Project Pre-Feasibility Report (PPR)

NATIONAL GLOF RISK MITIGATION PROGRAMME (NGRMP)

1. **Background (300 words):** *Overview of GLOF risks to State/UT*

Sikkim is a small, mountainous, landlocked border state in the eastern Himalayas. It covers a total area of 7096 square kilometers, of which about 900 square kilometers is covered by glaciers (Worni et al. 2013). The state has ten mountain peaks above 7,000 meters, 84 glaciers, and 320 glacial lakes. Mount Khangchendzonga (8,586 meters), the world's third-highest mountain peak and the highest in the country is located here. The state has the highest and steepest landscape in the country, with weak geology comprising low-grade metamorphic rocks, steep slopes, and rugged terrain. Also, the state receives torrential monsoon rainfall of 300 cm annually. Hence, the state is also a multi-hazard hotspot where natural hazards often cascade where one hazard triggers or exacerbates another, leading to compounded or simultaneous impacts. The cascading natural hazards include a combination of earthquakes, landslides, flash floods, and Glacial Lake Outburst Floods (GLOFs).

Sikkim is facing an increasing threat from GLOFs due to accelerated climate change, leading to glacier recession and the expansion of glacial lakes. These glacial lakes are located in remote, high-altitude regions with harsh climates and difficult accessibility. Of the 189 high-risk glacial lakes identified in the country by NDMA, 40 are located in Sikkim, of which 16 have been classified as Category-A high-risk lakes. These lakes exhibit high susceptibility due to large size, rapid expansion, and unstable moraine structures.

On October 4, 2023, a disaster struck Sikkim when a massive landslide in South Lhonak Lake triggered a glacial flood, destroying the 1,200 MW Teesta Hydroelectric Dam. This disaster severely impacted critical sectors such as transportation, energy, and tourism, causing economic losses estimated at ₹25,000 crores—nearly 60% of the state's GSDP. The event also caused irreversible changes to the river morphometry of the Teesta, with debris deposits raising the riverbed by 7–8 meters, increasing future flood risks. The state is still struggling to recover from this catastrophe. The South Lhonak glacial flood event was a wake-up call for the whole country and underscored the need for comprehensive GLOF risk management of the high-risk lakes.

2. **GLOF Risk Assessment of the State/UTs (500 words):** *This may include an overview of affected areas, available resources, impacted population, critical infrastructure like roads, schools, hospitals, dams, military establishments, power lines, and other public properties, and mention of existing mitigation measures (if any) with analysis of their effectiveness and limitations (if any)*

- **Overview of affected areas, impacted populations, and critical infrastructure, available resources, impacted population, critical infrastructure like roads, schools, hospitals, dams, military establishments, power lines and other public properties, and**

The NDMA has identified 40 high-risk glacial lakes in Sikkim, categorized into A, B, C, and Unclassified groups. Among them, 16 fall into the highest-risk A-category, with 3 in Gyalshing and 13 in Mangan. Twelve of these are in the Lachen Chu watershed, a GLOF hotspot, at elevations ranging from 4,740 to 5,470 m. Their sizes range from 2 to 183 ha, with water volumes of 0.5 to 106 MCM. Ten lakes lack surface outlets, making their moraine dams highly vulnerable. Four lakes have limited freeboard, and 14 face avalanche and icefall hazards. South Lhonak, Changsang, and Gurudongmar lakes have unstable slopes, while six lakes, including Shako Chho, South Lhonak, and Khangchung Chho, are at high risk due to rapid glacial melt (DST-Sikkim, 2024).

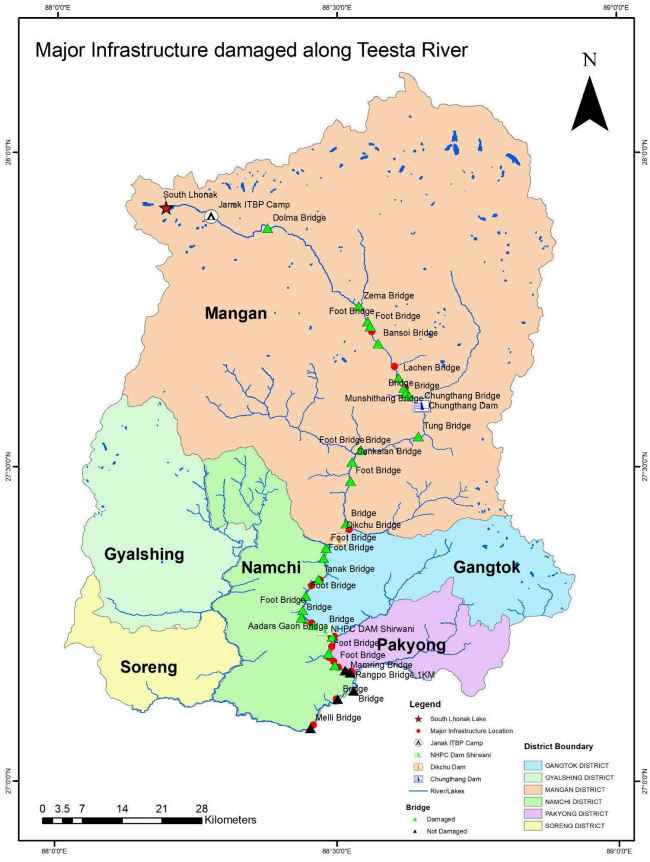

Figure 1. Major infrastructure damaged along the Teesta River due to 2023 glacial flood

The 2023 PDNA Report on the 2023 South Lhonak glacial flood disaster estimated a total loss and damages of Rs 2192.59 crores across multiple sectors, including hydropower, state infrastructure, forests, tourism, border roads, and defense. The report highlights that the destruction of critical infrastructure beyond Lachen was irreversible. The glacial flood has impacted 90,000 people across four districts, causing 48 deaths, 75 missing persons, and damage to over 2,000 houses. It also destroyed 33 bridges and severely affected critical infrastructure (SSDMA 2023).

In mountainous areas, essential infrastructure such as roads, bridges, and power plants are often concentrated along river valleys, making them especially susceptible to flooding and debris flows triggered by GLOFs. Mountain infrastructure, particularly in regions prone to GLOFs, faces unique vulnerabilities that require proactive measures. Early Warning Systems (EWS) are invaluable for saving lives during such disasters, but protecting critical infrastructure remains a pressing concern. Rebuilding damaged infrastructure in this remote and challenging terrain is costly and time-intensive, further underscoring the importance of safeguarding these assets. In the case of Sikkim, several hydroelectric projects are located along the Teesta River. Also, densely populated habitations such as Lachen, Chungthang, Toong, Sangkalang, Dickchu, Makha, Singtam, Bardang, Majhitar, Rangpo, Melli, and some parts of West Bengal which are located along the Teesta River. Industries such as the pharmaceutical, crusher plants, ONGC gas bottling plant, Sikkim Manipal University, Advanced Technical Training Institute, defence establishments, and other infrastructure are located on the Teesta river bank. Protecting mountain infrastructure, both public and private from GLOFs can be addressed only with GLOF risk mitigation projects.

- **mention of existing mitigation measures (if any) with analysis of their effectiveness and limitations**

Despite the urgent need for mitigation, no measures exist for high-risk glacial lakes in Sikkim. Following the disaster, AWS and a pressure probe were installed in Shako Chho and South Lhonak Lake jointly with NDMA and SDC to monitor weather and water level fluctuations, highlighting the necessity for further preventive actions. Therefore, immediate mitigation measures are crucial to safeguard these vital assets and prevent further socio-economic and infrastructural devastation.

3. **Project Overview (250 words):** *Concise summary of the proposed project.*

The project comprises four key components:

- **Comprehensive Hazard and Risk Assessment of High-Risk Glacial Lakes:** This involves field-based bathymetric studies to measure lake volume, electrical resistivity analysis of moraine dams for subsurface geophysical assessments, and hydrodynamic modeling to identify potential flood inundation zones and downstream risks. Multi-temporal change assessments of glacial lakes will also be conducted to monitor evolving hazards.
- **Lake-Level Lowering of Shako Chho Lake:** Based on studies by several agencies and multidisciplinary field studies by DST-Sikkim, Shako Chho Lake (4,960m) has been identified as a priority for risk reduction. Over two years, a non-structural approach using submersible solar pumps will lower the lake level, significantly reducing the GLOF risk and enhancing the safety of downstream communities.
- **Early Warning Systems:** The project will deploy early warning sensors at two key locations downstream of high-risk lakes. These systems will provide real-time monitoring, improving disaster preparedness and response capabilities.
- **Community Awareness and Capacity Building:** The final component focuses on training and equipping local communities and stakeholders with disaster preparedness and risk reduction strategies. Activities include awareness through IEC materials, mock drills, emergency evacuation plans, and educational programs in potential GLOF risk zones to enhance resilience readiness and preparedness.

  This integrated approach ensures proactive GLOF mitigation, combining scientific assessments, technological interventions, and community engagement to safeguard infrastructure and livelihoods in Sikkim's vulnerable mountain regions.

4. **Project Rationale & Objectives (500 words):** *Rationale and Objectives, including hazard assessment, planned mitigation measures, planned AWS & EWS, planned capacity building and community preparedness. Please mention the technical and physical process used to identify the targeted lakes for intervention under this project. Please list the target lakes in Annexure.*

- **Rationale and Objectives**

The rationale and objectives of the project are four-fold. Firstly, take up detailed hazard and risk assessment of the 16 high-risk category-A lakes identified by NDMA by undertaking field expeditions by a multi-disciplinary team. Secondly, GLOF hazard mitigation at Shako Chho Lake can be achieved by lowering the lake level using solar pumps. Thirdly, install EWS in the critical valleys to save human lives, and fourthly develop community preparedness in case of a GLOF event.

- **Hazard assessment**

For hazard assessment of the 16 high-risk Category-A lakes (Figure 2), various studies, such as bathymetric assessment, subsurface geophysical investigation, mass movement probability, 3D terrain mapping using drones, hydrological studies, hydrodynamic modeling for risk assessment, etc., will be carried out. These assessments will be carried out by a multi-disciplinary team of glaciologists, remote sensing scientists, hydrodynamic modelling scientists, ecologists, geographers, geologists, structural engineers, hydropower experts and others who are a part of the various departments of the Government of Sikkim as well as experts in the central government agencies and academia.

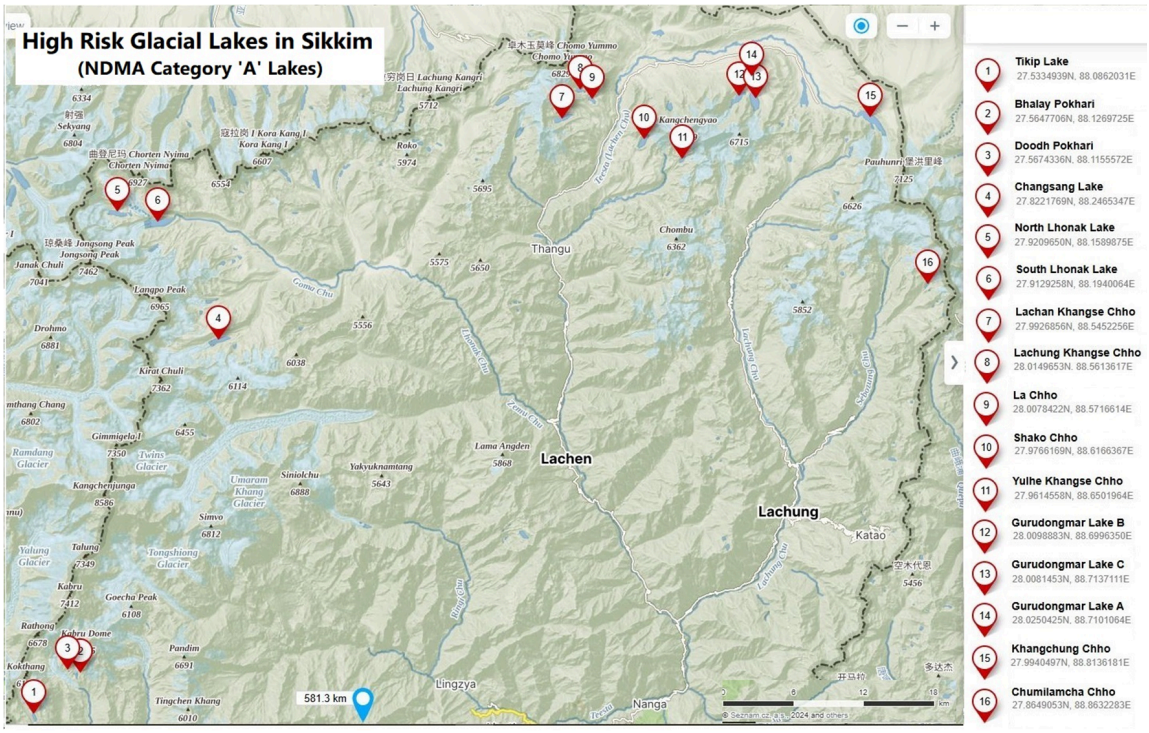

Figure 2: Distribution of the 16 high-risk glacial lakes of Sikkim as identified by NDMA. The location of Shako Chho lake is shown at S. No. 10.

- **Planned mitigation measures**

Shako Chho, a high-risk glacial lake at 4,960 meters elevation, is one of 16 high-risk lakes identified by NDMA (Figure 3). It holds 25 million cubic meters (mcm) of water and is the only one without a natural outlet, an unstable moraine dam through which the water is seeping and which flows immediately into the habitation area. It poses a significant threat, with habitations and Army establishments located just 15 km downstream (DST, 2024). The ERT study shows

that there is a seepage of water below 8 meters of terminal moraine (DMG, 2024). Following field studies of Shako Chho in 2024, the Department of Mines and Geology, Government of Sikkim made specific recommendations, emphasizing that while intervention is necessary, it must be carefully controlled. They recommended using either siphoning techniques or motorized methods to decrease the lake's water volume *(Annexure 2)*. They strongly cautioned that any physical intervention should not disturb the area's geological equilibrium beyond the necessary lowering of water levels.

Option analysis indicates that the structural intervention of the moraines is very risky and not advisable. Hence, non-structural intervention is the only option for lowering the lake level. The usage of the siphon system is ruled out due to the head difference between the lake water level and the moraine summit being more than 20 meters. The use of pump system is the only option. The nearest grid electricity point is at a distance of more than 20 km. Also, the head load distance for fuel carriage is more than 2 km. As heavy pumping is required, the fuel cost will be prohibitively high. Hence, the use of solar pumps seems to be the only option.

The proposed GLOF risk mitigation solution for Shako Chho involves an innovative solar-powered pumping system. The plan aims to reduce the lake's water level in a controlled manner over 48 months. The project will install solar panels on the land adjacent to the lake. The water pumped would be safely discharged into the Chhombo Chu stream and used for the ecological restoration of the dried-up alpine lakes.

Figure 3: Shako Chho Lake at 4960 m is a high-risk lake of Sikkim and holds 25 million cubic meters of water

- **Planned AWS & EWS,**

This proposal plans to install two sets of Early Warning Systems (EWS) integrated with Automated Weather Stations (AWS) sensors at two strategically chosen locations in Sikkim to enhance GLOF mitigation efforts. The system will initially transmit data through the GSM mobile network, with plans to upgrade to satellite communication in collaboration with the ISRO Space Applications Centre (SAC) in Ahmedabad. This will ensure real-time data sharing, allow timely disaster response, reduce hazard impacts, and provide a robust and effective mechanism for GLOF risk management and mitigation.

- **Planned capacity building and community preparedness**

Following the recent Glacial Lake Outburst Flood (GLOF) event, our team engaged communities along the Teesta River Basin through a Participatory Rural Appraisal exercise in May 2024. This initiative across Namchi, Mangan, Pakyong, and Gangtok districts focused on vulnerability assessment and hazard mapping to enhance local resilience.

While community participation yielded valuable insights, we identified gaps including incomplete map verification and partial resource identification in some locations.

Proposed Actions:

- **Map Verification Process**
  - Revisit communities to validate existing hazard maps
  - Incorporate local knowledge to improve accuracy
- **Comprehensive Data Collection**
  - Conduct supplementary surveys in areas with incomplete information
  - Document mobilizable emergency resources
- **Enhanced Awareness Programs**
  - Develop targeted GLOF preparedness materials
  - Conduct drills and establish early warning protocols
- **Community-based Disaster Management Initiatives**
  - Form Disaster Management Teams among local youth
  - Train community volunteers in first aid, search & rescue, and emergency response
  - Establish community-led rapid response groups
- **Stakeholder engagement & coordination**
  - Collaborate with local authorities
  - Organize capacity-building workshops for local leaders.

A sample of the map prepared during the PRA exercise is provided below:

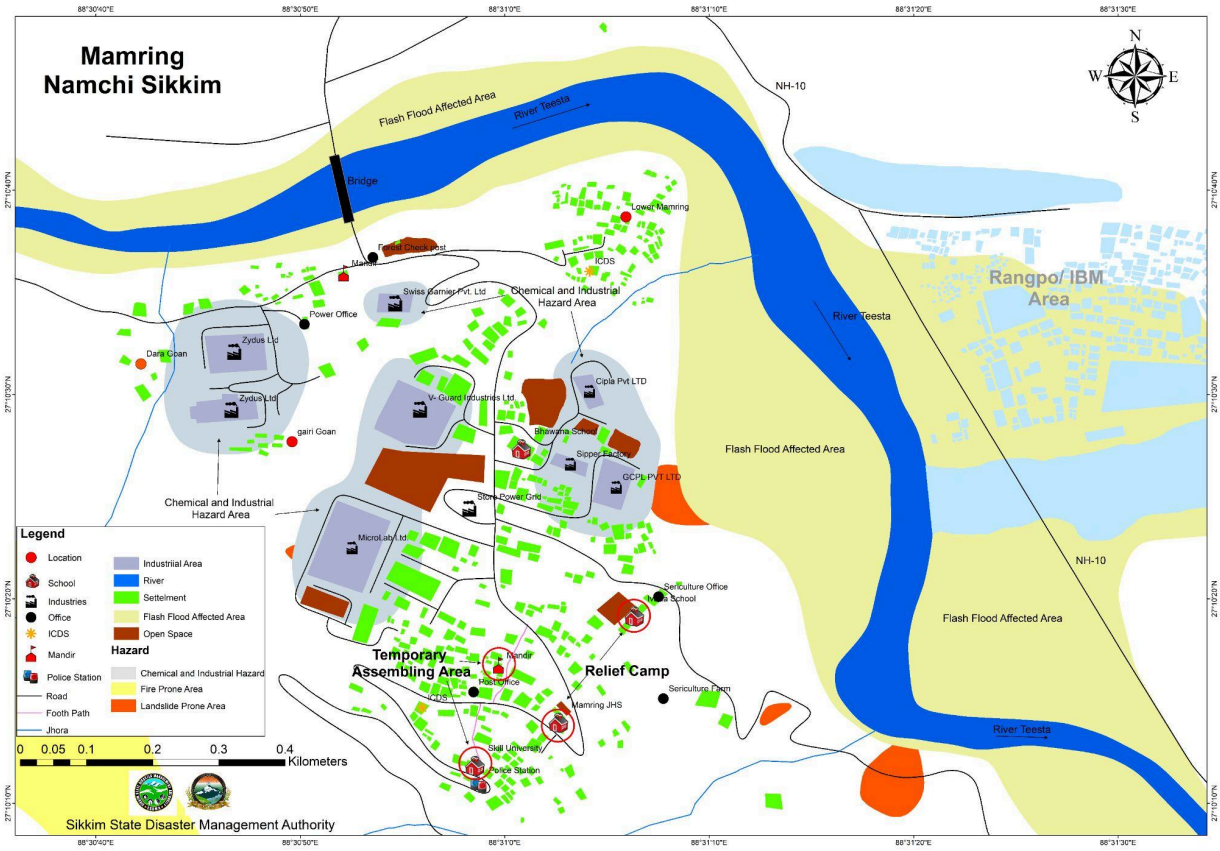

Figure 4. Hazard-risk map prepared for the PRA exercise by SSDMA

- **Please mention the technical and physical processes used to identify the targeted lakes for intervention under this project.**

Shako Chho was identified for intervention under this project based on its high risk assessed by several agencies, researchers, and multi-disciplinary studies conducted by the Sikkim Government in 2024. Shako Chho is one of 16 high-risk lakes identified by NDMA. It is the only one without a natural outlet, an unstable moraine dam through which the water is seeping and which flows immediately into the habitation area, thereby posing a high risk. As highlighted by multiple studies, Shako Chho presents a high risk that makes intervention essential (Worni et al. 2013; SDC 2021; Dubey and Goyal 2020; Rao et al., 2025 (NRSC)). The Swiss Development Corporation (SDC 2021) study identified it as having high failure potential. Thangu village and adjacent defence establishments would have only 8 minutes of warning time in the event of a GLOF, regardless of the flood magnitude, creating an extremely high-risk situation. The NRSC

2025 study assessed Shako Chho as vulnerable due to various key indicators, including the low width-to-height ratio of the end moraine, steep damming moraine composed of loose granular material, and a 1000 m high mountain slope rising above the lake. Field-based studies undertaken by the various departments of the Sikkim Government also validate these studies and underscore the need to urgently intervene to reduce the lake hazard. The detailed susceptibility assessment report of Shako Chho Lake is provided in Annexure 1.

5. Project Details:

Name of the Project (specific name by the State/UT if any)	**GLOF Risk Mitigation in Sikkim (Pilot Project)**
Type of Project (Structural/Non-Structural/Both)	**Both**
Total Budgeted Expenditure (Rs.cr)	**40**
Duration Of the Project (FY and Quarter-wise)	**48 months**

6. Proposed Project Components

Proposed Project Components	Percentage of NGRMP Allocation	Budgeted by State /UT Rs (Cr)	Nature of Proposed Activity
i. GLOF Risk and Vulnerability Assessment A Glacial Lake Outburst Flood (GLOF) risk vulnerability assessment evaluates potential flood risks from glacial lake failures. It identifies high-risk lakes using remote sensing, assesses hazards and risks, and develops mitigation strategies. This includes mapping, equipment procurement, expeditions, field data collection, and risk analysis. It involves multi-disciplinary studies and the classification of lakes by risk level.	15%	(6.00 crore)	A) Preliminary hazard assessment study of high-risk lakes B) Comprehensive hazard & Risk Assessment including 1. Bathymetric survey of high-risk glacial lakes 2. Sub-surface geo-physical investigation by Electrical Resistivity Method (ERT) to assess the moraine stability 3. Hydrodynamic modeling of GLOF for risk assessment 4. 3-D terrain mapping of vicinity/catchment area 5. Discharge measurement

ii. Early Warning Systems (EWS) The 40%funds earmarked for mitigation is insufficient to implement solar pumping at Shako Chho Lake. Hence, it is proposed that out of the total 35% fund allocation under EWS, 10% is sufficient, with the remaining 25% be made available for mitigation measures.	35% (10% is sufficient, Balance 25% will be used to supplement the mitigation component)	(4 crore is sufficient)	The plan involves installing two Early Warning Systems (EWS) at selected locations in Sikkim. Initially, data transmission will be facilitated through the GSM network, with a future upgrade to satellite communication for enhanced reliability and coverage.
iii. Proposed Mitigation Measures The plan aims to lower the lake water level of the high-risk Shako Chho Lake in a controlled manner using solar pumping. The water pumped would be safely discharged into the Chhombo Chu stream and also used for the ecological restoration of the adjacent dried-up alpine lakes.	40% (40 % is not sufficient, so funds will be supplemented from EWS component	(16 crore + 10 crore from EWS, Total = 26 crore)	Solar Pumping to reduce the lake water level of Shako Chho lake

iv. Awareness Generation and Capacity Building Awareness generation and capacity building enhance disaster preparedness by educating communities on hazards, promoting risk reduction, and empowering local populations. They strengthen institutional capacity, improve public participation, and reduce panic. This leads to better disaster response, minimizes losses, and supports sustainable development and climate adaptation.	10%	(4 crore)	1. Awareness through IEC Activities. 2. Incorporation of Traditional Knowledge 3. Community participation through exhibitions 4. GLOF EWS mock drills 5. Emergency Action plan at the community level with the use of signages and maps 6. Pre-trained Disaster Management Teams 7. Training modules/manuals for different target groups 8. Knowledge sharing through the collaboration of national and international organizations

Key challenges and uncertainties

- Understanding how the lake's surrounding environment, including the lake moraine and ecosystem, will react to a lake level lowering.
- In the post-lowering phase, whether the lake will maintain the lowered water level or it will gradually retain its original water level.
- Operating at such a high altitude presents unique technical and environmental challenges, particularly due to extreme cold and freezing conditions. The effectiveness of the technology such as solar pumps under these circumstances remains uncertain.
- If for some reason, the Shako Chho Solar Pumping project faces difficulties during execution, it will be shifted to another suitable glacial lake with prior approval of the State Government and NDMA.

7. Project Highlights (300-500 words): *To include types of interventions proposed (e.g., moraine stabilization, early warning systems, check dams, retention structures, river mouth widening, lake level lowering, etc), significant milestones, and critical deliverables.*

Note: State/UT may include any details thereof as Annexures

The GLOF hazard reduction of Shako Chho Glacial Lake is a novel project that proposes to use solar pumping for lake level lowering. In terms of sustainability assessment, an attempt will be made to restore the adjacent dried-up lakes using the pumped water ecologically. Pumping will not involve any physical tampering of the fragile lake system. Once the target pumping is achieved, after retaining some pumps for maintenance pumping, the remaining pumps can be re-used to lower other critical lakes. Hence, the cost of lowering the lake level will be subsequently reduced. Unlike fossil fuel-powered pumps, solar power is a green energy solution in a fragile ecosystem. The milestones of this project will be approval of the DPR, floating the tender, finalizing the firm, installing a few pumps and solar panels, Proof of Concept (PoC), installing remaining pumps and solar panels, and monitoring the volume of water pumped and the lake level lowered.

The critical deliverable will be to demonstrate proof of concept that the water level of critical glacial lakes can be lowered using solar pumping. It will demonstrate that solar pumping technology is feasible at 17,000 feet in alpine ecosystems to lower the lake water level significantly. The metrics used to measure the success of this project or the key performance indicator will be the volume of water (MCM) pumped and the resulting lowering of the lake level. The baseline data of the lake water level has already been assessed using bathymetric studies and the AWS with webcam and water level monitor installed there. This kind of project has not been undertaken anywhere in the country. This is a pioneering project and if successful, will demonstrate a novel technique for GLOF risk mitigation for the whole country.

In terms of the process, the project will implement the whole-of-government approach (WGA), in which different departments and agencies will work together to execute this project (Figure 5). Glaciologists, remote sensing scientists, hydrodynamic modelling scientists, ecologists, geographers, geologists, structural engineers, hydropower experts, project managers, administrators, and others who are a part of the various departments of the Government of Sikkim as well as experts in the central government agencies will be directly planning, implementing and monitoring this project. Hence, the WGA will involve collaboration across different sectors and levels of government.

Figure 5: Geologists from the Department of Mines and Geology undertaking a subsurface geophysical assessment of the Shako Chho in 2024 to ascertain the stability of the terminal moraine

8. Expected Outcomes (250 words): *To include outcomes like reduction in loss of life and property, impact of EWS, empowerment of local communities and initiation of means of economic resilience, etc.*

- **To include outcomes like reduction in loss of life and property**

The strategic locations downstream of Shako Chho include Thangu village, situated 15 km from the lake, along with other key towns such as Lachen, Chungthang, Toong, Sangkalang, Dickchu, Makha, Singtam, Bardang, Majhitar, Rangpo, Melli, and some parts of West Bengal. A potential GLOF event poses a significant threat to the population residing near the Teesta River, as well as critical infrastructure and military establishments. The study by SDC (2021) indicates that in the event of a GLOF, Thangu village would have an extremely short warning time of just 8 minutes, regardless of the flood magnitude—posing a severe risk to life and infrastructure. Additionally, the GLOF is expected to reach Chungthang more rapidly than those from South Lhonak Lake, with arrival times varying based on flood intensity. Mapping of infrastructure exposed to GLOFs in the Teesta Valley reveals that numerous buildings, defence establishments, and critical infrastructure situated along the river channel in Thangu and Chungthang are highly vulnerable (Figure 6). Beyond these major settlements, several smaller townships also fall within high- and

medium-hazard zones. With the GLOF hazard mitigation at Shako Chho Lake and the setting up of the EWS, this GLOF risk highlighted above is expected to be reduced significantly. More than 1 lakh population is expected to benefit from this initiative.

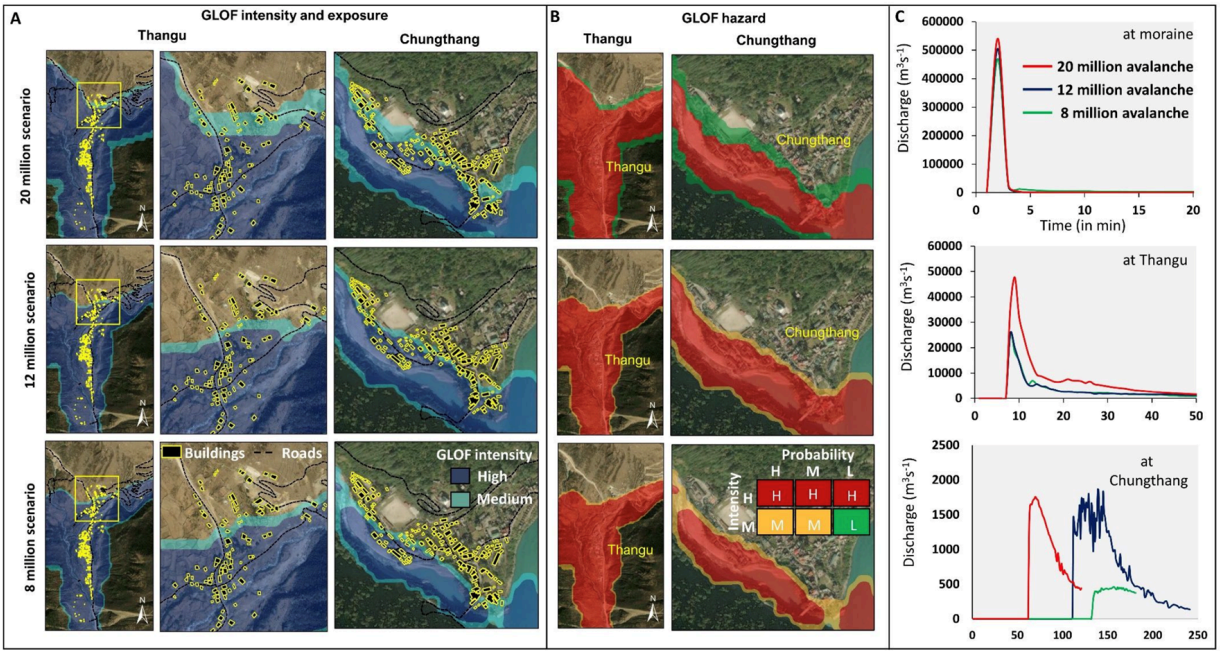

Figure 6. Flood propagation modeled for Shako Chho showing hazard and exposure in Thangu and Chungthang (Source: SDC 2021)

- **Impact of EWS**

Densely populated areas such as Thangu, Lachen, Chungthang, Toong, Sangkalang, Dickchu, Makha, Singtam, Bardang, Majhitar, Rangpo, Melli, and some parts of West Bengal lie in close proximity to the Teesta River, alongside critical infrastructure, including hydroelectric projects, pharmaceutical industries, educational institutions, and defense establishments. Given this high-risk landscape, deploying an early warning system (EWS) at strategic locations is essential for GLOF resilience. A well-integrated EWS can safeguard critical infrastructure—such as hydropower plants, bridges, and roads- by enabling timely protective actions like controlled water release and structural reinforcements. Early warnings also help mitigate economic losses by allowing authorities to implement precautionary measures before disaster strikes.

The devastating glacial flood from South Lhonak Lake in October 2023 underscored the urgent need for a real-time EWS in these high-density zones. The proposed real-time EWS with integrated GSM and satellite connectivity is crucial for protecting human lives and minimizing disaster impacts. It would enhance response times and ensure effective evacuations.

- **Empowerment of local communities**

The proposed community awareness and resilience-building initiative for the Teesta River Basin communities is expected to yield significant positive outcomes:

Through map verification, data collection, and enhanced awareness programs, local communities will develop comprehensive disaster preparedness capabilities. The communities will gain critical knowledge of GLOF hazards, evacuation routes, and emergency procedures, empowering them to make informed decisions during crises.

By actively participating in hazard mapping and resource identification, community members will develop a sense of ownership over the disaster management process. This participatory approach will strengthen social cohesion and establish community-based support networks that can be mobilized during emergencies.

9. Sources for Technical Assistance (300 words): *Please indicate source of such technical assistance for the three phases:*

a) Pre-Project Phase: Support for risk assessments and technical design preparation.

The risk assessments of the high-risk glacial lakes will be conducted by a multi-disciplinary team of scientists and engineers from the various line departments of the Government of Sikkim (such as the Department of Science and Technology, Department of Mines and Geology, Water Resources Department, SSDMA, Forest and Environment Department and Information and Public Relations Department), experts from Central Government Agencies such as the National Disaster Management Authority, Central Water Commission, Geological Survey of India etc. and academia. Various studies such as bathymetric assessment, subsurface geophysical investigation, mass movement probability, 3D terrain mapping using drones, hydrological studies, hydrodynamic modeling for risk assessment, etc. will be carried out by this team. The in-house engineering section of the Department of Science and Technology, Government of Sikkim will develop the technical design for GLOF hazard mitigation.

The Government of Sikkim has a State Executive Committee (SEC), and High-Level Steering Committee (HSLC) and a Multidisciplinary Task Force (MTF) vide notification no. 72/Home/2024, dated 11/9/2024 (Annexure 3). These multidisciplinary institutions include representatives from the State Government, central government agencies (CWC, GSI), and Academia. These committees will review and approve the GLOF risk mitigation projects.

b) Implementation Phase: Ensuring technical oversight and adherence to standards.

Detailed metrics will be developed, and periodic monitoring will be undertaken by setting up multiple sensors and a communication setup. The Multi-disciplinary Task Force (MTF) is also mandated to monitor the execution of the project and will take up periodic field visits to ensure technical oversight and adherence to standards.

c) Post-Completion Phase: Conduct performance reviews and recommending upgrades.

Performance reviews will be taken up by the Multi-disciplinary Task Force (MTF) who will also consult the stakeholders involved in this project. NDMA will also independently assess the performance. Various lessons learned, good practices, and upgrades for the future will be developed by the MTF.

10. Implementation and Monitoring Framework (300 words): *Define agency-wise responsibilities and detailed metrics for assessing progress, such as the number of interventions completed and community training sessions held.*

- **Agency wise responsibilities**

The Department of Science and Technology (DST) will implement the three components of i) GLOF Risk and Vulnerability Assessment, ii) Early Warning Systems (EWS), and iii) Proposed Mitigation Measures while the SSDMA will implement the Awareness Generation and Capacity Building initiative. The Government of Sikkim has constituted a State Executive Committee (SEC), and a High-Level Steering Committee (HSLC) and a Multi-disciplinary Task Force (MTF) constituted vide notification no. dated 72/Home/2024 dated 11/9/2024 *(Annexure 3)*. These multi-disciplinary institutions have representation from various line departments of the state government, central government agencies such as the Central Water Commission and Geological Survey of India, and representatives from academia in the form of the Sikkim University. These committees are mandated to carry out the planning, monitoring, and evaluation of the GLOF risk mitigation projects.

- **Metrics for assessing progress**

The DST will undertake multiple expeditions, during which the GLOF risk and vulnerability assessment will be undertaken for the Category-A high-risk lakes identified by NDMA. These expeditions will cover the Mangan and Gyalshing districts of Sikkim. The EWS will be installed in valleys to cover the maximum number of Category-A high-risk lakes identified by NDMA. GSM-based communication will be used. Hence, suitable locations such as Thangu, Zema, Yuksom, and others will be explored. For the Shako Chho solar pumping project the main physical parameter to measure the performance would be the volume (mcm) of water pumped out and the resultant reduction in the lake water level. The baseline data of the lake water level has already been assessed using bathymetric studies and the AWS with webcam and water level monitor installed there. The actual targets and performance indicators will be determined during

the project execution stage and a quarterly progress reporting (QPR) format will be developed with measurable performance indicators and targets, which can then be used to track the progress of the project. A baseline assessment of the water level of Shako Chho Lake has already been carried out using bathymetric studies and the installation of AWS with a water level monitor has already been completed.

Assessing the progress of capacity-building measures in the vulnerable GLOF (Glacial Lake Outburst Flood) areas will be made through key indicators like communities' evacuation route knowledge, maintenance of evacuation routes, mock drill frequency, community awareness levels during the emergency mock drills, functionality of early warning systems with emphasis on last mile connectivity, and updation of response plans. Additionally, response and recovery metrics, such as reduced casualties and economic losses, and long-term sustainability metrics, like community ownership and adaptive capacity, will provide a comprehensive evaluation.

11. Quality Assurance and Documentation (250 words): *Include third-party evaluations; maintain a comprehensive database of activities, lessons learned, and periodic progress reports; detailed completion report summarizing outcomes, including recommendations for future projects; and plan to ensure in-house capacity building through this project implementation process.*

- **Include third-party evaluations**

The Government of Sikkim has constituted a State Executive Committee (SEC), a High-Level Steering Committee (HSLC), and a Multi-disciplinary Task Force (MTF) vide notification no. dated 72/Home/2024 dated 11/9/2024 *(Annexure 3)*. These multi-disciplinary institutions have representation from the State Government, Central Government Agencies (CWC, GSI), and Academia. These committees are mandated to carry out the planning, monitoring, and evaluation of the GLOF risk mitigation projects.

- **Maintain a comprehensive database of activities, lessons learned,**

Comprehensive documentation will be carried out, including details of the activities taken, a database of the performance indicators, and photographs. The data generated will be stored in Excel format for ready reference and future analysis. Various challenges faced, common pitfalls, and good practices will be documented.

- **Periodic progress reports; detailed completion report summarizing outcomes, including recommendations for future projects; and**

Before the commencement of the project, a Quarterly Progress Report (QPR) with targets and milestones will be finalized and followed. This QPR will be cumulatively updated and will form the main periodic progress report. A baseline assessment of the water level of Shako Chho Lake

has already been carried out using bathymetric studies and the installation of AWS with a water level monitor (Figure 7). Once the project is completed, a detailed completion report will be prepared indicating the inputs, activities, outputs, and outcomes. It will also have a section on various challenges faced, common pitfalls, good practices, and recommendations for future projects.

Figure 7: An AWS with webcams and lake water level monitors has already been installed at Shako Chho Lake. This independent data, along with field-level monitoring, will help provide a robust monitoring framework for the lake-level-lowering project.

- **Plan to ensure in-house capacity building through this project implementation process.**

This project aims to implement the whole-of-government approach (WGA) to ensure in-house capacity building. Glaciologists, remote sensing scientists, hydrodynamic modelling scientists, ecologists, geographers, geologists, hydrologists, structural engineers, hydropower experts, and others who are a part of the various departments of the Government of Sikkim as well as experts in the central government agencies will be directly planning, implementing and monitoring this

project. Also, the local communities in the border areas will be actively involved and will participate in the project implementation.

Note: State/UT may include any details thereof as Annexures

12. Compliance with NDMF Guidelines (200 words): *Provide basic details of the project and explain how this project is going to fulfill the guidelines of NDMF.*

This project complies with the Guidelines on Constitution and Administration of the National Disaster Mitigation Fund (NDMF) and the State Disaster Mitigation Fund (SDMF) through the following measures:

Mitigation Measures: This project has Structural Mitigation measures by way of piloting an engineering intervention at the lake level and non-structural interventions by conducting intensive community-level exercises including preparation of evacuation and response plans, creation of disaster management teams, conducting mock drills, and other related activities.

Scope of NDMF & SDMF:

- This project is important from a disaster point of view as it has a regional impact.
- The Project will utilize 10% of the SDMF component
- The pilot project has an overall vision of protecting critical assets, ecosystems, and settlements within the State
- The project envisages community resilience through information and knowledge
- The project focuses on creating safe conditions of living for people from weaker socio-economic categories, people with disabilities, and women

This project will be vetted by the High-Level Committee formed by the Government of Sikkim as well as the State Executive Committee. It will also follow the mechanism for the execution of the project as laid down in the guidelines.

The project also conforms with the NDMA Guidelines Management of Glacial Lake Outburst Floods (GLOF), published in 2020:

- **Page 5 of NDMA GLOF Guidelines (Para 1)**
  Where potentially critical, high-priority lakes are identified, detailed hazard and risk assessments should be undertaken, combining sophisticated hazard modelling and mapping with an on-ground assessment of vulnerability and exposure to generate local hazard and risk maps. Field studies are crucial to establish conditions of the lake (depth, volume), the dam characteristics (composition, geometry, stability, etc.), and to engage with potentially affected downstream communities.

The first component of this proposal namely, "GLOF Risk and Vulnerability Assessment" wherein hazard and risk mapping along with field studies will be undertaken, is based on this guidance

- **Page 8 of NDMA GLOF Guidelines (Para 1) - Early Warning Systems**
  Early Warning Systems (EWS) are commonly agreed upon as the most effective approach to disaster risk reduction in communities that are exposed to climate-related disasters.
  The second component of this proposal namely "Early Warning Systems (EWS)" is based on this guidance.

- **Page 7 of NDMA GLOF Guidelines (Para 2)**
  Risk reduction and mitigation measures can be effective on each of the three components of risk, i.e. reduction of hazard, exposure or vulnerability, respectively (Fig. 4), and on different time scales (short- and long-term measures). In the short term actions on reduction of hazard in Figure 4, lowering of lake level (siphoning or pumping) is indicated.
  The third component of this proposal namely "Proposed Mitigation Measures" wherein lake level lowering of Shako Chho lake by solar pumping has been proposed is based on this guidance.

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Annexures

1. GLOF Susceptibility Assessment of Shako Chho, Mangan District, Sikkim (2024). Science and Technology Department, Government of Sikkim
2. Geological Report on Shako Chho Lake, Mangan District (2024). Department of Miners and Geology, Government of Sikkim
3. Constitution of a High-Level Steering Committee (HSLC) and Multi-disciplinary Task Force (MTF) by the State Government vide notification no. dated 72/Home/2024 dated 11/9/2024.