Deep Diving Capabilities and Operational Challenges of Armed Police Force, Nepal: Analysing the Simaltaal Accident

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Abstract

Nepal's geographical slopes and structure and road construction along the rivers have made road safety a critical concern, on key highways like the Kathmandu-Narayangadh, Karnali, Sunkoshi, etc. In particular, the road from Kathmandu-Narayangadh goes alongside the Trishuli River, and road accidents plunging into the river following are frequently observed on that highway. This study explores the capability of the Armed Police Force (APF), Nepal in deep diving and the operational challenges faced by the rescuers during the rescue operation in the Simaltaal accident, which needs to be addressed by the Government of Nepal for the safety and security of property and people. Because of the high number of incidents due to overspeeding, challenging terrain, and poor infrastructure, the APF, Nepal Disaster Management Training School (DMTS) plays a crucial role in rescuing victims. The research employs a descriptive design, and qualitative approach, employing both primary and secondary data to discuss the capability and operational challenges of deep diving rescuers. The findings reveal that the APF, Nepal's preparedness and response in disaster management particularly, in swift water rescue operations is effective and efficient. The available rescue devices and equipment such as pipe inspection sewer cameras, sound navigation and ranging, sewer, underwater drones, rubber boats, and outboard motors have been utilized effectively in swift water rescue operations. The research concludes with suggestions for further improving disaster rescue operations by providing advanced swift-water rescue devices and equipment, and welfare facilities to the rescuers.

1. Introduction

The fragile geology and steep topography have made Nepal the 20th topmost disaster-prone country in the world. Among 200 countries, Nepal ranks 4th, 11th, and 30th in relative vulnerability to climate change, earthquake, and flood hazards, respectively (*Ministry of Home Affairs*, 2023). Nepal's geographical positioning renders it vulnerable to various natural disasters, including earthquakes, fire, drought, epidemics, storm hailstorms, avalanches, Glacier Lake Out-Brust Flood (GLOF), floods, and landslides (Dixit, 2003). Accidents can be caused by human failure, material failure, or bad weather, and this may lead to damage that takes the form of the loss of the vessel, damage to the hull, personal damage, human loss, and ecological damage (Cahill, 1983; Li, 2017).

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Moreover, according to (Dewan, 2015), Nepal has more than 6000 snow-fed perennial rivers and rivulets. Most of those rivers, originated from the Himalayas and after sliding from hills, flow through the Terai plains making the entire Terai floodplain prone to severe floods. Nepal has been affected by extreme weather events resulting in natural disasters such as floods and landslides (Yogacharya & Gautam, 2008). Devastating floods occur in the central Himalayas of Nepal during the monsoon months of June through September.

In 2015, earthquakes and their aftershocks caused over 8,790 deaths, and 22,300 injuries; half a million homes were destroyed; and hundreds of historical and cultural monuments were destroyed or extensively damaged (Lizundia et al., 2017; National Planning Commission, 2015). Likewise, Jure village, Sindhupalchowk killed 156 people by a rainfall-induced massive landslide. So, these events show that natural disasters have a significant effect on human life in Nepal. Likewise, annual floods cause enormous damage worldwide (Jonkman, 2005), which is a sudden outflow of a high volume of water beyond the river channel for a short time (Leopold et al., 1964). According to Bipad Portal data, the total number of natural disaster events documented from 2023/08/23 to 2024/08/22 was 7827, with 577 deaths, 45 missing, and 1635 injured in Nepal. Moreover, particularly by flood and landslides, 185 people lost their lives in the 1004 incident (Bipad Portal, 2024). As Nepal is located in mountainous terrain in the Himalayan arc, landslides are common and are the main cause of natural hazards (Paudel et al., 2003).

A landslide, caused by continuous rainfall from the previous day, swept two buses with 65 passengers into the Trishuli River in Simaltaal, Chitwan district on July 12, 2024. The river was also flooded by the heavy rainfall. The continuous rain caused the landslide that swept the busses into the river where the passenger remained missing in the heavily flooded river. This chain series of hazards made a cascading disaster which showed the cascading effect in the human missing.

According to Pescaroli and Alexander (2015), cascading disaster and cascading effects mean:

“Cascading disasters are intense events, in which cascading effects increase in development over time and generate unexpected secondary events of strong impact. These tend to be at least as serious as the original event and contribute significantly to the overall duration of the disaster’s effects. These subsequent and unanticipated crises can be exacerbated by the failure of physical structures and the social functions that depend on them, including critical facilities, or by the inadequacy of disaster mitigation strategies, such as evacuation procedures, land use planning, and emergency management strategies. Cascading disasters tend to highlight unresolved vulnerabilities in human society. In cascading disasters, one or more secondary events can be identified and distinguished from the source of disaster.”

According to the definition of International Maritime Organization, "Search is an operation, normally coordinated by rescue coordination centre or rescue sub-centre, using available personnel and facilities to locate persons in distress and rescue as the operation to retrieve persons in distress, provide for their initial medical or other needs and deliver them to a place of safety (International Maritime Organization, 1974). From a technical point of view, search,

and rescue refers to the process of finding and providing assistance to those who are in danger or at risk from an external action. Any action aimed at avoiding a great ecological or economic tragedy can also be considered in the last as a rescue operation (Achutegui, 1990).

Simaltaal accident landslide, caused by continuous rainfall, swept two buses into the Trishuli River in Simaltaal, Bharatpur Metropolitan City Ward No. 29, Chitwan District, along the Mugling-Narayangadh road section. One bus, Bagmati Province 03-006 K 1516 Angel Deluxe, was en route from Birgunj to Kathmandu with about 37/38 passengers, and another bus, Bagmati Province 03-001 K 2495 Ganpati Deluxe, was heading from Kathmandu to Gaur with about 26/27 passengers. Among the 65 passengers, three managed to survive by jumping from the bus, but the rest were swept away by the landslide into the river and went missing.

Since the establishment of APF, Nepal DMTS in 2011, has been deploying in Kathmandu-Narayangadh, and Mugling-Pokhara road accidents. From the day of the tragic incident of Simaltaal APF, Nepal DMTS Kurintar, APF, Nepal No. 17th Battalion, Chitwan, Nepali Army, and Nepal Police were immediately deployed for rescue operations. The specialized Deep Diving team and disaster management trained personnel from APF, Nepal DMTS carried out search and rescue operations. During the search and rescue operations the Hi-Target surveying eco-sounder device of Innovative Technological Solution Pvt. was also employed by APF, Nepal. The team of the National Disaster Response Force, with advanced sonar and divers, also performed search and rescue operations jointly with APF, Nepal.

2. Methodology

This study employs a descriptive research design based on a qualitative approach to assess the role of APF, Nepal in responding to road accident rescue operations on the Kathmandu-Narayangadh highway by analyzing the accident of Simaltaal. Both primary and secondary data have been employed for the study. For the primary data, Key Informant Interviews (KII) were taken from rescuers of APF, Nepal DMTS who were directly involved in the rescue operation of the Simaltaal accident. Likewise, the details of disaster management units of APF, Nepal were collected from APF, Nepal Headquarters. The data was used to find out the deep diving capability and operational challenges of APF, Nepal in rescue operations in Trishuli River.

For the primary data, five deep-diving rescuers and experts from APF, Nepal DMTS, and KIs were interviewed to understand the capability, rescue methods, equipment, and challenges during the rescue operation. KIs were involved in Simaltaal rescue operations and other various road accidents, drowning cases, and swift water rescue operations along with the earthquake in 2015, the Melamchi flood, Jure landslides, etc.

Based on both findings derived from primary and secondary data, the suggestions for further improving disaster rescue operations by focusing on training, providing advanced tools, equipment, and technologies, and reward facilities for rescuers in enhancing deep diving rescue operations on hazardous rivers were forwarded. So, the response and rescue operation of APF, Nepal will be more efficient and effective.

3. Result and Discussion

3.1 Training and Capacity Building in Disaster Management

APF, Nepal DMTS has been conducting various training in the disaster management field such as collapsed structure search and rescue, swift water search and rescue, deep diving, firefighting dead body management, medical first responder, and rope rescue with cable car rescue training. Considering the recurrent accidents on the Kathmandu-Narayangadh and Mugling-Pokhara highways it has established a Trauma Hospital inside the DMTS with the help of the US Embassy. Some 2669 personnel have specialized in disaster management by conducting various training.

3.2 Methods Used in Search and Rescue Operations

Search and rescue (SAR) operations during river floods employ several innovative methods to enhance efficiency and safety. Recent advancements focus on utilizing unmanned vehicles, sensor networks, and path-planning algorithms to optimize rescue efforts. The remote-controlled unmanned water vehicles utilize the YOLOv4 algorithm for real-time human detection, achieving an accuracy of 91.49%. They provide live video feeds and GPS location data, significantly reducing risks to SAR personnel (Llanes et al., 2023). Likewise, unmanned aerial vehicles are employed for aerial imaging, which aids in mapping flooded areas and locating victims. This information is crucial for organizing rescue operations effectively (Ozkan et al., 2019).

APF, Nepal utilized its deep diving personnel with Pipe Inspection Sewer Cameras, Sound Navigation and Ranging (SONAR), Underwater Drone, and Out Board Motorboat (OBM) for effective and efficient search and rescue. Moreover, the rubber rafts were used for river surveillance by a group of rescuers from Simaltaal to the Shivghat area. According to rescuers, a total of 24 dead bodies were found but the remaining passengers and buses are still missing.

According to KI Sub Inspector (SI) Ramesh Thapa, they had utilized all available resources and technologies of APF, Nepal. When they got information they deployed with a mass-casualty response vehicle equipped with nurses, oxygen cylinders, and basic medicines.

3.3 Pipe Inspection Sewer Camera

A Pipe Inspection Sewer Camera is a specialized device used to assess the condition of sewer pipes by capturing video footage of their interiors. This technology is crucial for maintaining urban infrastructure and ensuring public safety by capturing video, processing images, and utilizing wireless technology to link video frames to specific locations with the pipeline, enhancing the accuracy of defect identifications (Chikamoto et al., 2023). Pipe inspection sewer cameras operate through advanced imaging and data transmission technologies to assess the condition of underground sewer systems. These systems utilize various methods, including video capture (Chikamoto et al.,

2023), image processing (Nishida *et al.*, 2024), and 3D reconstruction (Harshini et al., 2022), to identify defects and ensure infrastructure integrity.

The APF, Nepal had used a pipe inspection sewer camera in a search and rescue operation in Trishuli River locating the hole between the stones, woods, and corners, although these are effective in still water and to clear the obstruction inside the drainage and canal.

According to KI, Senior Officer:

"We used pipe inspection sewer cameras, too for the search and rescue of the victims. This camera is effective in corners, holes between the stones, etc. As the capacity to identify the object of this device in the monitor, is 20 meters, we located the corners, holes, and other suspected areas and utilized this device from Simaltaal to Shivghat for searching the victims and buses into rivers.

Furthermore, he stated that:

"Daily 5 deep diving team used to be deployed with other disaster management trained manpower. So, with the help of this device, we searched thoroughly in the suspected areas."

3.4 Sound Navigation and Ranging (SONAR)

Sound Navigation and Ranging (SONAR) is a technique that utilizes sound waves to determine the position and distance of objects underwater or in other challenging environments (Khare & Mani, 2022). Sound navigation and ranging (Sonar) play a crucial role in enhancing the effectiveness of rescue operations, particularly in challenging environments. Various technologies leverage sound for localization, navigation, and communication, significantly improving the chances of successful rescues (Goll & Maximova, 2019). In June 2009, to search for the missing Air France Flight 447 with passengers and crew over the South Atlantic, the Remote Environmental Monitoring Units (REMUS) autonomous underwater vehicles (AUVs), side-looking sonar, and side-scan sonar through Triton Remotely Operated Vehicles (ROV) were also accounted for surface searches in sea, which can operate in 3000 m water depth while it is equipped with various instruments enabling advanced survey activities in all subsea conditions (Stone et al., 2011).

Raymarine a56 (model e7077) is a marine multifunction display designed primarily for boating. It features a Global Positioning System (GPS) which supports SONAR functionality and connects with apps wirelessly for remote and data sharing. This device was used by the deep diving rescue team, which is available with APF, Nepal DMTS, to search and rescue at Simaltaal accident. Likewise, Innovative Technological Solution Pvt. Ltd., Lalitpur supported by providing a Hi-Target Surveying Eco Sounder Device in the search operation. This device is basically, more specialized and modern for hydrographic depth data record.

Moreover, along with 4 deep divers, a total of 12 personnel from the National Disaster Response Force (NDRF) from India deployed with advanced SONAR and magnetic devices together with APF, Nepal. Two magnetic devices of 14 kg and 19 kg were brought with them. The team searched from the accident place to 35 km up to the Kavreghat area. But due to the depth and high current of the river the missing buses and personnel couldn't be found.

According to KI, SI Ramesh Thapa:

"Our SONAR device was not as advanced as India's NDRF team has, still we tried our best to search the missing. The main obstacles or barriers were the high current of the river and its unknown depth. These devices are mainly, made for still water such as ponds, lakes, and, the sea but in the context of Nepal, we have to employ these devices in flowing water. Due to the geographical slope, the current of the rivers is high in the mountain and hilly regions. So, these devices cannot produce good results. Moreover, we have been working in this field for 12 years, and in this river for more than 5 years. So, we know the anatomy, characterization, and current of the river better than rescuers from another country. Despite high technology coordinating with Innovative Technological Solution, NDRF couldn't find out the missing buses and passengers because of the above reasons."

3.5 Under Water Drone

Underwater drones, or unmanned underwater vehicles (UUVs), are advanced robotic systems designed for various applications in aquatic environments. These drones are equipped with sophisticated technologies, including high-definition cameras and sensors, enabling them to perform tasks such as exploration, surveillance, and environmental monitoring. Moreover, many underwater drones are equipped with high-definition cameras for capturing images and videos, facilitating detailed exploration and monitoring of marine environments (V. V Dhole, 2024). Likewise, certain models are designed to operate in the air and underwater, showcasing versatility for military and research applications (Hosur et al., 2024).

The underwater drone was used by APF, Nepal to search the buses and missing passengers in the Simaltaal River. By sending the drone under the water the camera attached to it sends the image to the monitor outside and then the object can be identified by the shape.

According to KI, Senior Head Constable:

"The drone was used to search in the accident area and around 500 meters in the river. Due to the high current of the river, this underwater couldn't be as effective as it can be in sea, lakes, ponds, etc. When we drove the drone under water it used to sweep away because of the high current of the river. Therefore, this device couldn't be effective in the following river. The next thing is, the depth of the river is unknown from place to place, so there was a chance of losing the device. Another, as the capacity of the drone is very low, the search operations by using our underwater device couldn't be as expected."

3.6 Surveillance through River Run Using Raft Boat and Out Board Motor Boat (OBM)

Surveillance using raft boats for rescue operations is an innovative approach that enhances the efficiency and effectiveness of emergency responses, particularly in flood scenarios. Due to the high current and depth of the river, there was a need to inspect the area because the missing passengers and buses could be stocked in any place. Moreover, using a helicopter was risky because of the ridges and narrow hills, APF, Nepal started to search using robber boats side by side.

Moreover, outboard motors are essential for effective flood rescue operations in rivers, providing the necessary power and manoeuvrability to navigate turbulent waters. Their design allows for rapid deployment and efficient operation in emergencies, making them invaluable tools for rescuers (Mårtensson et al., 2015). Outboard motors enable rescue teams to reach victims quickly, even in fast-flowing currents, which is critical during floods (Terry, 2010).

APF, Nepal has been conducting OBM training since its establishment as a part of disaster management. It has medium-size OBM only and the main feature is; that it can be used only in static water. Though it was used by taking risks for search of the Trishuli River. Surveillance through the river can be best as the rescuers are involved in close inspection of the area. They utilized locally improvised methods to find out the location of the missing, too.

According to KI, Constable

> *In all the places sending drones and using SONAR was not appropriate and possible, so we used improvised devices such as long bamboo, sticks, etc. from which we could feel some strange objects inside the river.*

Moreover, he added about the adverse weather:

> *"The continuous heavy rain was the main challenge of the search team. Despite all the situation we were fully involved in the operations. The surveillance of the whole 34 km river was not possible in one day. So, we continued our search operation by dividing the different teams and marking the place. The challenge was that the marking signs used to be washed away by the heavy rain, the next day. Waking up early in the morning, preparing the search devices and equipment, and mobilizing to search the vehicles and missing people was day-by-day work. Though we employed all our capacity and available devices, we couldn't find all the missing passengers. Even the two buses are still unknown."*

3.7 Deep Diving

Deep diving training is a specialized preparation for rescuers involved in river flood operations, emphasizing safety and efficiency in high-risk environments. This training is crucial as it equips responders with the skills to handle emergencies effectively,

particularly in flood scenarios where drowning risks are heightened. Training programs enhance the knowledge and skills of water incident responders, enabling them to perform rescues safely and effectively during floods (Beerens et al., 2014).

According to APF, Nepal Headquarters for the deep diving training,25 APF Nepal personnel were sent to Bangladesh in 2069 to meet the need to rescue from rivers, ponds, lakes, etc. Among them, only 16 are remaining in the organization. Now, deep diving training has been given to its personnel by trained manpower of APF, Nepal, and reached a total number of 110. This trained manpower are deployed in all 7 Brigades, DMTS Kurintar, Chitwan, Disaster Rescue Battalion Sinamanga, Sindhuli, Khurkot, and 24 Battalion Kaski.

According to KI, SI Ramesh Thapa

"When we reached at accident place, we saw the landslide caused by flood which swept the road into the rivers. We consulted with the eye-witnessed and tried to locate the buses and the missing passengers. The flood of the Trishuli River was too high as the rainfall was continuous from the previous day. As we were all 25 disaster management personnel with a deep diving team we started search and rescue immediately."

According to another KI, HC Dilli Bhattarai:

"As the morning began, we started the search into the Trishuli River by wearing a Self-Contained Underwater Breathing Apparatus (SCUBA) Diving Set such as a Wet Suit, Oxygen Cylinder, Weight, Hood, Knife, Back Inflation Diving System/Buoyancy Control Device, Regular etc. By using those teams Open Circuit Diving System methods were used with Line Signals during search into the river. We (the Deep Diving Team) searched the 24 Kilometres from Simaltaal to Devghat by locating the suspected area.

3.8 Operational Challenges Faced During the Rescue

The challenges faced during the vehicle and missing person search and rescue operation were multifaceted. On the day of the incident, landslides blocked various points on the route that rescuers needed to access the accident site. The other main challenges were the water level, and its currents, created additional obstacles, including timing waves, whirlpools, and eddy lines which hampered the search efforts. Moreover, the hazardous river conditions are characterized by sharp and large rocks, and muddy, debris-filled water making it difficult to utilize available resources effectively.

The water level was extremely high with a rapid current which made it difficult to stabilize rafts, deep divers, and search devices such as underwater drones and pipe inspection sewer cameras. Likewise, the large crevices and massive logs carried by the river created a high risk to divers. Sometimes, the aquatic animals like crocodiles in the south of Devghat also became threats.

The main challenges included the lack of modern equipment, including difficulties using rafts and OBM in strong currents, the camera-based devices, and the SONAR device's

inability to capture clear sketches if the boat was not stationary, including fast-flowing rivers during the monsoon, was significant challenges.

Another challenge was the lack of motivation for the rescuers. According to the rescuers, the incentive is only 300 Nepali rupees on the day of deployment in the river rescue for deep divers. Though the APF, Nepal has provisioned for 10 lakh insurance, it is low compared to the threat the deep divers face during the swift water rescue.

In conclusion, the anatomy of the Trishuli River itself was a challenge during the search and rescue operation. Moreover, the high monsoon current and the river depth remain as challenges. The unavailability of modern equipment and devices was another challenge of the rescue operation.

4. Conclusion

The study highlights the complex challenges faced by the Armed Police Force (APF), Nepal, during search and rescue operations following a swift water disaster on the Trishuli River. The combination of severe weather, high river currents, and limited access to modern equipment complicated efforts to locate missing vehicles and passengers in the Trishuli River. Despite deploying deep divers and advanced technologies like sound navigation and ranging systems, underwater drones, and Pipe Inspection Sewer Cameras, the search yielded limited success due to the river's treacherous conditions. Operational obstacles included dangerous watercourse environments, inadequate resources, and insufficient incentives for rescuers. The research emphasizes the need for further improving disaster rescue operations by providing advanced swift-water rescue devices and equipment, and welfare facilities to the rescuers.

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