Vulnerability Analysis
- Risk Analysis
- Emergency Plan

7.2.1. Hazard Identification

Material ropeway may present a number of hazards to the general public, operating and maintenance staff. Ropeway will be liable to suffer from two types of disasters:

1. **Natural Disasters:** Natural disasters include earthquakes, landslides, rock falls, floods, storms, avalanche, lightning etc. Risk Analysis due to Natural Hazards are discussed ahead in this chapter.
2. **Human -caused occurrences:** Man-made occurrences include:
    - Fire
    - Electrical faults
    - Technical faults like rope with broken wires in service, drive / return sheave shaft failure / tension system failure, mount assembly parts failure, over speeding of ropeway / brake failure, rollback, slippage / fall of cabin, entanglement of cabin, swinging of cabin resulting in fall of material outside cabin, cabin derailment at station etc.
    - Security threat

Hazard analysis for the Natural & Man-made Disasters is discussed in the Table below:

Table 90. Hazard Analysis

Hazards	**Severity (1-5)**	**likelihood (1-5)**	**Severity x likelihood (1-25) (Hazards scoring 1-12 are less serious hazards & 13-25 are very serious hazards & need prior attention)**
Natural hazard			
Earthquake	5	1	5
Landslides	5	2	10
Flood	3	4	12
Wind & cyclone	3	3	9
Lightening	4	2	8
Drought	3	2	6
Man-made hazard			
Fire & explosion	5	2	10
Electrical	3	5	15
Technical/ Accident	4	5	20
Security	3	1	3

7.2.2. Vulnerability Analysis

As per the hazards analysis given in the above Table, the vulnerable areas during construction phase are mainly the immediate areas under construction.

The vulnerability analysis during operation phase is given for natural as well as man-made hazards as given in tables below:

Due to Natural Hazards

Table 91. Vulnerable locations/ areas for natural hazards

Hazards	**Vulnerability**
Earthquake	Damage to Towers, Terminal Stations, Cable Cars
Landslide	Damage to Towers if slope stability is not maintained.
Flooding	due to cloud burst or excess rain

Wind & cyclone	There are very minimal chances of wind & cyclone; this can cause damage to the cable car.
Lightning	Though the area is susceptible to the lightning but the frequency of lightning is quite low i.e one per year. This can damage terminal station buildings and towers.

Due to Man Made Hazards

Table 92. vulnerable locations of different man-made hazards

Hazard	**Vulnerable Locations**
Fire	Cable car, Terminal Stations, Control Room
Electrical	Cable Car, Transformer, Control room
Mechanical/ Accident	Cable car, Ropes, Terminal Stations, Ropeway Towers
Technical	Ropeway, Cable car, Terminal Stations
Security	Terminal Stations, Parking, Population at site

7.2.3. Risk Analysis

7.2.3.1. Environmentally Induced Risks and Hazards

Natural Calamity Hazard Profile

Hazard profile map of India (published by Home Ministry of India as a part of document 'Disaster Management Plan in India) is depicted in figure given below:

The region having project site is prone to following Hazards:

- Earthquake
- Landslides
- Flooding
- Wind & Cyclone
- Lightning
- Drought

Above findings are supported by a profile map of India for earthquakes, Landslides, flooding and wind & cyclones as depicted in Fig. below:

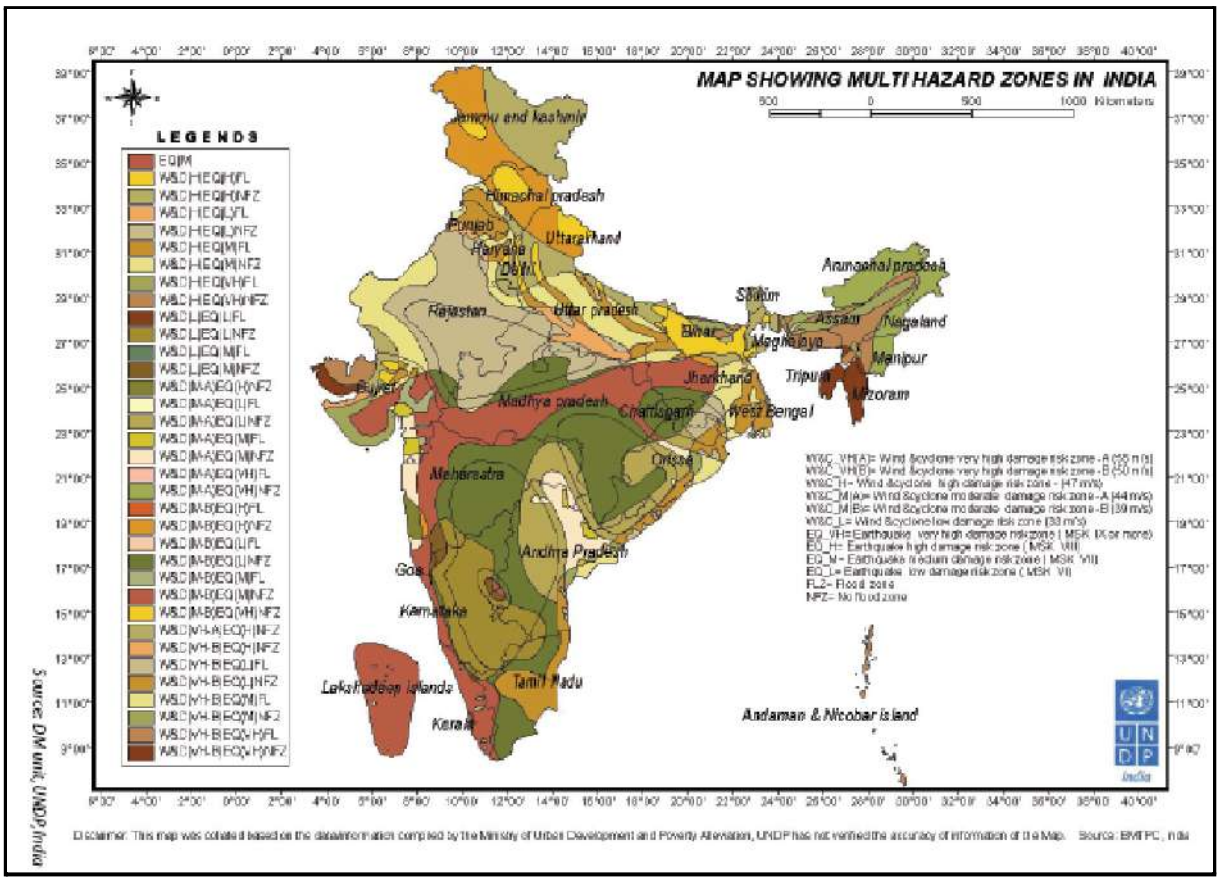

Figure 57. Natural Calamity Hazard Profile Of India

Seismicity: The project site is located in seismic zone III which indicates moderate damage risk zone. In the regional seismic zonation map of India, Kerala has been placed in Zone III and also the district Pathanamthitta where the maximum expected intensity is VIII in MM scale or 5.6 M in Richter scale. In the past fifty years, only four earthquakes have occurred in Kerala with more than 4 M. The destruction due to earthquakes is limited to ground cracks and damages to buildings. Seismicity study will be done to assess the impact of seismic activities.

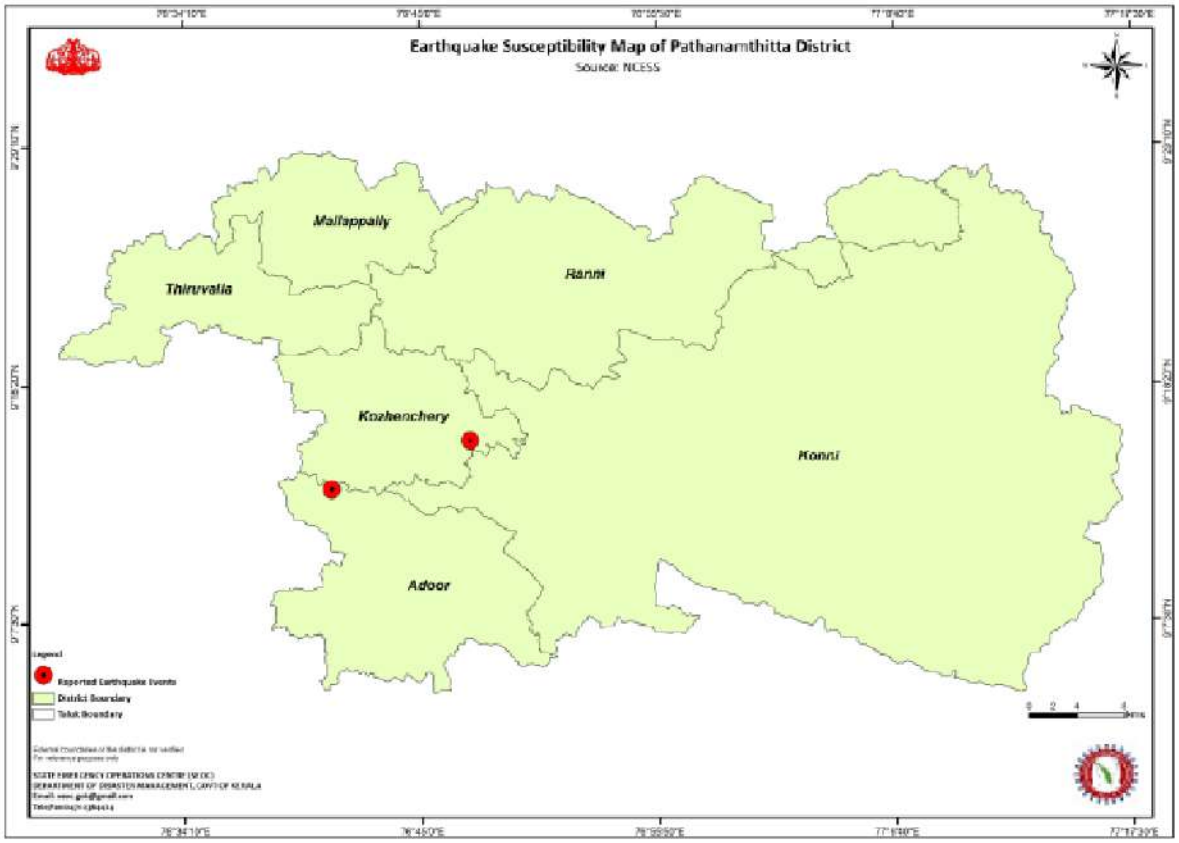

Figure 58. Earthquake susceptibility map of Pathanamthitta district (Source: District Disaster Management Plan by DDMA, Pathanamthitta)

Landslide: In Kerala, landslides commonly occur in localised areas of the Western Ghats region where the slope is steep and the soil is over saturated as a result of prolonged rainfall. The slope in the Western Ghats region is generally steep to very steep with plateau edges highly indented having > 25° slope. From the landslide susceptibility map of Pathanamthitta district given below it can be seen that Ranni taluk falls under moderate to low landslide hazard zonation hence the landslide is less likely.

The **Landslide Zonation map** published by Kerala State Disaster Management Authority is referred to and the project site is superimposed on the Landslide Zonation map and the same is provided at Figure given below. From the map, it can be inferred that **the LTP area is in Safe Zone and the UTP area is in Moderate Zone.**

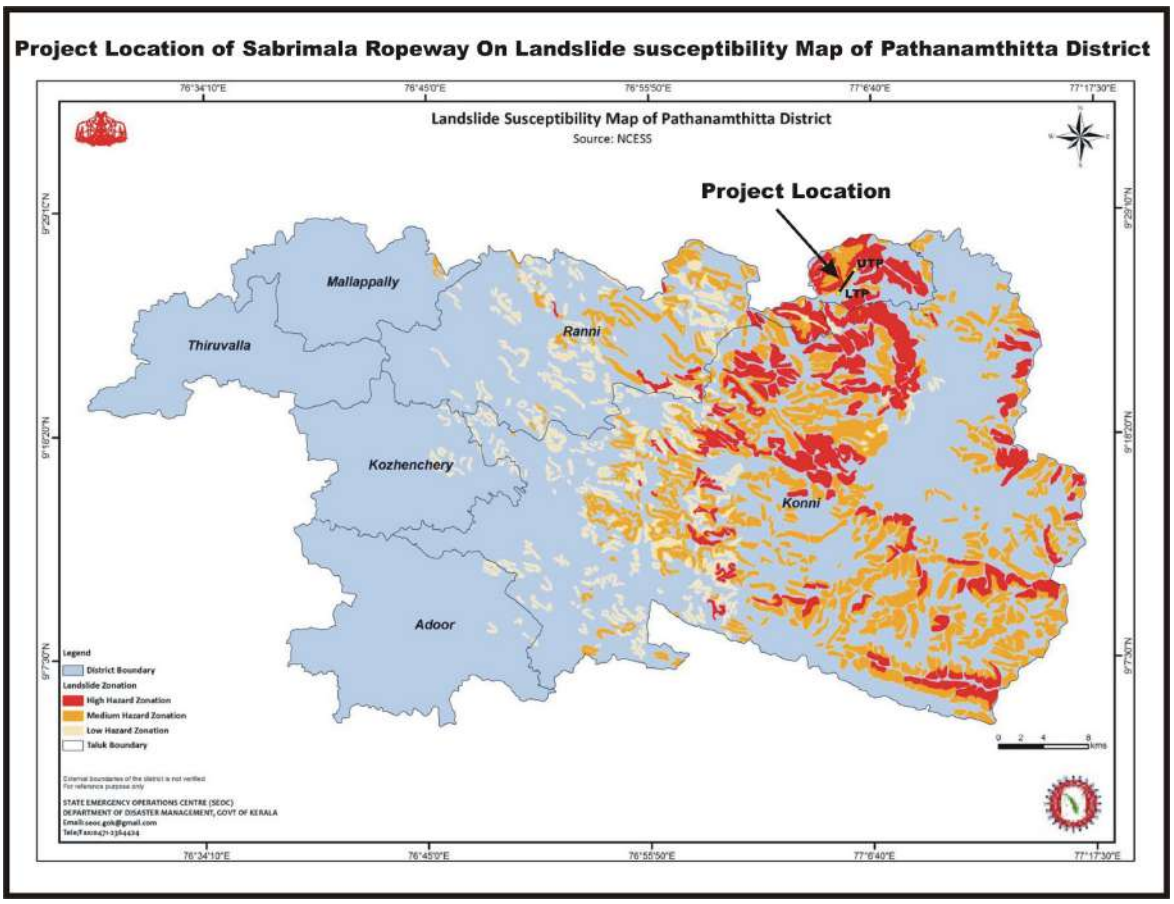

Figure 59. Project Location on Landslide susceptibility Map of Pathanamthitta District

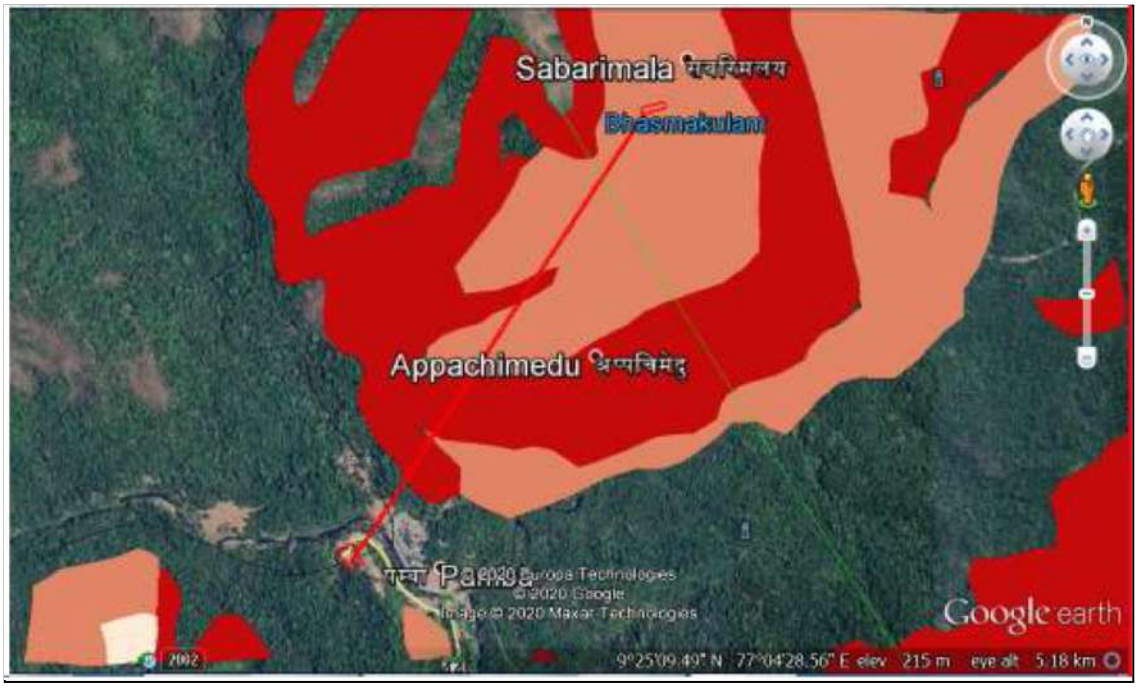

Figure 60. Landslide Zonation Map (Source: Map Published by State Disaster Management Authority, Kerala (vintage:2020)

Flooding: In Kerala, riverine flooding is a recurring event consequent to heavy or continuous rainfall exceeding the absorptive capacity of soil and flow capacity of streams and rivers. Ranni taluk of Pathanamthitta district where the project will be set up has less area covered under Flood Plain. Study will be done to assess the flood possibility and its impact on the study area.

As per Central Water Commission flood study report 2018, Due to heavy rainfall in the catchment of dam water was released from several dams. The water levels in several reservoirs were almost near their Full Reservoir Level (FRL) due to continuous rainfall from 1st of June. Severe spell of rainfall started from the 14th of August and continued till the 19th of August 2018, resulting in disastrous flooding in 13 out of 14 districts.

It was reported, during the Flood, water level reached the buildings and hotels located near the bank of river Pamba Aar at about 187 m AMSL. **The elevation of LTP is 220 AMSL which is much above the HFL 187 m AMSL of the area**. Hence it can be concluded that **floods will not affect the Ropeway**.

The Flood Zonation map published by Kerala State Disaster Management Authority is referred to and the project site is superimposed on the Flood Zonation map and the same is given below. From the map, **it can be inferred that the LTP area and UTP area are Safe Zone**

Figure 61. Flood Zonation Map (Source: Map Published by State Disaster Management Authority, Kerala (vintage:2020)

Wind & Cyclone: In Kerala, out of the 14 districts, 9 districts are bordering the sea coast vulnerable to various disasters such as floods, cyclones, coastal erosion, landslides etc Few names are Thiruvananthapuram, Kollam, Alappuzha, Ernakulam etc. However, Pathanamthitta where the project will be set up **does not fall into the category of Coastal Hazards.**

Figure 62. Coastal Hazard Map (Source BMTPC MAPS)

Lightning: Lightning is a weather phenomenon. It is essentially an electrical discharge. This is not a phenomenon peculiar to Kerala. It is part of a global electrical system known as the Global Electric Circuit involving the earth, ionosphere, and the atmosphere in between. On an average about 70 people in the state die due to lightning.

Though the Ranni Taluk of Pathanamthitta district, Kerala is susceptible to lightning but as a whole lightning frequency in the area has been one per year as shown in the map below.

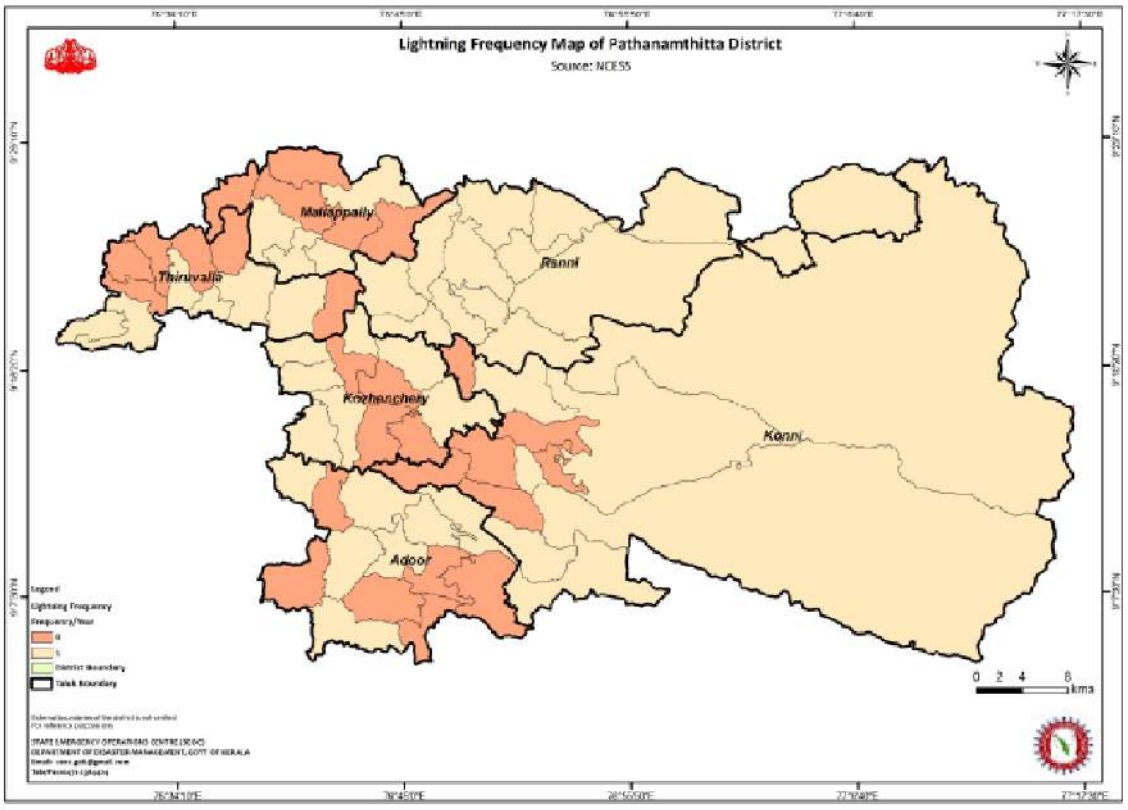

Figure 63. Lightning Frequency map of Pathanamthitta district (Source: District Disaster Management Plan by DDMA, Pathanamthitta)

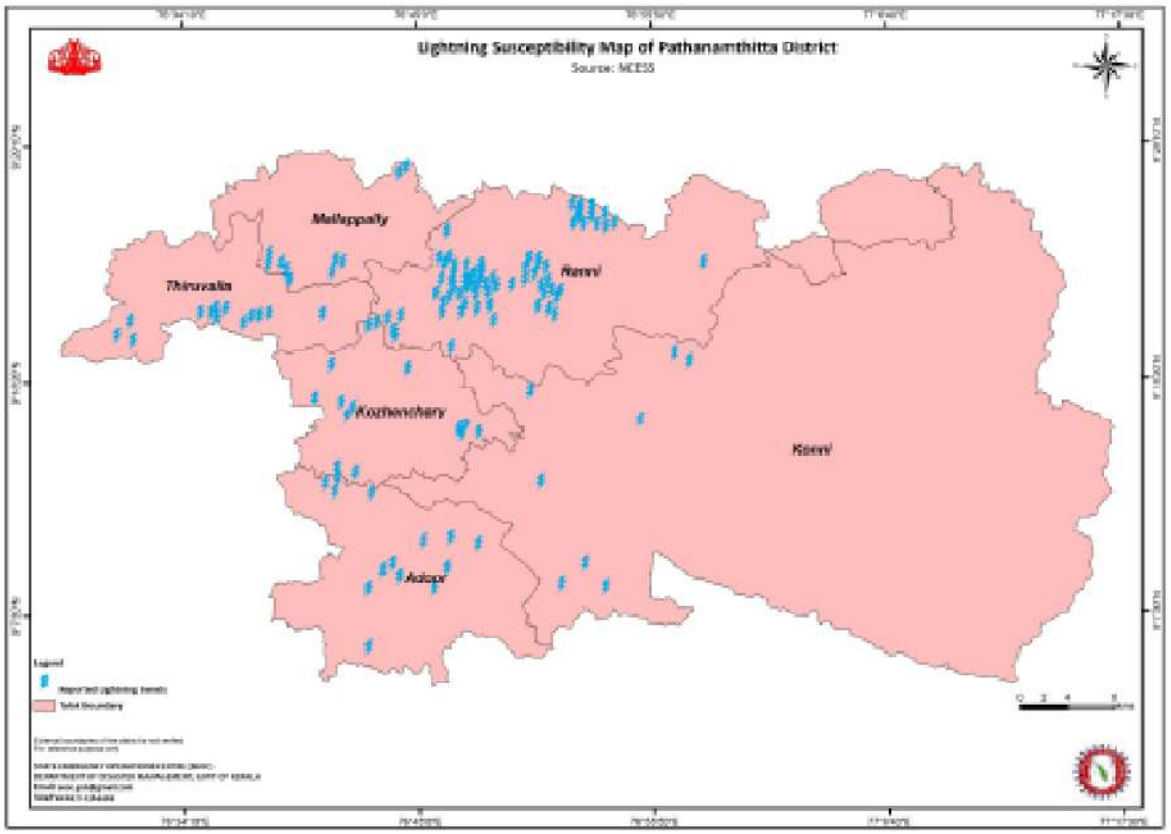

Figure 64. Lightning Susceptibility map of Pathanamthitta district (Source: District Disaster Management Plan by DDMA, Pathanamthitta)

Drought: As seen from the map below the Ranni taluk of Pathanamthitta district falls under a slightly drought prone area. Hence, drought is very effective and likely in the area, Proper mitigation and care will be taken for pre and post drought conditions.

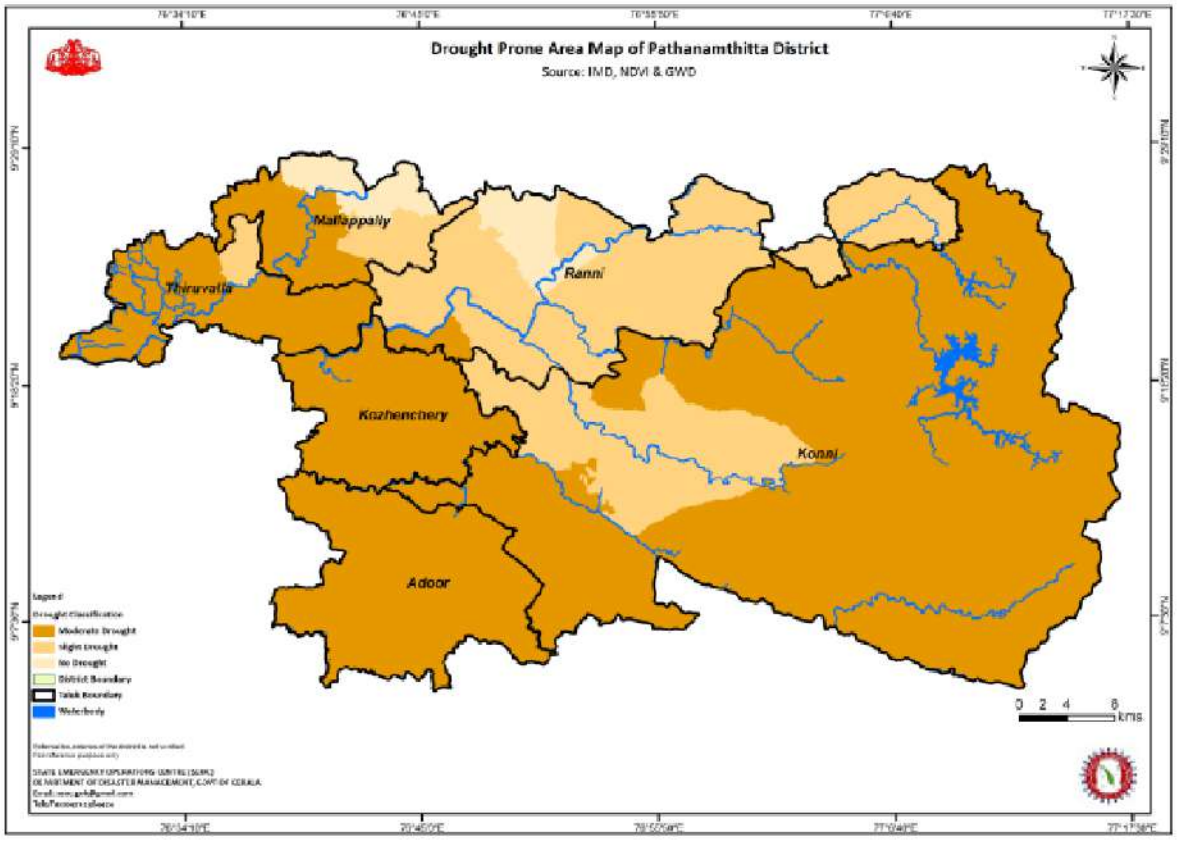

Figure 65. Drought Prone Area Map of Pathanamthitta district (Source: District Disaster Management Plan by DDMA, Pathanamthitta)

7.2.3.2. Human Induced Risks and Hazards

Fire & Explosion: Since it is a ropeway project, fire can mainly be caused due to electric spark in the electrical room, fire in the surrounding forest area, fire in fuel storage places, etc. The Fire & explosion can cause suffocation due to harmful gases generation & panic in people.

Electrical: The ropeway will run on electricity & hence electrical current can pass through cable cars & wires due to inadequate insulation or accidently.

Technical Failures/ Accident: As the ropeway consists of cable cars, ropes & big & heavy machinery, technical failures as discussed above can cause risks to people working in the area during construction phase & pilgrims (for Emergency evacuation) who will travel through the ropeway in operation phase. Consequences of the discussed hazards may result in an accident.

Security Threat: War, crisis & terrorists can cause panic among the public and staff.

7.2.4. Emergency Plans

Classification of Emergencies

Level of emergency should be declared as per criteria given hereunder:

Level 1 Emergency

- No immediate danger to the public or environment;
- Incident is confined to the lease or company property;
- Low potential for situation to escalate;
- Handled by company personnel; etc

Level 2 Emergency

- Potential for risk to the public/environment; the emergency could extend beyond company property;
- Control of incident is still possible;
- May require the involvement of external emergency services, federal, provincial or local agencies; etc

Level 3 Emergency

- There exists an immediate danger to the public or environment;
- Control of the situation has been lost;
- Extensive involvement of external emergency services, federal and/or provincial agencies;
- Emergency extends beyond company property;

Proposed ropeway shall involve Level-1 and Level-2 emergencies. However, in the case of natural calamity such as an earthquake, it may have Level-3 emergencies.

The ropeway manager will establish and draw up any special instructions necessary to be observed by staff to ensure the safety and shall ensure that such instructions are implemented and enforced by the staff.

Communication: Both an audible signal system and a two-way voice communication system shall be maintained between the drive station and all loading and unloading stations. If only one system fails to operate, the ropeway may continue to run, provided the remote attendant stop system is fully operational. In the event of the failure of both communication systems, the ropeway shall not be

operated. In the latter event, provided that adequate special precautions are taken, the ropeway may be run for the purpose of evacuation only.

No ropeway shall be operated without a functioning dedicated communication system.

7.2.4.1. Disaster Management

- Establish direct contact with district administration and District Disaster Management Authority (DDMA) for any update on forecast (warning);
    - Follow up agencies for forecast and keep records;
    - Indian Meteorological Department for cyclone and earthquake;
    - Central water commission for flood forecast;
- Establish an in-house rescue team of volunteers from each unit and impart training as per DDMA;
- Establish a first aid team of volunteers from each unit and impart training as per DDMA;
- Organize mock drills in association with DDMA;
- Establishment of Central Control Room for communication with Government agencies;
- Updated contact details should be kept for the following:
    - District Magistrate
    - District Police Administration
    - DDMA
    - District Fire Service
    - District Hospital
    - District electricity Supply Agency
    - District Water Supply Agency
- Development of Standard Operating Procedures for the role and responsibility of the individual of the response team.
- Warning System
- Inspection of design of buildings and towers with respect to severity of hazards presents;
- Removal of encroachments and keeping basic infrastructure like roads, power & water supply, waste and storm water drainage system, parking etc in healthy conditions;

- Demarcation of assembly points and evacuation routes for workers and the general public in case of emergency;
- Keep records of chemical inventorization and associated hazards with each unit;
- Planning for risk reduction measures due to chemical storage and traffic parking & movements;
- Assessment of impacts and design & implementation of remedial measures; etc
- An Emergency management Cell will be developed, which is discussed in Section 7.7.

7.3. Preventive Measures

7.3.1. Natural Occurrences

Earthquake: The project will be situated in the Seismic zone-III area. Attention shall be given to the structural design of foundation, elements of masonry, timber, plain concrete, reinforced concrete, pre-stressed concrete, and structural steel. All applicable guidelines will also be followed in this regard to ensure the safety of the building.

Landslide: The area where the ropeway is proposed is not prone to landslides. However, Structural stability & safety is a must to prevent ropeway damage due to landslides. Slope stability in the area shall be maintained at 45^0.

Flooding:

- Although the site is away from the coast and less prone to flooding hence the probability of flooding is less, however, proper designing of drainage systems shall be done to avoid any mishappening.
- All the wastewater shall be disposed of to STP for treatment.
- Structures shall be built in such a way that no harm occurs to the people working there & structures due to flooding due to natural calamities.

Lightning:

- Though lightning frequency in the area is one per year; but if necessary a lightning rod will be installed at the time of construction on the terminal station.

- Public awareness campaigns shall be organized.
- Adequate medicine/vaccination will be provided at the site.

Drought: The area falls under slightly drought conditions, to mitigate the same following measures will be adopted:

- Construction of check dams along the towers, cleaning and protection of existing water sources.
- Afforestation will be done
- Adequate rain water harvesting structure and proper conservation measures will be adopted.

7.3.2. Man-made Occurrences

Fire and Life Safety:

- Smoking must be prohibited.
- Electrical equipment must be explosion-proof to meet national electrical code requirements.
- Dry chemical extinguishers should be accessible for small fires. An adequate supply of handheld and wheeled types should be available.
- Hydrants should be strategically placed with adequate hoses.
- Small spills should be remediated with sand, earth, or other non-combustible absorbent material, and the area is then flushed with water.

Technical Faults & Accidents

- The carriage will be provided with a door lock.
- Carriage of each cabin shall be provided with detachable rope grips.
- The ropeway system will be provided with a minimum of two braking systems- Normal/ Emergency Brake and Service Brake. The emergency brake shall be weight operated & thrustor released brake which should be provided on the brake ring fitted on the drive sheave. The service brake shall be weight operator thrustor released brake shall be provided on high speed brake drum coupling.
- In the event of main power supply failure, the system should have a fully rated Diesel Generator to supply power to run drive motors.

- Standby diesel engines should be provided for each station to run ropeway at slow speed in case of failure of the main DC motor.
- Line safety devices should be installed on each trestle holds down & pressure frames which immediately stop the ropeway in the unlikely event of rope derailment. This should comprise an electrical trip limit switch with attachment mounted on a line sheave mount. In an accidental acse, if the hauling rope comes out of line sheaves it should automatically trip the ropeway by the actuation of the limit switch through the attachment.
- Rope catcher will be provided on mount beams on line trestle, P.F. and Stations to arrest/ support the hauling rope in case of deropement.
- Emergency push buttons will be provided at stations to stop the ropeway, if required.
- The ropeway main drive motors to be tripped if:
    - Set rope speed exceed by 5 %
    - Wind speed exceeds the set limit
- The project shall be provided with anemometers to monitor the wind speed and to provide trip signals to the main drive in case wind speed exceeds a predetermined set speed.
- Each station will have a first-aid medical facility.

7.4. Maintenance & Management of Ropeway

7.4.1. Maintenance Record

The ropeway operator will ensure that:

- Written procedures are developed for operating the equipment under all reasonably foreseeable conditions, and that all safety requirements are incorporated into these procedures.
- Records are kept of every critical safety stage in the operation of the ropeway.
- Operating procedures and all other relevant operating records are freely available to any person who operates the equipment.
- All operational data are available for inspection by any authorised person who is involved with the ropeway, including equipment inspectors.

7.4.2. Daily Operational Requirements

Starting of ropeway: The ropeway will be started by the competent person authorised by the management.

Daily inspections: Prior to transporting material/ pilgrims (for Emergency evacuation), a daily inspection will be conducted by competent personnel. As a minimum, the inspection will consist of the following:

- Inspect visually each terminal, station, and the entire length of the ropeway, including grips, hangers and carriers:
- Note the position of tension carriages and counterweights, and ensure that the tensioning system is free to move in both directions.
- Test the operation of all manual and automatic switches in terminals, stations, and loading and unloading areas, as per the manufacturer's specifications.
- Test the operation of main drive and braking systems.
- Test the operation of communication systems.
- Note the general condition of the hauling rope.

7.4.3. Operation Log

- A daily operational log shall be maintained for each ropeway.
- The daily operational log shall include at least the following:
    - Date;
    - Names and duty stations of operating personnel;
    - Operating hours and purpose of operations;
    - Temperature, wind, and weather conditions and changes, with times of changes noted;
    - Record of compliance with daily operational inspection;
    - Position and condition of the tensioning carriage and of the counterweight or other tensioning devices;
    - Accidents, malfunctions, or abnormal occurrences during operation; and
    - Signature of the operator.

7.4.4. Maintenance of Ropeway

The maintenance program will consist of procedures for addressing all components subject to load, wear, corrosion or fatigue. This would include:

- The types of lubricants required and frequency of application;
- The types of testing required and frequency of testing;
- The definitions and measurements to determine excessive wear and replacement criteria.
- The recommended frequency of service to specific parts and details of the service required.
- Identification of other areas that might require specific attention.

7.4.5. Ropeway Management

The ropeway management shall ensure that:

- The ropeway including all safety devices is maintained in accordance with the maintenance and inspection schedules and are kept in safe working condition at all times.
- A procedure is in place which requires any faults found in the ropeway to be reported immediately by the person who finds the fault, investigated and, where necessary, maintained, adjusted, repaired or altered.
- Ropeways that have been subject to maintenance, whether routine maintenance or maintenance in response to a fault found, shall be appropriately tested before re-entering service, to ensure their design compliance.
- All maintenance procedures relating to the ropeway shall be kept in controlled status regularly updated and continually improved and shall be executed by competent persons.

The operator of the ropeway will ensure that:

- The date, time and full details of any maintenance work undertaken and the results of any maintenance procedure carried out.
- Ensure that maintenance records are available for examination by all persons concerned, including equipment inspectors.

- Keep record of running hours and/or number of loading cycles operated by a material ropeway and its condition, where a material ropeway, or any of its components, is subject to condition monitoring.

7.4.6. Inspection of Ropeway

The owner /operator of the ropeway shall ensure that:

- Commissioning inspection has been carried out by an equipment inspector, who shall also witness all relevant tests.
- Formal pre- season inspections are carried out.
- The material ropeway is inspected in-service at least annually for the issue of certificate of inspection.
- Daily and periodic maintenance inspections are carried out.

Inspection Intervals: The operator will ensure that the ropeway is inspected in-service and is:

- Inspected at commissioning, after the first year of service and thereafter at least once in a year.
- Inspected after their re-erection or re-commissioning;
- Inspected after major repairs or alterations; and
- Inspected in the event that they are seriously damaged.

Records: A list of parts to be inspected will be maintained. The operator of the ropeway will maintain records of the date, time, time and results of any inspection carried out and the name of the inspection body engaged.

7.4.7. Tests of Ropeway Operation

The ropeway operator will ensure that:

- All routine tests of emergency procedures, and of alarms, and safety devices, relating to the ropeway, are carried out at appropriate intervals.
- Every overload test is carried out under strict conditions, is monitored at all times and does not exceed the limits specified in the relevant design or operating standard; and
- The material ropeway is not loaded above its safe working load, except for the purposes of an overload test.

The records of the following will be maintained:

- The date, time, details and results of any tests carried out are recorded.
- Comments on the performance of ropeway in any test, and on any maintenance done or any adjustment, alteration, or repair made as a result of any test are recorded; and
- Any data arising from testing are readily available for inspection by authorised persons including equipment inspectors.

7.5. Security Threat Plan and Action Plan to Meet the Eventualities

ISO 27001 and 27002, which are the international best practice information security management standards, defining and guiding Information Security Management System (ISMS) development shall be adopted. These will provide the necessary benchmarking for individual users to know the type of cover and the responsibilities that are defined and provided by that institution for its guests. Most importantly, training staff needs to be regularly imparted in dealing with such situations.

A four tier security plan will be designed for the project:

Tier I Protection against attack from Sky

Tier II: Securing Material Ropeway Terminal Building Externally and Ropeway corridor area

Tier III: Security of Ropeway Terminal Building from Internal Threats

Tier IV: Provision of:

1. proper Surveillance System
2. Training and Security Drills (including Contingency plans)
3. Security of Infrastructure Support Service System
4. Making of Standard Operating Procedures

Tier V: Emergency Response Team

7.5.1. Description of the Tiers:

Tier 1 Protection against attack from Sky

1. In case Terrorists are launched through Helicopters, then Mobile quick reaction teams move on terraces of stations with suitable arms and ammunition which will be backed by a reaction team.
2. Coordination of Security Control Room with Army Defense system through Central Control System of the city/Army/Air Force.

Tier II Securing Material Ropeway Terminal Building Externally and ropeway corridor

1. Manual Checks: At all terminals manual checking will be done for material being transported.
2. CCTV: At all important locations with a remote viewing facility and record back up. With highest resolution and picture quality. DVR being the backbone, its recording and replaying capabilities must be considered.
3. X-Ray Scanners: This may be installed and the bell desk may ensure that all the baggage while being shifted out or goes through the machines. One scanner shall be installed at the terminal station's entry.
4. RFID based access control and smart card applications can also control the movements of guests as well as staff.
5. Zoning System: Apart from these equipment there are agencies providing Zoning systems. This system would be integrated with the BMS and in the event of a terrorist strike it automatically will close the fire exit door and stairs door thus limiting the movement of the terrorist in one place.

Tier III Security of Ropeway Terminal Building from Internal Threats

1. Staff Profiling: All the staff shall be required after proper verification of identity. Smart card identification shall be given.
2. Metal Detectors: Every staff person will walk through metal detectors. There will be one metal detector at the staff entry gate.
3. Safety of weapons: The weapons shall be kept in security.
4. Communication Systems: Proper communication systems to security staff shall help them to coordinate better during emergencies.

Tier IV Provision of:

A. **Proper Surveillance System**

1. Bio – Meteric Access: All the electronic locks are replaced as bio matrix access control in the rooms. It is a suitable way to have fingerprints of staff/ pilgrims (for Emergency evacuation) in the name of a high-end technology.
2. Wireless Mobile Devices: These can be installed at various locations to intercept staff communications.
3. Glass protection System: This is a unique product combination of high security laminate films with chemicals which makes it blast resistant and thus protecting human life and property/material which is transported from the damage caused by splinters.
4. Explosive detectors: With the help of this detector, the security personnel can check various zones and material which is transported for traces of explosives.

B. Training and Security Drills (including Surveillance System)

Disaster planning is the responsibility of all sections of the community. The police, fire brigade, civil defense, Home Guards, press, clergy, industrial groups, and community groups must participate in the pre-disaster planning. The community as a whole has the responsibility to teach first aid to groups in the community that could be utilized in disaster situations. The disaster may involve the normal communication network itself. Therefore, two-way radio systems and messenger systems must be included as backups in the event of a communication-system failure.

Proper training, security drill and evacuation drill shall be conducted in a defined time period, so as to train the management people, security personnel, senior staff and all other staff to take control of all odds whatsoever come in the way. These training shall be conducted for use of weapons and Arms by some trained agencies for the said training. The training shall be done periodically.

C. Security of Infrastructure Support Service System

1. Hourly checking of buildings including Toilets and dust bins.
2. Regular checking of material which is being transported
3. Installation and Precautions of Public Addressing system.
4. Preventive measures for attack on D.G. Sets, Water Treatment System, Water Storages, Ventilation System.
5. Security against Chemical War & Anti hacking devices

D. **Making of Standard Operating Procedures**

A standard operating procedure manual shall be prepared, followed and maintained for all the eventualities due to attack by armed intruders.

Tier V Emergency Response Team

An emergency response team shall be formed.

7.6. Rescue Arrangement for material being transported and pilgrims (for emergency purposes):

- It will be ensured that each tower is accessible, e.g. for maintenance purposes.
- The chosen rescue equipment shall be such that the rescue operation can be carried out in a perfect manner even at the most critical points of the route (over water spread, rugged terrain, high elevation above ground, etc.)

Ambulance Car Arrangement for emergency purpose:

- The proposed ropeway will provide Ambulance activities and arrangements for first aid activities will be maintained for the same.
- Staff specialised in first aid activities will be allocated for the same.

7.7. Emergency Management Cell (Off-site Emergency Planning)

The actions necessary in an emergency depend upon the circumstances. It is imperative that required actions should be initiated and directed by a nominated team having specified responsibilities. An Emergency Management Cell will be formed, so that at the time of any Emergency, the team can work as a coordinator between all affected pilgrims and medical facilities/ requisite measures.

This avoids confusion arising out of a panic situation. The details of proposed Incident Emergency Response Team are as per given hereunder:

1. Site Controller

2. Incident Controller
3. Safety & Security Coordinator
4. Information Officer
5. First aid coordinator
6. Medical Officer
7. Primary Controller

7.8. Role of External Agencies During Emergency

It is expected that the following roles shall be performed by various agencies:

Medical Facilities: Nearest Hospital: Govt Hospital 0.19 Km E (UTP), Government Hospital-0.44 Km SE (UTP), Amrita Hospital 0.33 Km SE (LTP), Govt Hospital Pampa-0.31 Km NE (LTP),

Airport Facility: Trivandrum International Airport-104.22 Km SSW