

From Early Warning to Recovery: A Conceptual Model of Multi-Agency Coordination and Emergency Operations During Cyclone Biparjoy in Gujarat

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Abstract

Disaster management is increasingly moving from purely reactive emergency response to a combination of preparedness, well-orchestrated operations, and a robust recovery. Cyclone Biparjoy, which hit the Gujarat coast in June 2023, offers a good example to study how early warning systems, joint efforts by institutions, technology-supported decisionmaking, and post-disaster recovery together can be disaster resilience tools. This paper proposes a conceptual model through the disaster management cycle from early warning to the end of recovery using the Cyclone Biparjoy operational response in Gujarat as a basis. The study draws together different literatures, government documents, and published evidence to detail how the role of the India Meteorological Department (IMD), the State Emergency Operation Centre (SEOC), the Gujarat State Disaster Management Authority (GSDMA), the National Disaster Response Force (NDRF), the State Disaster Response Force (SDRF), and the other organizations contribute to preparedness and emergency operations at different levels. Apart from that, the paper touches upon the topics such as evacuation planning, humanitarian aid, resource mobilization, geospatial tech, GIS-based decision support and post-disaster restoration work. The proposed conceptual framework illustrates that timely information dissemination, good teamwork across multiple departments, technological intervention for accurate awareness about the situation and constant institutional learning can effectively improve not only the disaster response but also the community's overall resilience against disasters. Closing remarks draw attention to the role and relevance of coordinated governance, forward-looking strategies, and regular strengthening of capabilities to enhance existing as well as future disaster risk reduction plans for cyclogonal storm.

Keywords: Cyclone Biparjoy, Multi-Agency Coordination, Disaster Preparedness, Emergency Operations, Disaster Resilience

Introduction

Cyclones are extremely low-pressure atmospheric systems distinguished mainly by very strong winds and heavy rainfall; they often come with storm surges and thunderstorms (Sheikh & Sheikh, 2023). Typically, cyclones form in the warm tropical seas where sea surface temperatures are above 26.5°C. In such conditions the atmosphere is capable of developing and maintaining strong rotating storms (Rathaur et al., 2023). Depending on the location of the country these kinds of systems are called tropical cyclones, hurricanes or typhoons. The Indian Meteorological Department (IMD) in the North Indian Ocean uses a scale from Depression to Super Cyclonic Storm with wind speeds as a criteria for classification (Srivastava et al., 2025). In general, it has been found that climate variations, global warming, and different atmospheric

conditions are the reasons for increased strength of cyclones. This fact is another reminder about the necessity of efficient forecasting methods, adequate preparation to minimize impact of disasters, and cooperation in handling such crises, all of which are required to reduce losses and improve community response (Sheikh & Sheikh, 2023).

Cyclone Biparjoy was one of the most powerful and longest-lasting tropical cyclones to form over the Arabian Sea in the 2023 pre-monsoon season (Rathaur et al., 2023). According to Sheikh and Sheikh (2023) the name "Biparjoy" which in Bengali translates into "disaster" or "calamity", was proposed by Bangladesh and is part of the World Meteorological Organization's cyclone naming system.

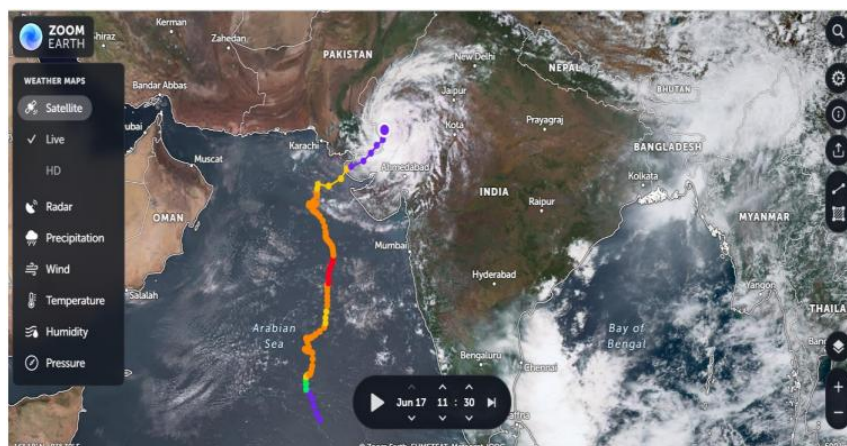


Figure 1: Track Map of Biparjoy Cyclone

Source: Zoom Earth Map

The cyclone began as a low-pressure condition over the southeast Arabian Sea on 6 June 2023 and rapidly deepened into an Extremely Severe Cyclonic Storm, taking advantage of favorable oceanic and atmospheric conditions (Rathaur et al., 2023).

This was followed by an extremely long path that crossed the Arabian Sea before it hit the area close to Jakhau Port in Gujarat in India on 15th June, 2023. The winds that were sustained there were around 115-125 km/h and gusts came up to 140 km/h (Sheikh & Sheikh, 2023). The cyclone represented a major danger threatening life, facilities as well as people's way of living.

However, the prompt warnings made by the India Meteorological Department and the thorough preparedness, evacuation and coordinated emergency response by the Government of Gujarat were very important in significantly curtailing the number of deaths (Srivastava, et al. 2025). We could say that Cyclone Biparjoy has presented a very good example of effectively prepared disaster mitigation measures, coordination between agencies through inter-agency and resilient ways of managing emergencies (Sheikh & Sheikh, 2023).

1.1 Aim and objectives

To understand how, in the context of Cyclone Biparjoy in Gujarat, early warning systems, multi-agency working, emergency response measures, technological initiatives, post-disaster recovery all together increase the effectiveness of disaster management efforts conceptually.

Objectives of the Study

1. To examine the disaster preparedness and early warning framework adopted during Cyclone Biparjoy in Gujarat.
2. To analyse the role of the State Emergency Operation Centre (SEOC) and multi-agency coordination in managing emergency operations.
3. To evaluate evacuation planning, humanitarian

assistance, and resource management strategies implemented during the cyclone.

4. To assess the contribution of GIS, satellite monitoring, and real-time decision support technologies in disaster management.
5. To examine post-cyclone recovery, restoration, and institutional learning for strengthening future disaster resilience.

2. Disaster Preparedness and Early Warning Framework

Cyclone Biparjoy was followed by an extremely long path that crossed the Arabian Sea before it hit the area close to Jakhau Port in Gujarat in India on 15th June, 2023. The winds that were sustained there were around 115-125 km/h and gusts came up to 140 km/h (Sheikh & Sheikh, 2023). The cyclone represented a major danger threatening life, facilities as well as people's way of living. However, the prompt warnings made by the India Meteorological Department and the thorough preparedness, evacuation and coordinated emergency response by the Government of Gujarat were very important in significantly curtailing the number of deaths (Srivastava, et al. 2025). We could say that Cyclone Biparjoy has presented a very good example of effectively prepared disaster mitigation measures, coordination between agencies through inter-agency and resilient ways of managing emergencies (Sheikh & Sheikh, 2023).

In light of cyclone forecasts, authorities in Gujarat pinpointed the vulnerable coastal districts like Kutch, Devbhumi Dwarka, Jamnagar, Porbandar, Morbi, Junagadh, Rajkot, and Gir Somnath for immediate focus in the emergency planning process (Sheikh & Sheikh, 2023). With GIS-based map, storm surge models and meteorological forecasting, it was evaluated which areas of the coastline would be most affected and the appropriate locations for evacuation were determined (Rathaur et al., 2023).

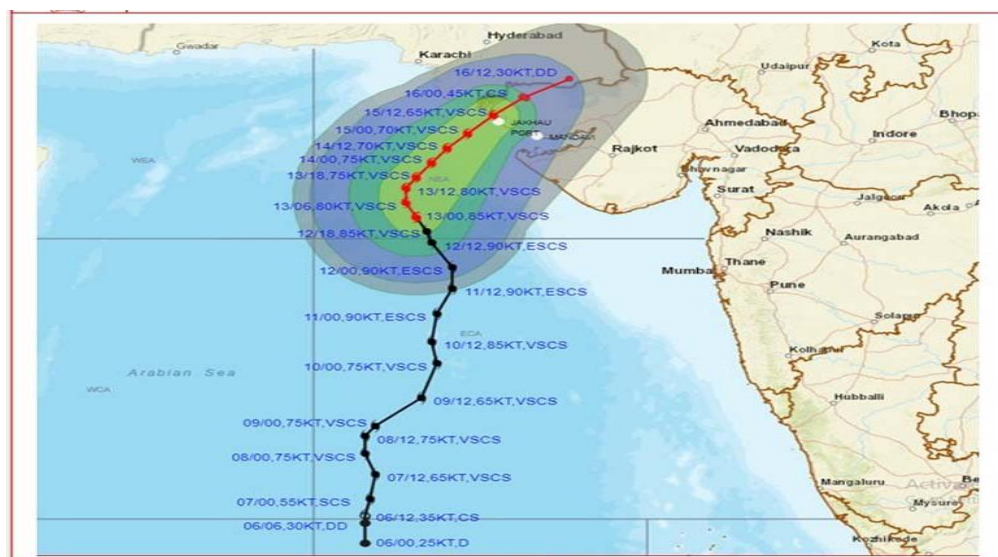


Figure 2: Route and Intensity of Biparjoy Cyclon

Source: <https://www.oneindia.com/india/cyclone-biparjoy-weakens-into-very-severe-storm-but-continues-march-towards-gujarat-coast-3571836.html>

Elderly people, pregnant women, children, disabled individuals, fishermen, and livestock were particular groups that needed special care and protection. Thanks to this thorough risk determination, authorities could effectively organize resources and carry out preparedness steps that were specific to areas before the cyclone touched shore.

In the face of Cyclone Biparjoy, one of the factors contributing to Gujarat's well-preparedness was community engagement. Awareness drives were done by means of police cars, speakers, FM broadcast, TVs, online platforms, and phones. Through village-level and school sharing, disaster management training videos produced by NDMA and GSDMA were disseminated. On the other hand, volunteers of the Aapda Mitras, Home Guards, and the village staff engaged in a visit to the families' homes in order to persuade them to relocate their homes to less vulnerable zones (Sheikh & Sheikh, 2023). Ongoing communication with the public resulted in an increased level of community interaction, high level of compliance with evacuate order, and strong public reliance on the preparedness of the government measures. Besides that, this effort had been a great success leading to the minimal casualties during the storm (Srivastava, et al., 2025).

The Government of Gujarat started the emergency plan much in advance of the landfall of Cyclone Biparjoy. They deployed strategically SDRF, NDRF, Gujarat Police, Coast Guard, and other rescue teams in the districts affected by the cyclone. Basic things required after natural disaster such as food, water, medicine, generators, rescue gear, ambulances, communicational systems, and accommodation arrangements were all kept in reserve to respond quickly (Sheikh & Sheikh, 2023). Hospitals were also on standby mode and teams working on electrical supply restoration, roadworks, and fixing

communicational systems were prepared ahead of time. Over 1, 00, 000 people were evacuated from the coastal areas that were affected before the cyclone made the landfall, which indicates how well in advance the planning, logistics, and mobilising resources were done (Rathaur et al., 2023). This kind of preparedness which was done in a proactive manner greatly helped avoid the effects of disaster and also the operations of emergency were run much better after the event happened (Srivastava et al., 2025).

3. Gujarat SEOC Command Structure and Multi-Agency Coordination Mechanism

The State Emergency Operation Centre (SEOG) acted as a disaster management central command and coordination hub during Cyclone Biparjoy. The SEOC monitored developments of the cyclone, operated 24/7, analysing real-time information from India Meteorological Department (IMD) and coordinated with District Emergency Operation Centres (DEOCs) to facilitate communication among various response agencies (Parmar, 2024). The SEOC was the one issuing operational orders, checking progress of evacuation, keeping track of deployment of the rescue teams resources in different affected areas, and conveying messages to interested parties in the shortest possible time. Thanks to the centralized coordination by the SEOC, the decision making process was very prompt and the disaster operations were optimally handled in the event of the cyclone (Rajhans et al., 2025)

The reaction and preparedness against the Cyclone Biparjoy demonstrated an organized flow through the administrative hierarchy to make rapid and coordinated decisions. Chief Minister provided strategic directions under Chief Secretary's guidance, DGP, Additional Chief Secretary (Revenue), Commissioner of Relief, and heads of various line

departments. The regular review meetings, constant monitoring of the situation, and clearly assigned work roles empowered the management to execute evacuation, mobilize resources, and provide

emergency relief on time (Parmar, 2024). The formal leadership structure made the authorities responsible and the operations efficient at different levels of disaster management (Rajhans et al., 2025).

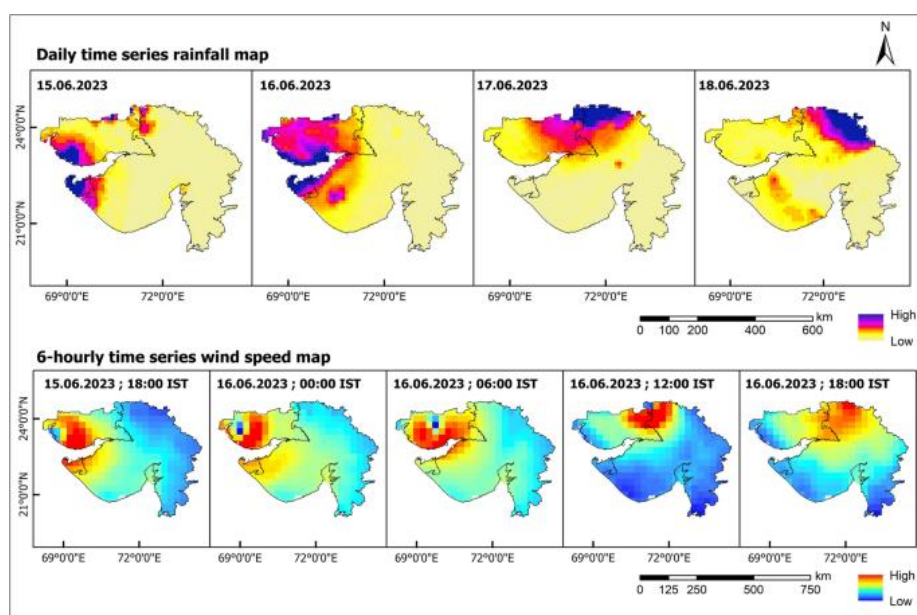


Figure 3: Satellite imagery-based tropical cyclone impact

Source: <https://link.springer.com/article/10.1007/s10661-024-12902-w>

Biparjoy Cyclone was managed through joint efforts by several government departments and emergency response agencies. Single Emergency Operation Centre SEOC was closely working with Gujarat State Disaster Management Authority GSDMA, State Disaster Response Force SDRF, National Disaster Response Force NDRF, Gujarat Police, Home Guards, Indian Coast Guard, Indian Army, Indian Air Force, local governments, health departments, electricity board, transportation, water supply, and communication sectors to have a single and effective line of action (Parmar, 2024). Information like geospatial data, satellite images, and weather forecasts were used to support emergency operational planning and awareness of situations (Patra et al., 2024; Kalhoro et al., 2024). The combination of different agencies helped the large-scale evacuation, resource deployment, quick recovery of basic services, and humanitarian aid to the people affected through multiple districts (Rajhans et al., 2025).

4. Operational Response Strategy: Evacuation, Resource Management and Humanitarian Support

The cyclone emergency management plan for Cyclone Biparjoy was based on forecast-derived risk assessments and standard evacuation procedures. Following the warnings of the Indian Meteorological Department, the State Executive Officer, Gujarat, ordered various administrations to relocate residents

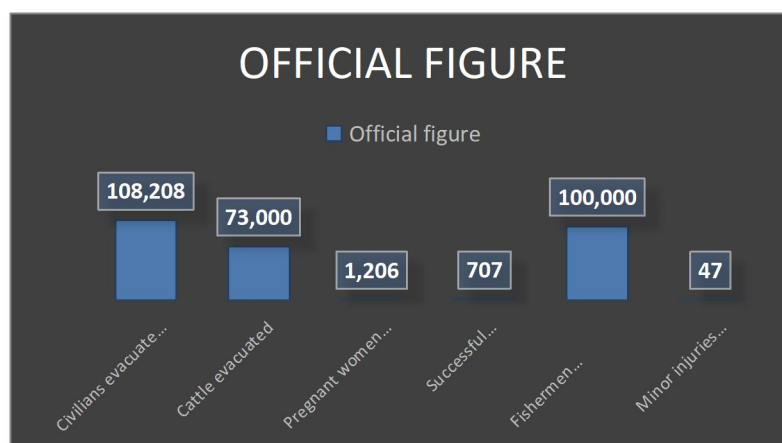
in low-lying coastal villages to safer places. The evacuation was carried out by prioritizing those settlements within 5 km, 15 km, and 25 km from the coastline more so in Kutch, Devbhumi Dwarka, Jamnagar, Morbi and Porbandar. About 1, 08, 208 people, among them 1, 00, 000 fishermen, were evacuated, and moved to safer places prior to the cyclone making its landfall at the coast. The operation of the evacuation mainly involved the involvement of SDRF, NDRF, Gujarat Police, Home Guards and local volunteers who worked hard to complete the evacuation operation before the approaching cyclone struck them (Mohapatra et al., 2025).

More than a thousand temporary shelters, that ranged from schools, community halls to government buildings, were utilised to house the evacuated residents. Shelter managers arranged basic necessities like potable water supply, food, hygiene measures, electricity generation, medical aid and security (Mohan, 2022). Mohanty and others pointed out that certain vulnerable categories like pregnant women, seniors, children, PWDs and animal husbandry were given special priority in this scenario. About 1, 206 pregnant women, however, were moved to hospitals prior to landfall resulting in about 707 baby deliveries being safe during the cyclone period. Besides people, cattle were also given shelter and fed to avoid the loss of livelihood and animal husbandry was minimised

Table 1: Evacuation and Humanitarian Response during Cyclone Biparjoy in Gujarat, 2023

Indicator	Official figure
Civilians evacuated to safer places	1,08,208 people
Cattle evacuated	73,000
Pregnant women moved to hospitals	1,206
Successful deliveries during the disaster period	707
Fishermen brought back to shore	More than 1,00,000
Minor injuries reported	47

Source: <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1933147&reg=48&lang=2>

**Figure 4: Evacuation and Humanitarian Response during Cyclone Biparjoy in Gujarat, 2023**

The figures of evacuation show how Gujarat's proactive disaster preparedness and response plan proved so fruitful during Cyclone Biparjoy. The timely evacuation of 1, 08, 208 people, relocation of 73, 000 cattle, transfer of 1, 206 women in their final trimester of pregnancy to hospitals, safe delivery of 707 babies, and return of more than 1, 00, 000 fishermen back to the port just before the storm came on land have substantially prevented the potential loss of lives. With major injuries to 47 persons and total absence of death, these results have proven that the whole operation of coordinated planning and evacuation in the first few hours of the storm and the subsequent response by various agencies of government have been highly efficient. The Special Emergency Operations Cell (SEOC) directed the movements of SDRF, NDRF, Gujarat Police, Home Guards, Coast Guard, Indian Navy, and other emergency agencies to vulnerable districts. Before the storm reached the ground, rescue boats, ambulances, cranes, earth-moving machines, communication vehicles, generators, and emergency lighting units were placed. In preparation for the first phase of rescue operations, food packets, drinking water, milk, medicines, feed for livestock, fuel, and various relief supplies were already stocked up at different areas. Besides ground monitoring with rescue teams, the situation of damaged regions was kept under watch through the means of satellite images and GIS-based information (Patra et al., 2024).

After Cyclone Biparjoy, to ensure minimal interruption of services and daily operations, the government of Gujarat initiated several emergency

plans. The department of electricity, water supply, health, telecommunications, transport and public works made their emergency teams available throughout the cyclone period. Backup power, mobile hospitals, communication facilities and repair squads were put to immediate use of their equipment and skills in restoring basic services just after the storm. The constant observation by a high-tech centre of the SEOC helped in detecting problems quickly and planning and carrying out joint recovery operations across the districts affected (Pandey et al., 2025).

5. Technology-Enabled Disaster Management and Decision Support Systems

Geospatial technologies played a very important part in disaster management support during Biparjoy cyclone. The pre-landfall GIS mapped-out identification of coastal villages in danger zone, evacuated routes mapping, shelters for cyclone, key locations of infrastructure, and resources was quite detailed. The combination of weather forecasts with spatial information allowed authorities to determine risky areas first and more efficient usage of emergency resources. Emergency managers were able to track field operations, monitoring on evacuation, road conditions and relief activities in a single screen via interactive dashboards which also helped in better operational preparation and decision making (Verma et al., 2024).

Cyclone Biparjoy used several satellite pictures and weather data to track cyclone movement, strength, rainfall and sea weather conditions. The India

Meteorological Department (IMD), ISRO and BISAG supplied up-to-date geospatial data and weather conditions all along to the disaster management agencies. Remote sensing data, satellite images and sea observations were combined to track the path of the cyclone, evaluate the effects on the coastal areas and assist with the evacuation planning. The use of these technologies allowed the emergency management officials to carry out preventive response actions and reduce the levels of unpredictability that the decision-making might have faced otherwise (Kar et al., 2024; Verma et al., 2024). Real-time monitoring played a significant role in tracing Cyclone Biparjoy during all the phases from its birth till post-landfall recovery. The State Emergency Operation Centre (SEOC) received constant updates from IMD, district administrations, emergency response agencies, and field teams for assessing the situation on the ground. Live information on weather conditions, evacuation efforts, damages to infrastructure, communication facilities, and emergency operations allowed authorities to adapt their response methods for dealing with the crisis.

Continuous monitoring of developments in the situation also ensured the quick restoration of essential services and rational use of emergency resources (Khidri et al., 2023).

6. Post-Cyclone Recovery, Restoration and Institutional Learning

Government agencies after the arrival of Cyclone Biparjoy started damage assessment activities to determine damage incurred on housing, public infrastructure, agriculture, energy systems, transportation and coastal livelihoods. District authorities along with technical agencies performed ground inspections to find the affected districts and evaluate their rehabilitation costs, which would also assist in giving priority to the relief process, the restoration of infrastructure and financial assistance to the affected people. The conducted assessments not only helped in informing future planning and risk reduction strategies (Rajhans et al., 2025) but also allowed the authorities to acquire knowledge on post-disaster assessment process (Thiruppugazh, 2014).

Table 2: Flooded area after Biparjoy

Area	Flooded area after Biparjoy
Kachchh district	6,556.73 km ²
Devbhumi Dwarka district	104.49 km ²
Most affected land-cover type in Kachchh	Bare ground: 38.95%; rangeland: 38.94%
Most affected land-cover type in Dwarka	Cropland: 33.04%
Pre-image classification accuracy	93.2%
Post-image classification accuracy	89.5%

Source: <https://pubmed.ncbi.nlm.nih.gov/39023687/>

The report on the effect of floods suggests that the most affected area was Kachchh district after the impact of the cyclone Biparjoy where the main impact was on wasteland and pastureland but Godhavar Dwarka was mainly affected by impact of destruction to agricultural land only. Satellite data analysis shows that the use of remote sensing has proved to be effective for studying land cover change due to cyclone and supporting decisions regarding disaster management.

As soon as cyclone Biparjoy was weakened, the teams

for restoration work from electricity, public work, water supply, telecommunication, and local administration started working in disaster-affected districts and main focus was on the restoration of fallen trees, damaged wires, blocked roads and disrupted communication networks, which would make it possible to provide critical services. Good coordination among utility services and emergency service teams made it possible to restore connectivity and public services much quicker which minimizes the problems for affected people (Rajhans et al., 2025).

Table 3: Post-Cyclone Relief, Restoration and Rehabilitation Work after Cyclone Biparjoy in Gujarat

S. No.	Area of work	Activities undertaken	Real data / result
1	Evacuation	People were shifted from vulnerable coastal areas to safe shelters.	143,053 people evacuated in Gujarat
2	Rescue	NDRF teams rescued stranded people and livestock.	7 people and 2 livestock rescued in Gujarat
3	Road clearance	Fallen trees, electric poles and debris were removed from roads.	10.1 km of roads cleared; 71 trees and 10 electric poles removed
4	Electricity restoration	Electricity teams repaired damaged lines, substations and distribution systems.	1,127 restoration teams deployed
5	Substation maintenance	Specialist teams restored and monitored electricity substations.	714 substations covered by 51 specialist teams
6	Tree removal	Forest Department teams cleared fallen	581 fallen trees removed

		trees from roads and public areas.	
7	Telecommunication restoration	Mobile networks and communication services were repaired.	More than 2,000 mobile base stations restored
8	Temporary shelters	Evacuated residents were provided accommodation and basic services.	Approximately 1,500 temporary shelters used
9	Medical support	Medical teams and ambulances were deployed in affected districts.	1,005 medical teams and 504 ambulances deployed
10	Food and essential relief	Relief materials, drinking water and essential supplies were provided to affected people.	Relief operations conducted in affected coastal districts
11	Agriculture and livelihood recovery	Damage to crops, orchards, livestock and fishing-related livelihoods was assessed.	Compensation and livelihood assistance provided to affected communities
12	Government financial assistance	Funds were released for recovery, infrastructure repair and rehabilitation.	₹338.24 crore central assistance approved for Gujarat

Source: <https://www.pib.gov.in/PressReleasePage.aspx?PRID=1985429&reg=48&lang=2>

The table shows that the work that commenced after the cyclone Biparjoy concentrated primarily on saving lives and restoring basic services. A total of over 143,000 people were evacuated, and efforts of NDRF unit were focused on rescue and clearance buildings and roads from fallen trees and power poles. Restoration of electricity and communication took special attention with the deployment of over 1,127 teams in charge of restoring power to the consumers and over 2,000 mobile communication stations already repaired. The medical support was also provided in the form of the deployment of 1,005 medical teams and 504 ambulances. All this, together with the provision of temporary shelters and central government assistance of ₹338.24 crores contributed to the recovery and rehabilitation of the distressed population of the state of Gujarat.

Successful management of Cyclone Biparjoy has shown the significance of systematic post-disaster evaluation and organisational learning. Government authorities analysed their operational performance, co-ordination among various agencies, effectiveness of evacuations, communication systems and resource deployment in order to find out the strengths and weaknesses in response to disasters. The lessons learned from the cyclone have underlined the importance of having early warning systems, proactive evacuation procedures, technology-based decision-making and unified command structures for mitigating the effects of disasters (Thiruppugazh, 2014). The findings of these analyses provide a strong basis for improving future preparedness and operational planning.

Cyclone Biparjoy's experience has re-emphasized the significance of sustained investment in resilient infrastructure, cutting-edge forecasting technology, community awareness, and integrated disaster governance. It is critical to ensure improved cooperation between government departments, better geospatial decision support systems, greater public awareness, and adoption of climate-smart planning in order to deal with future cyclone-related crises (African Development Bank Group, 2019).

Furthermore, the success stories from Biparjoy highlight the importance of combining scientific forecasting with robust institutional capacity in achieving long-term disaster resilience (Kalhoro et al., 2024).

7. Conclusion

Cyclone Biparjoy has highlighted how effective disaster management is about more than just responding to an emergency. It includes planning, coordination, technology, and recovery. The success achieved in Gujarat during the cyclone is a testament to how effective timely early warning systems, the evacuation of residents, the mobilization of resources, and institutional cooperation have become. Coordination between the SEOC, IMD, GSDMA, NDRF, SDRF, district administrations, and other agencies involved in the disaster has led to decisions and emergency activities being carried out in record time, making it possible to minimize the number of victims of the cyclone.

In addition, the study provides proof of the rising significance of technology-supported disaster management using GIS, satellite observation, remote sensing, and real-time monitoring units that considerably increase awareness of conditions and efficiency in operation execution. There was also great importance in post-disaster recovery actions related to the restoration of technical facilities, humanitarian assistance programs, loss assessment, and learning through experience-related institutional actions that are crucial for increasing long-term resilience and preparedness for disasters.

The suggested conceptual model indicates that achieving disaster resilience involves the integration of early warning dissemination, coordinated government actions, technological innovations, effective operations in the time of emergency, and ongoing organisational learning. The model can be used as a guide for policymakers, disaster management practitioners, and researchers working

towards the improvement of systems of disaster preparedness and response in areas that deal with those natural phenomena. Investing in forecasting technologies, sustainable infrastructure, and the involvement of the local population can be extremely important for mitigation of risks connected to disasters.

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