आज़ादी का अमृत महोत्सव

सत्यमेव जयते

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Documentation on Dam Leakage, Breaching and Disaster Management at Karam Dam, Madhya Pradesh

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National Institute of Disaster Management

Ministry of Home Affairs, Government of India

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Documentation on Dam Leakage, Breaching and Disaster Management at Karam Dam, Madhya Pradesh

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The document can be downloaded from the website https://www.nidm.gov.in

शिवराज सिंह चौहान
मुख्यमंत्री
मध्यप्रदेश

अर्द्ध शास. पत्र क्र. 804/मुम.का./2023
दिनांक 25 JUL 2023

संदेश

दुनिया में बांधों से जल रिसाव तथा बांधों का टूटने तथा बांधों के पुराने बुनियादी ढांचों एवं बांधों के विनाशकारी विफलताओं की संभावना जन-जीवन के लिए चिंता का विषय बन गई है। यही कारण है कि इसके बेहतर प्रबंधन हेतु विस्तृत कार्ययोजना तैयार की जाना न केवल आवश्यक है बल्कि प्रासंगिक भी ।

मुझे यह जानकर प्रसन्नता है कि राष्ट्रीय आपदा संस्थान नई दिल्ली द्वारा कारम बांध आपदा के अनुक्रम में युद्धस्तर पर बांध में रिसाव से निपटने एवं आपदा प्रबंधन के लिए मिशन मोड में किए गए प्रयासों का दस्तावेजीकरण किया गया है । मैं समय पर की गई प्रभावी कार्यवाहियों और बांध सुरक्षा हेतु भविष्य के अनुप्रयोग हेतु किए गए दस्तावेजीकरण के लिए राष्ट्रीय आपदा प्रबंधन संस्थान की टीम को बधाई देता हूं।

मुझे विश्वास है कि बांध प्रबंधन विषयक यह प्रलेख भविष्य की योजना, जोखिम मूल्यांकन, आपातकालीन योजना, रखरखाव एवं निगरानी, नियामक अनुपालन तथा हितधारक जुड़ाव की तैयारी के लिए एक मूल्यवान दस्तावेज सिद्ध होगा ताकि बांधों के निर्माण और रखरखाव हेतु समुचित उपाय कर जनमानस तथा पर्यावरण की रक्षा की जा सके।

(शिवराज सिंह चौहान)
मुख्यमंत्री, म.प्र. शासन

6, श्यामला हिल्स, भोपाल - 462 002

Foreword

I am writing to express my heartfelt appreciation for the exceptional documentation carried out by the National Institute of Disaster Management (NIDM) regarding the recent Karam Dam breach incident in Madhya Pradesh.

As the Additional Chief Secretary of the state, it is crucial for me to acknowledge the remarkable efforts and dedication exhibited by NIDM team throughout the documentation process. The thoroughness, attention to detail, and professionalism showcased in this report are truly commendable.

The comprehensive documentation provided by NIDM has played a pivotal role in understanding the magnitude of the disaster and its impact on the surrounding areas. The meticulous analysis of the breach incident, including its causes, timeline, and consequences, has provided valuable insights that will aid the state in formulating effective strategies for prevention and mitigation of disaster incidents in the future.

The report also highlights the commendable rescue and relief efforts carried out by various agencies in response to the dam breach, highlighting the importance of collaborative action during times of crisis. By shedding light on the challenges faced and the lessons learned, this documentation will serve as a valuable resource for disaster management authorities and stakeholders involved in the safety and resilience of state's infrastructure.

I would like to extend my gratitude and appreciation to every member of the NIDM along with the Water Resource Department, Home department, MPSDMA, Administration of Dhar district, for support and cooperation etc in the documentation process. The report has documented the disaster incident with accuracy and clarity, ensuring that valuable knowledge is captured for future references. Findings from this documentation to strengthen our disaster management systems and enhance the safety of citizens of the state.

I look forward to continued collaboration and mutual support in our collective efforts to build a safer and more disaster resilient Madhya Pradesh.

(Dr. Rajesh Rajora)
Additional Chief Secretary,
Govt. of Madhya Pradesh

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राजेन्द्र रत्नू, भा. प्र. से.
कार्यकारी निदेशक
Rajendra Ratnoo, IAS
Executive Director

सत्यमेव जयते

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Foreword

India has a long experience of dealing with dam failures. The Machchu dam failure (1979) of Gujarat is one of the worst experiences in the history of India. Other than that, there are various incidents of dam failures that caused colossal damages/ losses like Kaddam (1957), Panshet (1961), Khadakwasla (1961), Chikkhole (1962), Nanak Sagar (1967), Kodaganar Dam(1977), Machchu Dam, Pratappura Dam (2005) and Tiware Dam (2019).

The matter pertains with the under-construction dam on the Karam river near Kothida village in Dhar district, about 280 km from Madhya Pradesh's capital Bhopal. Villagers had noticed a leak in a portion of the mud structure on 10th August 2022. The outer part of the structure collapsed on 12th August 2022. The dam, being built on the Karam River, a tributary of the Narmada, threatened to flood 18 villages, which were evacuated in a very short span of time.

Under the Disaster Management Act 2005, National Institute of Disaster Management (NIDM) has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation and policy advocacy in the field of disaster management. NIDM and its professional Faculty Members have made substantial contributions since it is conducting Capacity Building programmes and providing technical support for numerous initiatives.

This document on Dam leakage, breaching and Disaster Management at Karam dam, Madhya Pradesh will go a long way in learning about disaster management concepts and response mechanism, approaches and initiatives by the government during Karam dam breach. This document will also facilitate understanding of the role of multiple stakeholders – local governments, non-governmental organizations, and academic institutions in Disaster Management and disaster situations.

I complement Prof. Surya Parkash, Head GMR Division, NIDM and other team members for their meticulous work and immense personal contribution who have facilitated the process. I also express my gratitude for the sincere and professional inputs from the external reviewers in assisting the NIDM in the formulation of this document.

(Rajendra Ratnoo)

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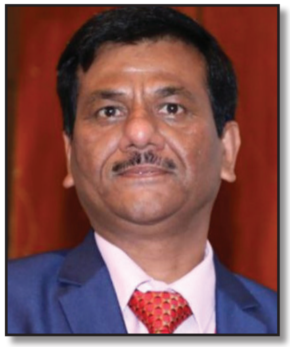

Preface

It is with great concern and a sense of responsibility that I present this documentation on Dam leakage, breaching and Disaster Management at Karam dam, Madhya Pradesh. In India, there are 5334 existing large dams while the other 411 large dams are under various stages of construction. Maharashtra leads with 2394 dams while Madhya Pradesh and Gujarat are at the second and third spots in terms of the number of dams. India's dams annually store about 300 billion cubic meters of water. These dams are ageing over the years with about 80% of dams exceeding 25 years of age, and over 227 dams exceeding 100 years. The ageing of dams and deferred maintenance of the dam have made dam safety a matter of concern.

Leakage and dam breach are two critical issues that India has been grappling with for a long time. India is a country that is heavily dependent on its water resources for its agriculture, industry, and daily needs. Therefore, it is imperative that the dams and other water storage structures in the country are adequately maintained to prevent any accidents or incidents that may lead to loss of life and property.

Leakage in dams is a common problem in India due to the age of many of the dams, inadequate maintenance, and the lack of proper monitoring systems. Leakage can lead to the weakening of the dam structure and eventually result in a breach. When a dam breaches, it can cause a catastrophic flood, which can result in the loss of human lives, damage to property, and destruction of infrastructure.

India has seen several instances of dam leakage and breaches in the past, with the most recent one being the breach of the Karam Dam in district Dhar, Madhya Pradesh in August, 2022. The breach resulted in the partial loss of property. The incident was attributed to the negligence of the local authorities in ensuring the safety of the dam.

To prevent such incidents, the government has taken several measures to ensure the safety of the dams in the country. It has also mandated regular inspections of the dams to detect any issues and ensure timely repairs. There is also a focus on modernizing the monitoring systems of the dams to detect any anomalies and take corrective measures before any damage is caused.

The Dam Safety Act, 2021 was enacted by the Parliament and came into force with effect from 30th December 2021. The Act is aimed at ensuring surveillance, inspection, operation and maintenance of the specified dam for prevention of dam failure-related disasters and to provide for an institutional mechanism to ensure their safe functioning.

In conclusion, leakage and dam breach are critical issues that India has been dealing with for a long time. The safety of the dams in the country is of utmost importance, and the government must take all necessary measures to ensure their safety. The Dam Safety Act and the creation of the National Dam Safety Authority are appropriate legal and regulatory stops, but more needs to be done to prevent any future incidents.

Comprehending the severity of Karam dam breach and the mandate to document the major disasters, NIDM endeavours to clutch the lessons of the event in order to strengthen our future strategies for dam leakage, breaches and its safety.

(Surya Parkash)

Acknowledgement

At the outset, I would like to express sincere thanks to Sh. Rajendra Ratnoo, IAS, Executive Director, NIDM and Sh. Taj Hassan, IPS, Former Executive Director, National Institute of Disaster Management (NIDM), New Delhi for the kind encouragement and support in documentation of Dam leakage, Breaching and Disaster Management at Karam dam, Madhya Pradesh.

I would like to place on record the significant contributions made by different persons in compiling the information and literature apropos of Karam Dam breach.

Heartfelt sincere thanks are due to Sh. Shivraj Singh Chouhan, Chief Minister, Madhya Pradesh; Sh. Rajesh Rajora, IAS, ACS (Home); Sh. S.N. Mishra, IAS, ACS (WRD); Sh, Gaurav Rajput, IPS, Secretary (Home); Dr. Pawan Sharma, IAS, Divisional Commissioner, Indore; Sh. Pawan Kumar Jain, IPS, DG (Homeguard, Civil Defence and Disaster Management) Dr. Pankaj Jain, IAS, DM Dhar; Sh. Kumar Purushottam, IAS, DM Khargone; Shri Shrangaar Shrivastav, ADM Dhar; Sh. Aditya Pratap Singh, IPS, SP Dhar; Sh. Navjivan Vijay Pawar, SDM Kukshi; Ms. Roshni Patidar, SDM Nalchha, Ms. Divya Patel, SDM Maheshwar administration and local community of District Dhar and Khargone.

I would like to express my gratitude to Sh. Saurabh Singh, Deputy Director, MPSDMA and Sh. Dilip Singh, Deputy Director, MPSDMA for reviewing the document, their support during the visit of the central team at Karam dam site.

It gives me immense pleasure in acknowledging the cooperation from CWC, particularly Sh. Sharad Chandra, Director, CWC and Sh. Hari Hara Kumar Devada, Sh. Ajit Batham, Dr. A.L. Haldar and my colleagues from GMR Division as walk as supporting staff at NIDM including Sh. S. K. Tiwari, Ms. Karanpreet Kaur, Ms. Sakshi Goswami and Mr. Ajay Kumar, without which it would not have been possible in preparation of this document completed.

Sincere thanks are due to co-authors of this document, who made every effort to collect, compile, analyze and assess all available information on breaching of Karam Dam and helped in preparation and finalization of this document.

Last but not the least, I would like to thank my wife Reeta and daughter Rasika, without whose consistent moral and logistic support, I would not have been able to give due attention and time to this work. Finally, I am grateful to the Almighty without whose grace and kindness, I would not have been capable to carry this task successfully.

(Surya Parkash)

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The right action at the right place at the right time can prevent the hazards from turning into disasters. The Karam dam has been one such example where the administration noticed the threatening leakage from the dam and carried out a planned supervised breaching of under-construction dam to prevent any likely sudden disaster. The whole operation of the dam breach has been well managed through coordination at various levels. Thus, the timely decisions resulted in zero loss of human lives and livestock during the operation.

The seepage of water from the under-construction Karam Dam in the Dhar district of Madhya Pradesh, where reservoir filling was done to certain level has set off alarm bells on 11th August 2022, prompting the evacuation of people in the downstream areas from 18 villages in the Dhar and Khargone districts to safer places. **The dam has a length of 590m and a height of 52 m with a capacity of 15 million cubic meters (MCM) of water in its reservoir.** The dam has been planned for better irrigation development in water-starved areas of the tribal region to improve the economic conditions of the farmers in nearly 52 villages and to improve the life of the populace with provision for drinking water.

The construction of the earthen wall & spillway were not up to the required level before the monsoon season over the area. The uncontrolled filling of the reservoir with adverse conditions of closure of the dam, quality of construction combined with the rainfall in the catchment area, resulted in the seepage at the earthen dam. Some attempts were made to control this seepage but it did not succeed well. So the administration got scared with the likelihood of the overtopping and breach of the dam that could cause huge devastation in the downstream villages. Hence, it issued the alert call to all the concerned stakeholders.

Considering the Severity level of likely hazard, the teams of the Army and the National Disaster Response Force (NDRF), State Disaster Emergency Response Force SDERF, and Home-guards have requested and kept on stand-by mode at the Dam site apart from the higher officials and various staff of concerned line departments in the State Government to take care of the emergency action, rescue, evacuation, etc. The State administration with the help of the Central Water Commission (CWC) and National Dam Safety Authority (NDSA) handled the situation with due diligence and careful steps to deplete the reservoir with minimal impacts in the dam site areas. Finally, the safe release of water has been done by creating a channel at the right abutment of the dam and averted the disaster without any loss of human life and livestock.

Subsequently, the Government of Madhya Pradesh made a request to National Institute of Disaster Management (NIDM), Ministry of Home Affairs (MHA), Delhi to document this event and the pursuant action from disaster management perspective for suggestions/ recommendations to avoid this kind of event in the near future. Keeping in view the existence several of such dams in the country, and likely hazards associated with them, NIDM decided to document the Karam dam breach to disseminate the good and bad practices related to dam safety and risk management.

In order to document the Karam dam breach, the NIDM constituted a team consisting of NIDM and Central Water Commission officials to visit the dam site. The team visited the site in Madhya Pradesh from 9th September to 13th September 2022. The team made observation at the dam site, affected villages, and shelters and met the officials as well as volunteers who were involved in the incident for emergency support, rescue, evacuation & shelters, relief, arrangement for depleting water from the dam etc. and also the affected community. The team also conducted meetings and discussions at various levels. At the state level, the team met the state administration including Hon'ble Chief

Minister of Madhya Pradesh, ACS (Home), ACS (Water Resources Department), DG (Home Guards), Commissioner, District Magistrates and officials of the respective states and CWC officials to get their views regarding the situation and steps taken to avert the disaster tactfully. At the site level, a meeting has held with the district officials who averted disaster of the dam breach. At the community level, the team visited the villages which were affected during this dam breach and held consultations with the villagers, NGOs and other stakeholders which supported the district administration in providing relief facilities to the evacuated people from the downstream villages.

This document attempts to chronologically discuss the evolving incident situation and highlight the response from all the stake holders involved in averting the disaster timely in an appropriate manner. It also elaborates on the importance of effective resource (both human & logistics) allocation in disaster management.

Further, the report endeavors to assimilate the lessons learnt from this case study and the need to strengthen our future strategies for avoiding/ preventing dam leakage/ breaches with some recommendations to achieve risk reduction and resilience in dam management.

Chapter 1

1.0 Introduction

The state of Madhya Pradesh is regarded as the "Heart of India" due to its geographic location along with its cultural and spiritual heritage. Madhya Pradesh lies between latitudes 21^{0} 6' and 26^{0} 54'N and the longitudes 74^{0} and 82^{0} 47'E. It covers a geographical area of 308,245 sq. km which is about 9.38% of the total area of India. The State is land - locked and at no point is the sea less than 300 km away. It is surrounded by 6 states namely Uttar Pradesh, Chhattisgarh, Andhra Pradesh, Maharashtra, Gujarat, and Rajasthan.

Most of the State lies on the tableland of Central India bounded by the Upper Gangetic plains in the north; the Godavari valley in the south; the plains of Gujarat in the west; and the plateau of Bundelkhand and Chhattisgarh in the east. The State is traversed by the Vindhya, Satpura, and Maikal hill ranges running east-west. The highest point is at Dhupgarh near Pachmarhi in the Hoshangabad district at 1,350 m. Most of the State has an elevation of between 305 and 610 m above MSL. Low-lying areas are in the narrow Narmada valley in the central southern parts. Based on the topography, the state can be divided into (Fig. 1-1)

- The Plateau of Malwa,
- The Plateau of Central India,
- The Plateau of Bundelkhand,
- The Plateau of Rewa and Panna,
- The Narmada and Sone valley,
- The Satpura and Maikal region
- The Eastern Plateau.

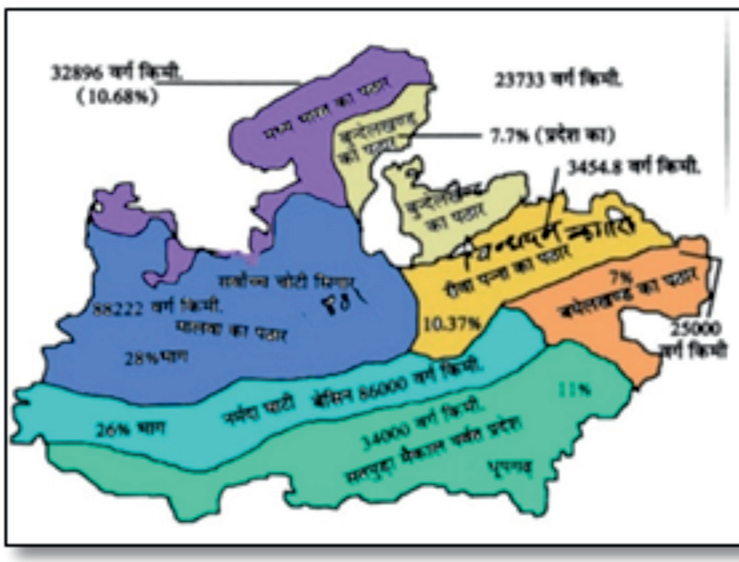


Figure 1- 1 : Topography of Madhya Pradesh

Owning to the unique geo-climatic and topographical features, the state of Madhya Pradesh is prone to various hazards. The major natural hazards for the State are earthquakes, floods, drought, fire, etc. Out of 52 districts, 24 districts that come under Zone –III and 28 districts come under Zone – II in the seismic zonation map of India (Fig. 1-2).

Likewise in the last 26 years, there are 32 districts of the State affected by the flood (Fig. 1-3) and around 7 districts highly affected by droughts (Fig.1-4). The State is also vulnerable to anthropogenic disasters like chemical and industrial disasters etc. There are more than 400 industries working in various districts (Fig.1-5).

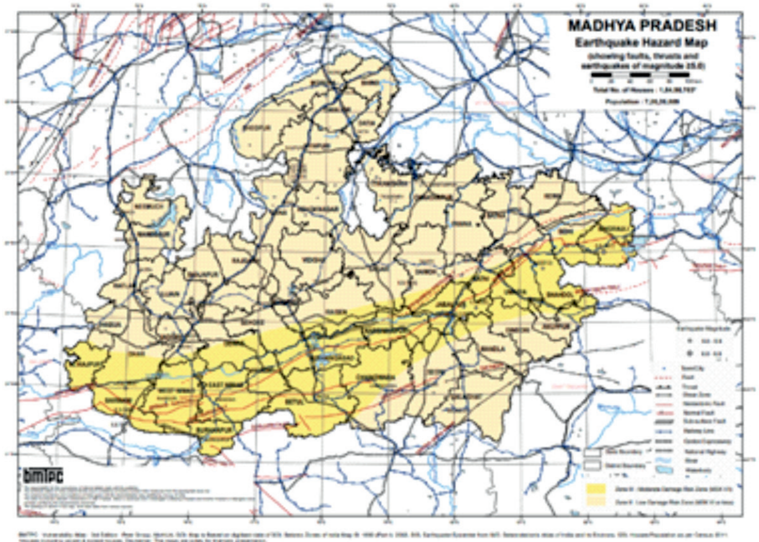


Figure 1-2 : Seismic zonation map of Madhya Pradesh - Source:MPSDMP

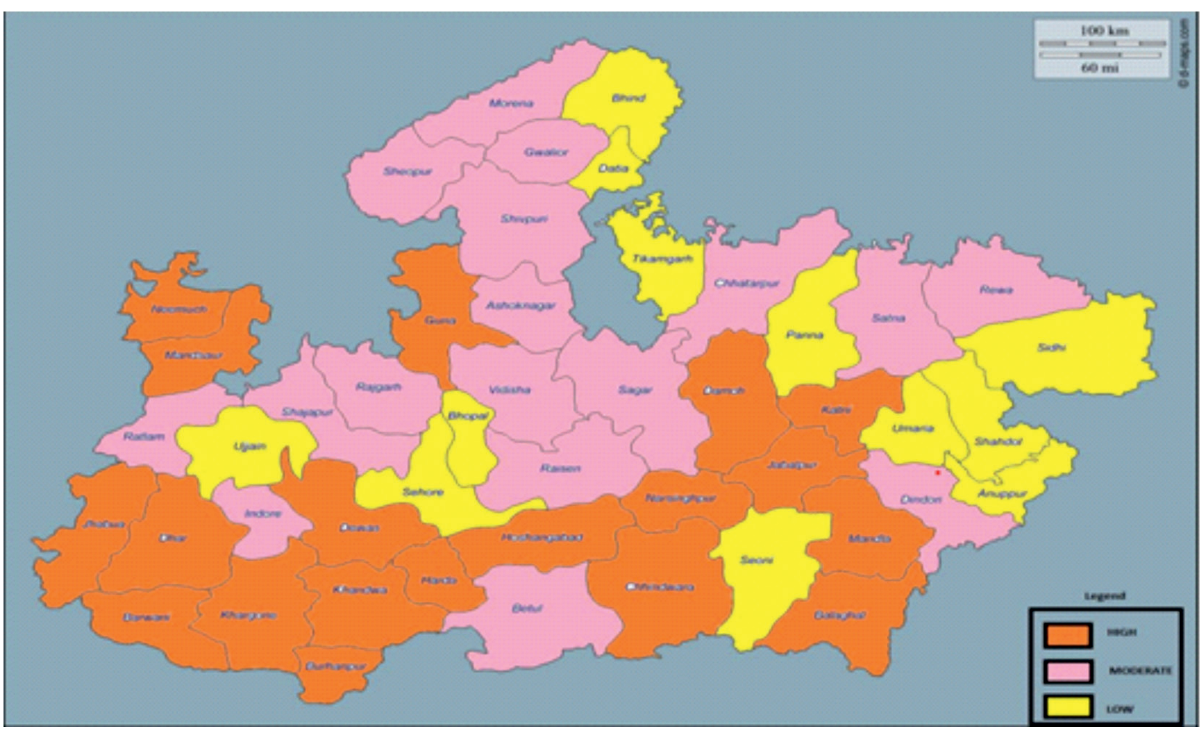


Figure 1-3 : Flood-prone districts of MP - Source:MPSDMP

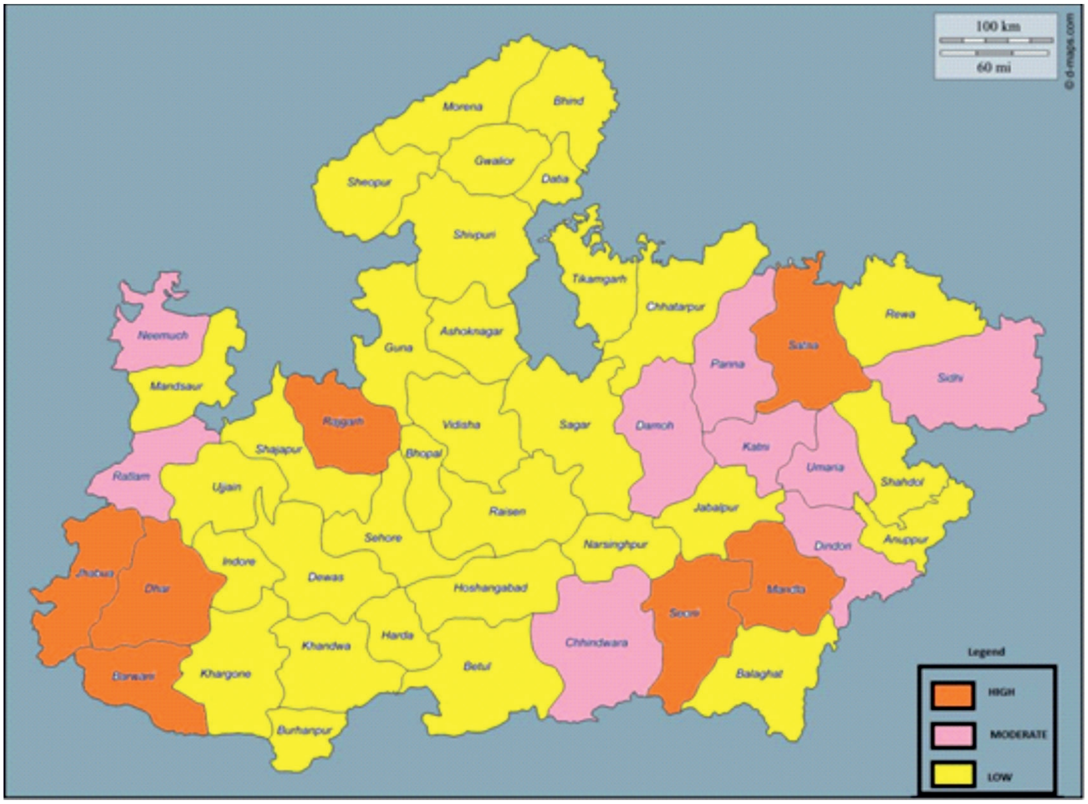


Figure 1-4 : Drought-prone districts of MP- Source: MPSDMP

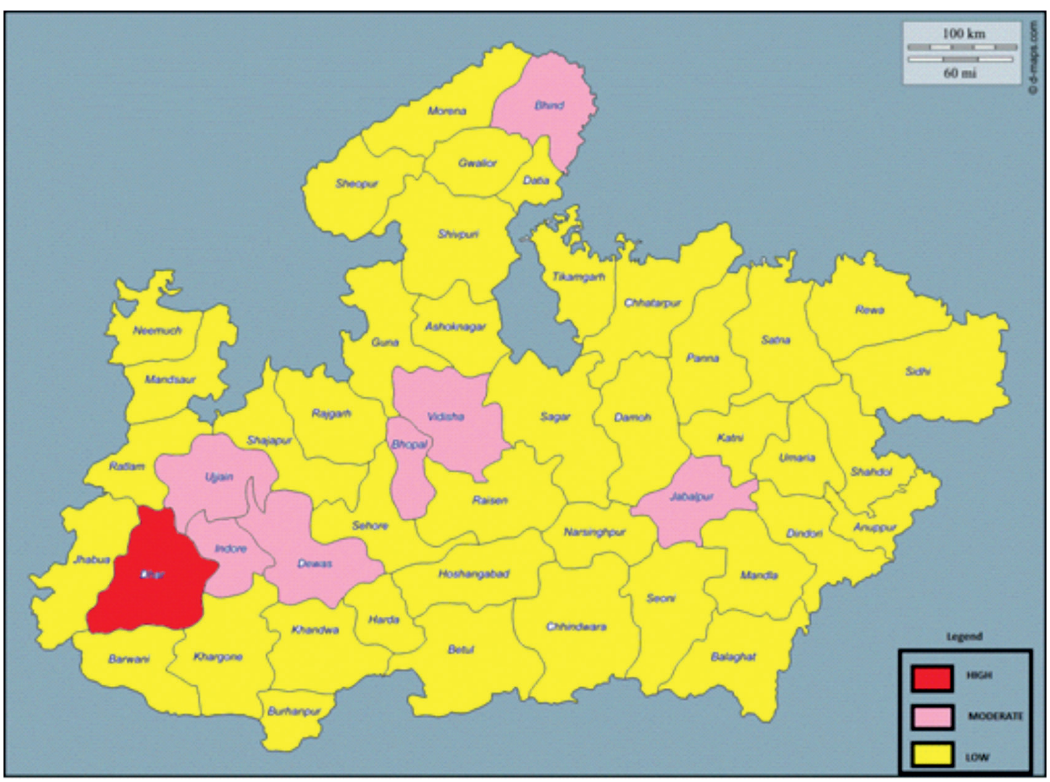


Figure 1-5 : Potential Industrial Hazardous Places in Madhya Pradesh Source:MPSDMP

As administrative report of WRD 2021-22, the state of Madhya Pradesh has 5238 dams (21 Major dam Projects, 101 medium dam projects, 5116 minor dam projects) and 361 dams (27 Major dam Project, 46 medium dam project, 288 minor dam projects) in under construction phase. The Karam Dam is one of the 361 dams under construction in the state of Madhya Pradesh.

1.1 Significant case studies of dam breaches/failures in India and abroad

A dam failure is defined simply as an uncontrolled release of water from a reservoir through a dam as a result of structural failures or construction deficiencies in the dam. Dam failures can range from fairly minor to catastrophic and can possibly harm human life and property downstream from the failure. Between the years 2000 and 2009, more than 200 notable dam failures happened worldwide (Pattikonda, 2020).

Dam failures can be extremely harmful, because of the immense destruction that can occur with a dam breach. Dams are considered as "installations containing dangerous forces" under International Humanitarian Law (IHL). Throughout history, a large number of dam failures have caused immense property damage when flood waters destroyed infrastructure. In addition, ecosystems and habitats are destroyed as a result of waters flooding them. Along with this, dam failures over the years have taken thousands of human lives and livestock. The older that dams get, the more potential exists for catastrophic dam failures. Some of the biggest dam failures in the history of India and other countries have been briefly discussed here.

1.2 Major Dam Breaches in other countries

Dams are built to serve various functions like supplying water for irrigation, flood control, and generations of hydroelectricity. Dams are also associated with several disadvantages like loss of ecological balance in the areas where they are built, displacement of people and wildlife in such areas, etc. Worse happens when dams fail or give way. When a dam bursts, there is a sudden release of massive volumes of water with high discharge velocity, which floods areas around the dam causing extreme loss of lives and property. A few of the worst dam failures in other countries have been briefly discussed.

1.2.1 St. Francis Dam (Los Angeles, California) Failure, 1928

On 12th March 1928, one of the worst civil engineering disasters of the 20th century occurred with no warning. St. Francis Dam, located 64 km northwest of Los Angeles, California, failed unexpectedly. Due to the failure of the dam, 47 million cubic meters of water were released into San Francis Quito Canyon. The result was devastating and over 400 people died due to the failure of the dam (J. David Rogers, 1993)

The dam was initially designed as a stepped concrete gravity arch of 152 m radius and the initial design height was 53 m from the floor of the canyon. The resulting reservoir capacity would be approximately 38 million cubic meters of water. Several uncalculated design modifications to the height of the dam were incorporated during construction. Due to this, the final height of the dam was 59 m with a reservoir capacity of 47 million cubic meters. Construction of the dam began in 1924 and was completed in 1926. However, the life of the dam was very short as it failed just after two years of operation.

Although a definitive cause for the dam failure was never determined, but various proposed theories such as sabotage, geology, and poor construction, several reasons for the failure have been investigated.

Eventually, it was concluded that the failure was entirely due to the geology of the site. The site location of St. Francis Dam was unsuitable for a concrete gravity dam. The varying geology between the two canyon walls and the inconsistent and instability features of the rock slopes were unacceptable for a dam foundation.

Not only the geology of the site was in question, but also the design and construction techniques were questionable. The failure to incorporate essential dam safety features into the design had resulted in the collapse.

A lack of uplift relief and expansion joints, along with drastic modifications of the dam during the construction contributed to the collapse of St. Francis Dam. The failure of the dam caused a huge devastation in downstream resulted in flooding and submergence of downstream settlements as shown in the below Figure 1-6.

Figure 1-6 : Losses due to failure St. Francis Dam (California, 1928)
Source: J. David Rogers, 2013 AEG Shlemon Specialty Conference

The St. Francis Dam failure brought several changes in the way future dams were to be designed. This failure made changes in the traditional practice of construction of dams where extensive geological surveys and the foundation and seepage prevention design were adopted. This failure also brought reforms in the legislations where new laws were enacted by the state of California that required any proposed dam design to be evaluated by an independent review panel before approval for construction.

1.2.2 Malpasset Dam, France failure, 1959

The failure of the Malpasset Dam represented the first failure of an arch dam. The unforeseen of the failure, given that nothing abnormal had been detected at the dam within the hours preceding the event added to the uncertainty. (Fig. 1-7)

The Malpasset Dam was located in southern France. It was a double curvature arch dam with a maximum height of about 60 m and a crest length of about 223 m. The thickness of the concrete varied from 1.5 m at the crest to 6.8 m at the center of the base. The dam created a reservoir with an estimated total capacity of about

51 million cubic meters, which was filled very slowly over five years.

At the time of the failure, the level of the water was 0.3 m below the spillway elevation. Incidentally, when the water level was 0.3 m, heavy rains occurred. This resulted in the rise of the water level by almost 4 m within three days. It was decided to open the bottom outlet gate in the dam. **This permit led a controlled release of water and prevent damage to a highway bridge under construction downstream of the dam.**

The response of the dam had been monitored intermittently during filling by surveying equipment located on the downstream face of the dam.

Within hours of the bottom outlet gate being opened on 2nd December 1959, the dam failed without warning. The city of Frejus, 7 km downstream of the dam suffered heavy losses resulting from the release of the water and debris. More than 300 people died in this disaster (Panwar, 2020). Blocks of concrete from the dam were washed as much as 1.5 km downstream.

Figure 1-7 : Malpasset Dam
Source: wikipedia

1.2.3 Vajont Dam (Italy) Failure, 1963

On 9th October 1963, Vajont Dam, located in Italy, suffered a failure of its southern rock slope over an approximate length of 2 km. The result was devastating and 5 villages and 2,040 lives were lost due to the failure of the dam (Figure 1-8) (Quarantelli, 1979).

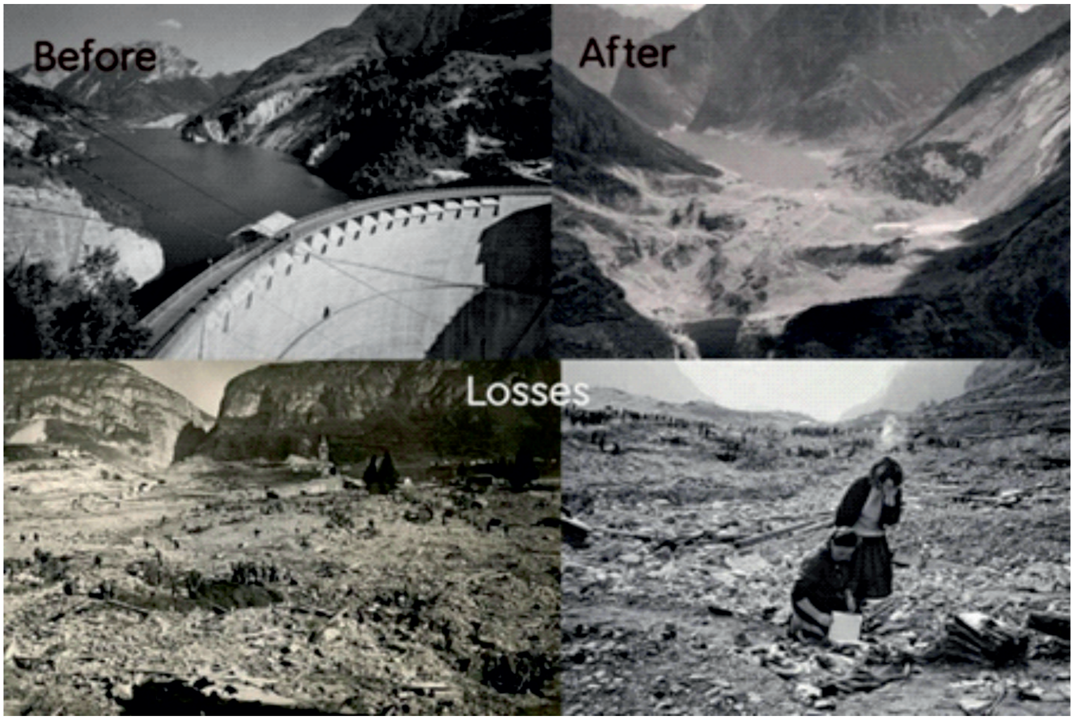


Figure 1-8 : The Vajont Dam
Source: Environment and Society portal

A 276 m high double-arched dam across the Vajont River valley in northern Italy was constructed between 1957 and 1960. The dam created a reservoir with an estimated capacity of about 169 million cubic meters.

The reservoir's possible slope stability issues generated some worries in 1959, which required additional analysis of the dam. The research conducted supported the existence of a sliding issue. The quantity of information that would be included in a slide, however, was disputed. The range of material volume projected by researchers for sliding was from very small volumes to 10-20 m deep volumes.

The fundamental cause of the sliding problem was the magnitude of deep-seated movements associated with large fissure cracks. In 1960, a monitoring programme was put in place as a result of the identification of potential slope stability issues.

It was thought that altering the reservoir's water level may regulate how quickly the sliding occurred. The monitoring effort over the subsequent three years, which largely used equipment to detect surface movements, produced results that supported a connection between the reservoir level and the mass movement of the slide. However, the analysis failed to predict the rate at which the ultimate failure would have occurred.

The massive slide into the Vajont reservoir yielded important lessons regarding the analysis and monitoring of slope movements. The difficulty of predicting when a slide mass will accelerate or fail became evident. Also, the difficulty of estimating changes in states of stress and strength during sliding was reinforced.

1.2.4 Sempor Dam (Indonesia) Failure, 1967

The Sempor embankment dam exists on the Sempor River in the Indonesian Gombong District. The dam provides water for irrigation as well as a tourist destination with leisure opportunities. Flood control and hydroelectricity production are additional functions. The dam is associated with a disaster in the same year as its construction which was 1967. On 29th November 1967, floodwaters resulting from flash floods in the region over-topped the dam leading to its failure. Many people were killed in the three nearby towns. Heavy loss of property was also incurred. Following the disaster, the dam was rebuilt and completed in 1980.

1.2.5 Lower San Fernando Dam (California) Failure, 1971

The construction of the Lower San Fernando Dam started in 1912 as part of a hydraulic fill reservoir system in San Fernando, California. The hydraulic fill was placed between 1912 and 1915. The material was excavated from the bottom of the reservoir and discharged through sluice pipes located at starter dikes on the upstream and downstream edges of the dam. Lower San Fernando Dam was constructed at the height of 40 m as a hydraulic-fill earthen dam. The construction configuration resulted in upstream and downstream shells of sands and silts, and a central core region of silty clays. The dam created a reservoir with an estimated capacity of about 25 million cubic meters.

On 9th February 1971, the San Fernando earthquake occurred with an estimated magnitude of 6.6 on the Richter scale. At the time of the earthquake, the water level in the reservoir was about 11 m below the crest. This reduced level was due to an earlier seismic stability analysis that imposed a minimum operating freeboard criterion of 6 m. During and immediately after the earthquake, a major slide event involving the upstream slope and the upper part of the downstream slope occurred (Fig. 1-9). As a result of the slide, a freeboard of about 1.5 m remained.

Figure 1-9 : Upstream slope of the dam after earthquake and draining of lake; Tower No. 2 is in the background (standing). Source: H.B. Seed

Given the likelihood of further damage in the presence of aftershocks, 80,000 people living downstream of the dam were evacuated over a single day. As predicted, aftershocks resulted in the overflow of the dam and approximately 275 million cubic meters of water flowed to the downstream side. Due to the failure of the dam, over 340 people died. (Colenco, 1989)

The devastating San Fernando Dam slide had a significant influence on future earth dam design and building techniques. Seismograph data particular to a given location made it possible to do in-depth analysis and display the results for planning. The San Fernando Dam fall led to the development of new methodologies for dynamic stability studies of earth dams and possible issues with hydraulic fill structures, among other things.

1.2.6 Banqiao Dam (China), 1975

The Banqiao Reservoir Dam (along with 63 other dams) in the Henan province of China failed in 1975, killing an estimated 1,71,000 people (although some reports suggest the number could be as high as 2,30,000) (Energy Education). When the dam failed, it destroyed the homes millions of people and is considered the largest dam failure in history.

In August 1975, the region experienced an extreme flood, resulting in quantities of water falling that had not been considered during the construction of the dam. More than a year's worth of rain fell in only 24 hours, and the dam failed on the 8th August as shown in Figure 1-10. The breaching of the dam leads to the release of 700 million cubic meters of floodwater which caused flooding in the communities and homes downstream.

Figure 1-10 : The Banqiao dam after failure

Source: osu.edu

After this burst, a chain reaction began and the other 61 reservoirs located in the area collapsed, releasing another six billion cubic meters of floodwater. The water covered an area equal to 10,000 square kilometers. The failure to plan and account for extreme floodwaters resulted in the immediate death of 26,000 people as a result of the water itself (Yao Xu, 2012). More than 1,45,000 people died as a result of epidemics and famine following the flood.

1.2.7 Teton Dam Failure, Fremont & Madison counties, Idaho U. S. A., 1976

Teton Dam was an earthen dam constructed between 1972 and 1975. The failure of the dam occurred in June 1976, when the water was being filled for the first time inside it. The flooding of the downstream regions after the failure of the dam resulted in the loss of 14 lives and caused an estimated loss of $400 million.

A 90 m high zone-filled earth dam was constructed in a steep-walled canyon eroded by the Teton River in Idaho. It had a wide silt core, with upstream and downstream shells consisting mainly of sand, gravel, and cobbles.

In the main section of the dam, the impervious core was keyed into the foundation of 30 m depth to serve as a cutoff trench. Lesser cutoff trenches were excavated at both abutments through the permeable rock. Reservoir filling commenced in November 1975 at an intended rate of about 0.3 m/day. Delays in completing the construction of the outlet work combined with heavier than expected spring melt run-off resulted in a filling rate of up to 1.2 m per day in May 1976. The dam failed on 5th June 1976, when the water level in the reservoir was at an elevation of 9 m below the embankment crest and 1m below the spillway crest. Breach of the dam crest and complete failure was preceded by a period of two days by increasing quantities of seepage. This seepage was observed initially 460 m downstream and later on the downstream face of the dam. Noticeable increase in seepage rate from the face of the dam adjacent to the abutment about 40 m below the crest occurred during the morning of 5th June 1976. By approximately 10:30 AM, the flow rate of seepage increased to about 0.4 m^3/sec. This quantity continued to increase as a 1.8 m diameter tunnel formed perpendicular to the longitudinal axis of the dam. By 11:00 AM, a vortex was observed in the reservoir. The seepage flow rate increased rapidly from this time onwards, accompanied by progressive upward erosion of the tunnel crown. The dam crest was breached at about 11:55 AM, with the complete failure of the dam as shown in Figure 1-11.

The failure of the Teton Dam contributed to significant learnings as it was the tallest earthen dam to have failed. **It provided important lessons regarding the need for instrumentation, the need for protective filters to prevent uncontrolled seepage erosion, the design of cutoff trenches, consideration of the impact of frost action, and the importance of adequate compaction control criteria and methods.**

Figure 1-11 : The Banqiao dam after failure
Source: osu.edu

1.2.8 Kaloko Dam (Kilauea, Hawaii) failure 2006

The devastating failure of the Kaloko Dam took place on 14th March 2006. More than 13.6 m^3 of water flowing furiously wiped out almost everything on its way sweeping away 7 people as well (Ancheta 2021 updated). **The dam failure was a result of unusually heavy rainfalls. The water flooded downhill through a ravine east of the town of Kilauea, Hawaii, being 20-70 feet high. Investigations brought out the possible reasons for failure as inadequate inspection of the dam and low maintenance** as shown in Figure 1-12.

Figure 1-12 : Kaloko dam failure
Source: wikipedia

1.3 Major Dam Breaches in India

India has a long experience of dealing with dam failures. The Machchu dam failure of Gujarat is one of the worst experiences in the history of India. Other than that, there are various incidents of dam failures that caused colossal damages/ losses like Kaddam (1957), Panshet (1961), Khadakwasla (1961), Chikkhole (1962), Nanak Sagar (1967), Kodaganar Dam(1977), Machchu Dam(1979), Pratappura Dam (2005) and Tiware Dam (2019).

1.3.1 Kodaganar Dam (Tamil Nadu) Failure 1977

Kodaganar Dam was constructed in 1977, standing on the Kodaganar River, served the entire river basin for irrigation, industry & domestic use, expanding to almost 2000 sq km. The water of the reservoir is mainly used in the Dindigul district and a small part of the Karur district of Tamil Nadu. It is an earthen gravity and masonry dam with regulators, having five vertical lift shutters each 3.05 m wide. The original dam was 15.75 m high from the foundation basement with a height of 11.45 m above the river bed. The storage capacity at the full reservoir level was 12.3 million cubic meters, while the flood capacity was 1275 cubic meters per second. A 2.5 m free board above the maximum water level was provided.

The heavy rains in the Kodaikanal range during 1977 in Western Ghats resulted in flooding due to overtopping by the river water. **The waters flowed over the downstream slopes of the embankment and breached the dam along various reaches. In addition, there was an earthquake registered during the period of failure, although the foundation was strong. Tough shutters were promptly operated during the flood, the staff could only partially lift the shutters, and due to power failure, the additional stand-by generator**

commissioned did not help either. The staff then opted for the manual operation of the shutters. In spite of all efforts, water eventually overtopped the embankment. Water gushed over the rear slopes, as a cascade of water was eroding the slopes. Breaches of length 20 m to 200 m were observed. It appeared as if the entire dam was overtopped and breached, and flooding happened downstream villages of Madurai district and Tiruchirappalli district which leads to loss of lives.

1.3.2 Machchu (Gujarat) dam failure, 1979

The Machchu dam failure or Morbi disaster is a dam-related flood disaster which occurred on 11th August 1979. Machchu Dam was built in 1959 on the river Machchu in the Morbi district (previously in Rajkot district) of Gujarat, India. It was built with the motive to serve for irrigation purposes with a catchment area of 730 sq. km. The dam failed, sending a wall of water through the town of Morbi (now in the Morbi district) of Gujarat, India (The Inundation of Morvi, 1979). According to Government reports, 1,800 people lost their lives but some media reported deaths of nearly 25,000 people due to the flash flood (Refer Fig 1-13).

Figure 1-13 : View of a destroyed part of Morbi after the Machchu dam failure

The failure was caused by excessive rain and massive flooding leading to the disintegration of the earthen walls of the 4 km long Machchu dam. The actual observed flow following the intense rainfall reached 16,307 m^3/s, thrice what the dam was designed for, resulting in its collapse. The 762 m of left and 365m of the right embankment of the dam were collapsed. Within 20 minutes, the floods of 3.7 to 9.1m height inundated the low-lying areas of Morbi industrial town located 5 km below the dam.

1.3.3 Pratappura dam Vadodara (Gujarat) Failure, 2005

The Pratappura dam also known as the Pratapsingh Tank, is basically a huge catchment area spread over 4040 acres of land. It consists of 7 gates in total. 4 gates out of the seven connect it to Sayaji Sarovar via canals, while the other 3 gates connect to the vishwamitri river as shown in Fig. 1-14. The rain water from the surrounding Halol & Pavagadh areas is stored in this catchment area. In case of emergency, when Ajwa reservoir is full, the excess water from the pratappura dam is sent off to the Vishwamitri river.

Figure 1-14 : The condition of Pratappura dam gates
Source: History of Vadodara

A 50-metre-wide breach caused on Friday, 1^{st} July 2005 by the Pratappura dam had severely inundated five villages in its vicinity besides letting a huge flow of water to flow into the city of Vadodara causing water logging in many low-lying areas. After conducting an extensive X-ray study of the reservoir, the administration took up measures to strengthen the dam.

Again, the breach in the reservoir was spotted on the 13^{th} August 2012 morning and was only around four to five feet initially. However, by the next day, it had become around 25 feet wide. A new breach also appeared in the reservoir that was around 10 to 15 feet wide near the existing one. Officials said that the widening was expected given the fact that the reservoir is an earthen dam. The two separate breaches are now expected to become one with just a retaining wall that is around five feet wide separating them. However, the steady water discharge averted any flood-like situation in the city due to Vishwamitri into which the water is being discharged. There is no damage to crops and life in the areas around the reservoir. As per the officials, **there was a possibility that the new soil that was put to repair the breach that took place in 2005 may not have bounded well with the one that was used in the original earthen dam built over 90 years ago.**

1.3.4 Tiware dam (Maharashtra) failure 2019

On 2^{nd} July 2019, the Tiware dam in Ratnagiri district of Maharashtra state, India failed due to heavy rains in the region. The Tiware dam has a storage capacity of 20 lakh cubic meters. The dam breach caused a flood-like situation in seven downstream villages, with 12 houses being swept away. 23 persons were dead after this dam failure in Maharashtra's coastal Konkan region breached following incessant rains leading to a flood-like situation in downstream villages. The dam is in Chiplun taluka of Ratnagiri district has a storage capacity of 20 lakh cubic meters.

1.3.5 Critical related to dam failures in India

The dual problem of aging dam infrastructure and poor maintenance has been considered as one of the major issues in dam failures in India. The UN report anticipates that, by 2050, "most people on Earth" will live downstream from tens of thousands of large dams built in the 20th century, a large number of which will be operating far beyond their design life. Some of the oldest dams in the world exist in India but dam decommissioning is a widely debated subject. Demands for decommissioning have already been raised for the Mullaperiyar dam, Dumbur dam over the Gumti River in Tripura, and Jaikawadi Dam in Maharashtra in different contexts by civil society groups and independent experts.

Hence, subjecting to the failure of standards and quality mixed with natural phenomenon there is a huge risk for the dam failures in any watershed within national/state boundaries or across boundaries in different countries also. The breach in the Karam dam is one of the recent dam failures which created a calamity situation in Madhya Pradesh again raised the need to address the safety and management of dams in India.

1.4 Vulnerability and Risk of Dam Failures/breaches

About 55% of the world's dams are in just four Asian countries, including India. All over the world, many large dams built in the 20th century may start to show signs of aging, and many may already be operating at or beyond their design life. As per the recent study, India has 4,407 large dams of which more than 1,000 would be 50 years or older by 2025. For India, 2025 is set to be a big year as more than 1,000 dams would turn roughly 50 years or older. Older dams pose greater safety risks, cost higher in terms of maintenance, and have declining functionality due to sedimentation. Fifty years is not a defining age for all dams because the design life also depends on factors such as construction and maintenance, the study said, adding that a well-constructed and well-maintained dam can go up to 100 years.

India has 5,334 large dams, according to 2019 data from the Jal Shakti ministry's Central Water Commission, the third-highest number in the world after China (23,841) and the US (9,263). Over 1,115 large dams will be about 50 years old by 2025. In less than 30 years, by 2050, over 4,250 large dams would pass 50 years of age, with 64 large dams being 150 years old. (Harsha, 2019)

India's dams are more vulnerable to deterioration because a large proportion of them are earthen – built by compacting successive layers of earth, and not concrete – and are hence more prone to aging. Secondly, the country gets concentrated rainfall every year for a designated time period as opposed to distributed rainfall, which contributes to the dam's vulnerability. Thirdly, siltation, which is the accumulation of silt and debris behind the reservoir, leads to a reduction in the storage capacity of the dams. Furthermore, in India, the downstream areas are often exposed to flood disasters even without a dam breach, in which water creates an opening in a dam due to rapid erosion of a section of the embankment. Flooding caused 44% of dam failures in India, while the remaining was caused by other factors, including inadequate spillway capacity, piping, and poor workmanship, as per the Central Water Commission.

1.5 Background to Karam Dam and Present study

Irrigation development in the state of Madhya Pradesh is only 28.2% which is below as compared to the national average of 38.75%. The District Dhar is located in Madhya Pradesh where the irrigation development is below the state's average of 28.2%. Crop cultivation in this district is totally dependent on rainfall and on the vagaries of monsoon. The State and the Region are experiencing erratic rainfall, which has further worsened the situation. Fertile land is available in Kukshi Tehsil of Dhar district where the reliable irrigation system can make a great difference in the yield of crops in many folds. Therefore, potential irrigation will improve the economic condition of the farmers in that area and will also improve the life of the populace providing drinking water, setting up of new industry etc. This will result in the overall development of the region and make the region greenery.

Further, during the summer season, the groundwater table goes deep, and the region suffers from an acute shortage of groundwater. Creation of water bodies and developing of an irrigation system will result in the recharge of groundwater and the improvement of ecology and will have a great positive impact on the environment and wildlife of the region. To improve the scenario and to have overall development of the area, Govt. of Madhya Pradesh is dedicated to provide irrigation in the areas of Kukshi by storing the river flow from the upper part of the Karam River in the area near village Kothida (Fig. 1-15). Therefore, the Earthen Karam dam was proposed of Length 355.04 m with a height 52.00 m during the year 2018 (Fig. 1-16). The design specification of the dam are attached in Annexure-1. The reservoir is located at latitude 22^{0}22'4.766''N and Longitude 75^{0}29'3.474''E and in Survey of India Toposheet No. 40 N/07. The nearest rain gauge stations are Dharampuri and Nalchha. The rainfall this year between June and September at Dharampuri and Nalchha are 599.00 mm & 786.20 mm. The rainfall at Dharampuri and Nalchha from 2018 to 2022 between June and September are shown in Annexure-2 reflected that 2022 had the maximum rainfall recorded. The water level data of Karam dam at Dahiwar water gauge station (newly set up) record high during the year 2020 (Annexure -3) before commencing the heavy influx of Karam dam breach in 2022.

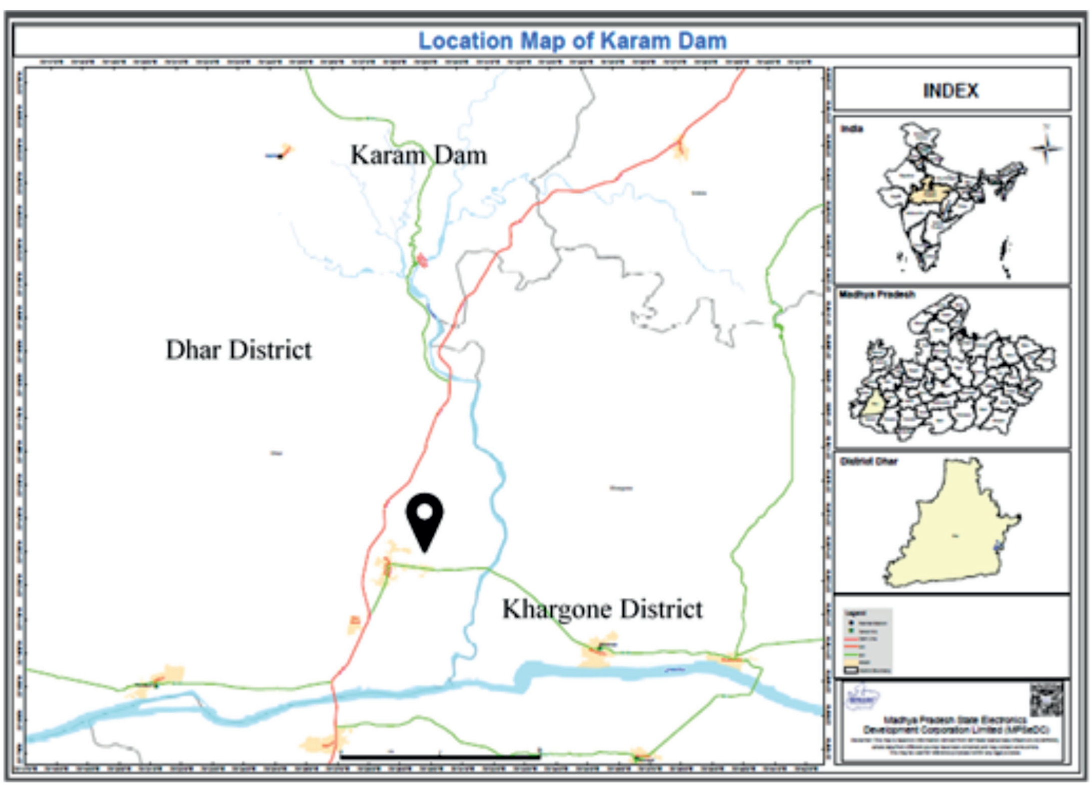


Figure 1-15 : Location Map of Karam Dam

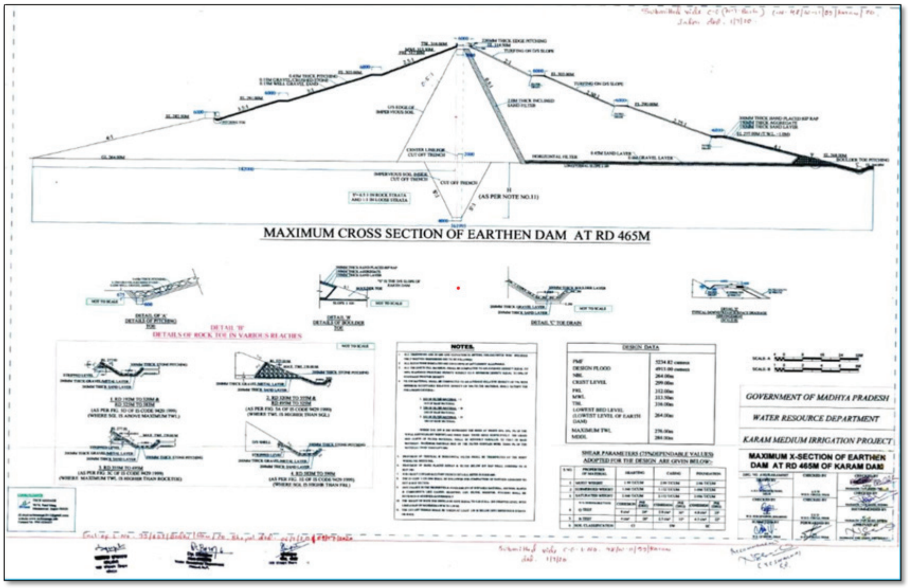


Figure 1-16 : Approved Design of the Karam dam

It was known from the CWC official that during breach the flood water level was maximum, but measurement record could not be obtained during the visit. The nature of the catchment area (Fig 1.17) is hilly and there are 35 upstream projects (as reported by WRD, MP). As per the topography of the command area (Fig 1.18) and storage of water, the Karam Medium project was proposed to provide an irrigation facility to 8750.00 ha later it was increased to 10500.00 Ha through gravity flow. A total of 52 no. of villages mostly inhabited by tribal would be benefitted in the drought-prone region. The domestic water supply and for industrial use of the Mandav village, a provision of 5.00 MCM of water has been considered. Total catchment area of the Project is 342.50 sq. km (Fig 1.17). Further, a provision for 3.04 MCM of water was made for future expansion.

Geologically, the dam area is occupied with Deccan Trap Basalt. The Deccan Trap Basalt rock belongs to the Malwa Group of the Upper Cretaceous to Paleocene geological age. The colour of the basaltic rock is greyish black, nature of the rock is fine grained, porphyritic hard compact rock to road metal rock in range.

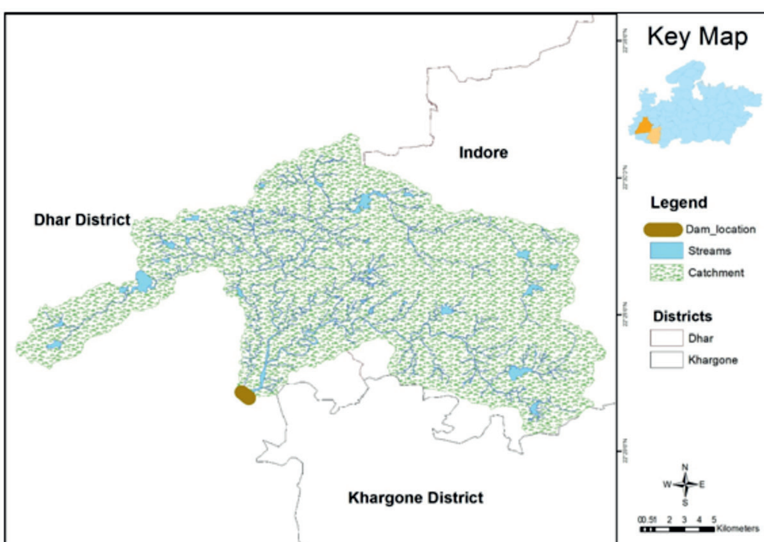


Figure 1-17 : Catchment area of the Karam Dam

In the Deccan Trap Basalt lava flows with Porphyritic to mega Porphyritic flows (7 flows) of Mandelaswar formation and the flows with mega porphyritic flows (11 flows) of Kalisindh formation are exposed at the top surface. A very small thickness of alluvium is restricted to the river side. Geomorphologically, the Karam dam area is occupied by shallow and narrow alluvial plains. The rest of the area is covered with plateau units. The nature of the plateau is ranging from un-dissected to moderately dissect. Intrusion of Dolerite Dykes are also reported in the nearby structurally controlled area. Dissection and weathering were very common due to the semi-arid climate and the nature of drainages in the area.

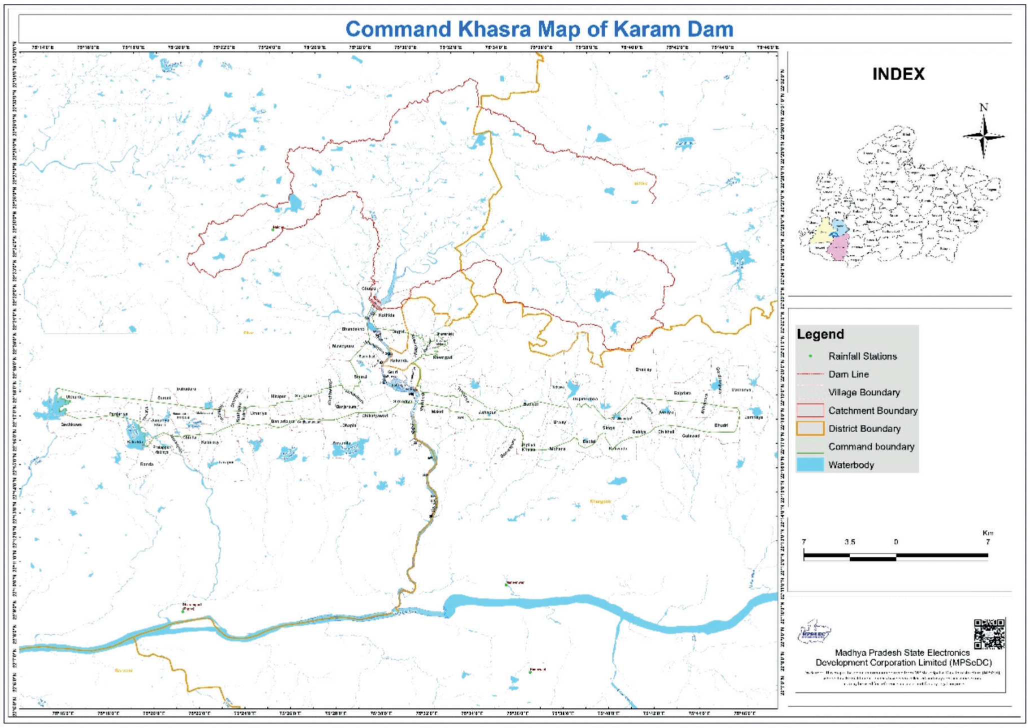


Figure 1-18 : Command area of Karam dam

Source:MPSDeC

1.6 Karam Dam Specifications

The Karam dam project was proposed for irrigation purpose only. Earthen Dam along with gated left flank spillway (Fig. 1-19 & 1-20). The profession of the people of this area is based on agriculture; the area comes under drought prone area. The percentage of irrigation of this district is very low compared to other districts in the state. To improve the percentage of irrigation, the Karam Irrigation project is proposed for the development of the irrigation percentage of this area. The General and Longitudinal section of the dam specifications are kept in Appendix I&II.

Figure 1-19 : Earthen Portion of the dam during construction

Figure 1-20 : Spill way under construction

Chapter 2

2.0 The Karam Dam Breach -Timeline of Situation Reporting and Actions/ Reactions

The seepage of water from the under-constructed Karam Dam in Dhar district of Madhya Pradesh had set off alarm bells on Thursday, 11th August 2022 at about 2:15 PM, prompting the evacuation of more than 6,000 people from 18 villages in the Dhar and Khargone districts. The officials were concerned about the grave risk that posed threat to human lives and livestock besides the probable damage and losses to the agricultural fields and infrastructure. As a precautionary measure, people from 12 villages in Dhar district and 6 villages in Khargone district were shifted to safer places (shelters) as those settlements were prone to huge devastation if dam breaches. Teams of the Army and the National Disaster Response Force (NDRF), State Disaster Emergency Response Force (SDERF), and Home guards have reached the Dam site apart from the higher officials and various departmental staffs of State Govt. for the emergency response, rescue, evacuation, and other expected disaster situations. The successful completion of the dam breach without a single life loss took four days from the initial observation of seepage on 2:15 PM, 11th August 2022 (referred to as day one) to 10:00 PM of 14th August 2022 (referred to as day four) by the stored water is discharged to the Narmada river smoothly. The situation, actions, measures, and implementation mechanism followed by the administration have been described chronologically in this chapter.

2.1 The initial observations, events, and actions on 11th August 2022 (Day-1)

Around 2:15 PM on 11th August 2022, the villagers near the Karam dam site noticed the piping from the bund, and the same was informed to the district authority through a video record of the piping in the dam. Immediately, after receiving the information District Magistrate and Superintendent of Police of Dhar district were alerted and rushed to the dam site to analyze the severity of the situation (Fig. 2-1). The technical teams (WRD, Project management) and administrative teams (DM, ADM, SDM, SP, and others) gathered at the site quickly to assess the situation. The initial assessment of habitations downstream as a precautionary measure was made.

Figure 2-1 : Inspection of leakage Dam site being done by District Magistrate, Dhar and Superintendent of Police, Dhar, ADM Dhar & Dam Engineers

The WRD engineers initially surveyed the structure and started working on leakage repair by roller compaction on top of the embankment (Fig. 2-2). The seepage is controlled to an extent. However, the downstream habitations were alerted about the likelihood of dam failure. An official of Executive Magistrate rank was deployed on-site for the precautionary measures. The initial analysis found that the dam was not constructed as per the design as shown in Figure 2-3. Some of the probable causes for the failure of under constructed Karam dam are discussed below:

Figure 2-2 : Roller compaction of Embankment crest

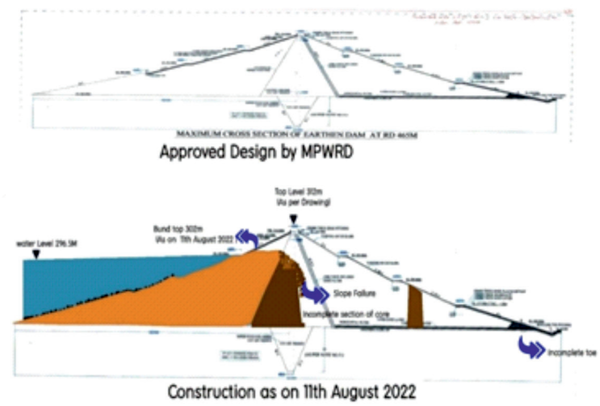


Figure 2-3 : Status of dam construction as on 11th august 2022

- The methodology adopted for the dam construction was not as per the design and specifications. The incident at Karam Dam should not be anticipated as a dam failure as the dam was in the construction phase. The improper construction methodology adopted during the dam construction led to its collapse.
- In the concrete spillway portion, the sluice valves were proposed in Non-Overflowing (N.O.F.) section, but at the time of the incident, these valves were found to be not properly installed. As a result, the mechanical failure happened because of the excess water pressure, which hindered the excess discharge flow from the sluice opening.
- Improper planning of the construction activities, including lack of compaction in the earth dam, nalla closure activities, and necessary measures for spilling excess water in case of heavy and sudden rainfall in the catchment.

2.2 The call for Emergency on Friday, 12th August 2022 (Day 2)

On 11th August 2022, the efforts made by the administration and technical teams to control the seepage succeeded and everyone felt that the situation was under control. On the early morning of 12th August 2022 around 7:30 AM, a large earthen portion of the dam bund of about 10 meters in height and 20 meters in length slides (Figs. 2-4 & 2-5) in the hearting zone (comprises black cotton soil) which again lead to a severe panic of a dam breach. District Magistrate and Superintendent of Police rushed to the dam site with their teams and appraised the incident to the hon’ble Chief minister (CM) and Chief Secretary (CS) of the state.

Figure 2-4 : Slacking of soil from the embankment

Figure 2-5 : Dam site collapse of hearting scene at 11:00 AM on Day 1, 12th August

2.2.1 Activation of Administrative Machinery

The partial slope failure of the dam structure indicated the probable dam failure, the administration decided to evacuate the downstream villages on the bank of the Karam river. The district administration activated this process and the executive magistrate, engineering wings, and rural development functionaries reached the spot. Relief camps and shelters were set up within an hour to evacuate the people. Social and Non-Governmental organizations (NGOs) were also requested to join in relief work.

After setting up relief camps and shelters, the villagers were moved to the shelters and a few villagers were moved to higher areas within a short duration of 2 hours. The downstream 12 villages from Dhar district and 6 from Khargone were put on high alert. The district magistrates of both districts along with police personnel continuously toured villages to take stock of the prevailing situation.

2.2.2 Requisition of Resources

Upon consideration of the severity of the dam breach, a formal request was made for assistance from Army and NDRF. The additional SDERF teams also reached the dam sites by 9:00 AM. The efforts to open the sluice valve to discharge the stored water by the local technical persons (Fig. 2-6) were also tried but did not succeed well. The Earthmoving machinery from nearby project sites was moved to the spot for the urgent requirement.

Figure 2-6 : Efforts to open the Sluice gate which was closed

2.2.3 Operationalization of Communication Channels

The Hon'ble Chief Minister (CM) and Chief Secretary (CS) along with senior officials in Bhopal continuously monitored the situation and briefed all all concerned stakeholders and the media at regular intervals. The officials of both districts were kept on alert and responsibilities were delegated. A communication channel on social media (WhatsApp group) was formed for the smooth flow of information from the dam site to villages and vice versa. The District administration started the evacuation of the downstream villages in a proactive manner (Figs. 2.7 & 2.8)

Figure 2-7 : Police announcing about the possible breach of dam in Kothida village

Figure 2-8 : District Magistrate, Dhar, monitoring evacuation in Pharaspura village

2.2.4 Support from the response forces

As requested by the district administration, 4 units of the National Disaster Response Force were moved to the Dam site. NDRF and Army were briefed about the work in detail and deployed for evacuation operations and to prevent people from re-entering their villages. However, NDRF expressed their views about the evacuation and vigilance work which is out of their expertise in search and rescue works. Additionally, 2 army helicopters were arranged for the rescue operations in case of emergency.

2.2.5 Call for action instead of waiting

On 12th August, 2022 the district administration took the call for safeguarding their population by evacuating to safe places. Till 3:00 PM, the district administration continuously monitored the situation at the dam, and various alternatives were explored such as opening on the left side in the spillway portion through blasting, creating a channel at the right abutment, and blasting the bottom of the channel to increase the depth, excavation from dam top which need >2 months, increasing the width of the channel in right abutment (by position changes left flank to right flank). Finally, at 3:00 PM, a decision was made to safely release water by forming a channel at the right abutment of the dam. Upon making the decision, the engineers of the irrigation department started working to dig a side channel on the right flank of the dam (Fig 2-9). After excavating to some centimeter's depth, the rocky/ hard strata were encountered which made everyone rethink the strategy. At the other end of the dam, efforts were continued to open the sluice valve. It was realized that a specialized team is needed to open the sluice valve and the technical team who knew the method was not available at the dam site and the tools for opening the valve screw were also not available which made things difficult.

Figure 2-9 : Excavation for bypass channel

2.2.6 Expecting the worst scenario

While making the channel on the right flank a hard & big stone encountered by the machines faced difficulties in achieving the required depth of the channel (Fig. 2-10). The administration and technical teams were not sure about the extent and exact nature of the flood because of cutting/controlled cutting which was taking longer time than expected. At the same time, the administration was also aware that the dam could breach at any moment because of the seepage which can cause a flash flood with an uncontrolled flow of water from the dam. As a result, the entire population/ villages (to be affected) were shifted to safe locations and SHGs were roped in for making food arrangements at relief camps. The district administration made sure that all domestic animals were also moved away to safe places. There was a total of 23 relief camps in both districts which were established to accommodate the population. The alert warnings of dam breaches were placed in the villages (Fig. 2-11).

Figure 2-10 : Excavation on right flank to make a channel

Figure 2-11 : Warning Signs in villages

2.2.7 The continuous efforts to avert the disaster -The night of 12th August 2022

The total administration is on high alert and continuing their efforts to smooth the discharge of water from the dam (Figs. 2-12 & 2-13). Two ministers and district administration monitored the situation at the dam site and executive magistrates along with police teams patrolled villages with the highest level of alertness. A live feed channel had established with the Situation room in Bhopal to closely watch the situation. Real-time information was broadcasted directly from CM House to tackle the spread of false rumors through the media.

After working for more than 8 hours, by 2:00 AM on 13th August 2022 technical teams and their earth movers could create the originally planned channel by 50% but that brings down the level to 295.5 m from 296 m. By 4:00 AM, everyone on site realized a cut needed to be made on the dam structure to release water. At 4:30 AM, Additional Chief Secretary (ACS), Water Resources Department (WRD), and Commissioner Indore were briefed on the necessity of the planned cut to the dam structure (Fig. 2-14).

Figure 2-12 : Cutting the hillock and creating the channel

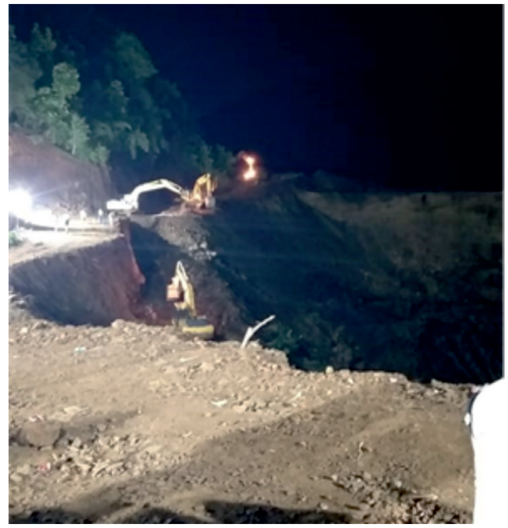


Figure 2-13 : The continued Excavation efforts

Figure 2-14 : District Magistrate Dhar briefing the possibilities of depleting the reservoir to Divisional Commissioner, Indore

Wing Commander airbase New Delhi Mr. Shivam Manchanda and Major Baljeet arrived on spot in a helicopter for the emergency work at the dam site (Fig 2.15). It was with the purpose of conducting an aerial survey and aiding the evacuation operation. Army from 4 Mahar Border Regiment, Mhow, and 56 Rapid (S) and Engineer Regiment / 36 Infantry Division, Sagar joined the operation for rescue purposes.

Figure 2-15 : Helicopter from Nagpur Arrived

2.3 The continued efforts on 13th August (Day 3)

In the early morning, the current situation was briefed to HCM by CS and ACS. HCM, CS, DGP, ACS-H, ACS-WRD, ADGP-L&O, and ADGP-INT had a series of meetings at Vallabh Bhavan Situation Room (VBSR), Bhopal on the issue of how to release the huge stored water (Fig. 2-16). Vallabh Bhavan Situation Room (VBSR), Bhopal established a live connection with the Dam site to monitor and guide the operations and live.

Experts from the WRD department have geared up further and drawn a map for submergence in case of collapse. As per the design drawing, the dam was designed for the outflow of 5000 cubic meters per second (cumecs). Keeping in view of a probable dam break, even the map was generated for the expected flow of 9200 cumecs and identified the probable inundation in the villages. The map was shared with the teams in both districts and asked to treat the map as tentative for the evacuation (Fig. 2-17). Later, the estimated discharge was doubled and respective villages were evacuated out of fear and uncertainties in coordination with all the response forces (Figs. 2-18 & 2-19).

Figure 2-16 : Hon'ble Chief Minister of M.P., Shri Shivraj Singh Chouhan Monitoring the situation

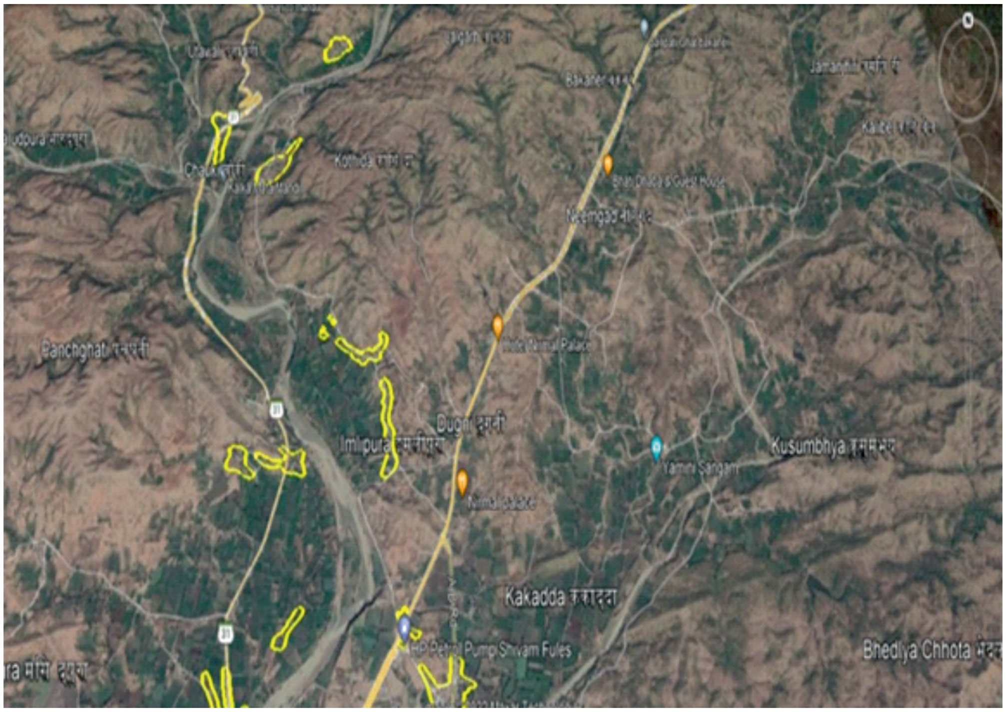


Figure 2-17 : Probable inundation maps circulated for evacuation

Figure 2-18 : Divisional Commissioner Indore, DIG Rural, IG Indore Division monitoring the situation on dam site

Figure 2-19 : SDERF and State Police on evacuation

2.3.1 Time to take calls- coordination between technical and administrative teams

The rate of discharge of water through the channel was not as per the expected range. After a thorough discussions with the technical personnel, it was decided to breach/ cut the dam at the earliest instead of waiting for the narrow channel. The experts from Central Water Commission (CWC), National Dam Safety Authority (NDSA), and an expert from IIT Roorkee, were consulted for technical guidance to breach/cut the dam (as shown in Fig. 2-20). Keeping in view the critical condition of the dam, the first priority was to deplete the reservoir as soon as possible through controlled discharge of water from the reservoir. Various alternatives were explored such as i) Creating a channel at the right abutment and blasting the bottom of the channel to increase the depth ii) Excavation from the Dam Top iii) Increasing the width of the channel in the right abutment by moving the working platform from right to left.

In order to increase the discharge, officials were of the opinion to blast the hard rock and clear the path of the water to increase the water flow. However, the blasting expert advised controlled blasting which will take 18 hours to achieve the desired results and the engineering team was not confident about the repercussion of blasting on the structural stability of the dam. Further, the dam safety engineer was of opinion that blasting might impact the structural stability of the dam. Eventually, the idea of blasting was dropped.

Figure 2-20 : High level discussion between Pawan Kumar Sharma Indore Commissioner), Aditya Sharma (NDSA), Vivek Tripathi (CWC)

2.3.2 Preparation to face the adverse scenario– at 2:00 PM for the unwanted incident

The district administration focused on ensuring the complete evacuation from the villages of both humans and animals by deploying the officers of Deputy Collector and SP rank (Fig. 2-21). The teams were instructed in real time and rechecked the evacuated areas. The district administration focused on ensuring the complete evacuation from the villages of both humans and animals by deploying the officers of Deputy Collector and SP rank. The teams were instructed in real time and rechecked the evacuated area. Despite the challenges in some areas where people were resistant to leave their homes, the administration handled the situation in an effective manner. Orders under section 144 Cr. PC. issued to restrict anyone from re-entering the villages. Extra teams with trucks were deployed and ensured the shifting of livestock (Cow, Buffalo, Goat, Hen, etc.) as shown in Fig. 2-23.

At 3:00 PM team on the west flank was able to finally open the sluice valve completely by breaking off the cover with the help of an excavator (Fig. 2-24). The capacity of the sluice valve to release the water was very low, i.e. 5 cumecs only. Technical teams were still working on the hard rock in the narrow channel till 4:00 PM. The team was working at the opening point and the stone breaker/ cutter was working on the same rock for the last 18 hours.

Figure 2-21 : SDM (Sri Bhupinder Rawat evacuating people in Jahagirpura and SDM (Sri VirendraKatare) joining evacuation in Pharaspura village

Figure 2-22 : Executive Engineer BP Meena explaining Dam channel

Figure 2-23 : Shifting of Cattle in Goshala at Dharampuri

Figure 2-24 : Discharge of water through a sluice valve

On the dam site, the CWC officials completed the inspection and they were surprised at the quality of construction. The CWC officials did the technical analysis of breaching the dam and put forth the pros and cons of breaching the dam. The same was briefed to the CM in live interaction between 5:15 PM to 6:15 PM. After several administrative discussions at the state level, Chief Sectary (CS) directed the field teams that the state has decided to breach the dams per technical advice. The technical team at the site started the creation of the channel by cutting the embankment within minutes (as shown in Fig. 2-25).

Figure 2-25 : Rising levels of uncertainty due to hard rock on 13th August, 2022

Finally, at 11:00 PM water from the dam started to come out through the channel on the right side. A free-flowing jet of water started but against expectations, muddy water in very small quantities were coming out. The water has become clear and looked like a small free-flowing stream, but, too small to empty a Dam.

2.4 The ray of hope - Events and actions 14th August (Day-3)

In the early morning of 14th August, at 8:00 AM, CM directed the officials and teams to speed up the Dam flow and finish the rescue operation. CM called the villagers to enquire about the stay-food arrangement for rescued people and animals (Fig. 2-26).

Figure 2-26 : Hon'ble Chief Minister of M.P., is interacting with the villagers and officials

He was particularly happy to note enthusiastic public participation in the evacuation activities. He directed the officials to treat the evacuated villagers as 'State Guests'.

At 10:00 AM, the flow at the Dam site was substantial, however, not sufficient. The engineers had created five meters head at the starting point, but the actual head was just around one meter. Due a rock had appeared in the channel, reducing the actual head as well as the flow amount. Thereafter, a stone cutter/ breaker was put on the job and one more was engaged along with 2 poclain machines at the created channel in the Dam side to cut the compacted rock and widen the flow path.

Though there was the discharge of water through the channel and sluice valve for the whole night, the water level instead of decreasing had increased to 296.7 m from 296.45 m due to the rainfall in the upper catchment area (Fig. 2-27). At midnight, the depth and width of the bypass channel were about 1 meter. Due to the rise in the water level, the team discussed on the decision of increasing the depth and width of the bypass channel to increase the discharge (Fig. 2-28) of water. At 10:55 AM the water flow had increased in the channel since midnight giving hope.

Figure 2-27 : Water level status at dam

Figure 2-28 : Deepening status of channel at 12.00 noon

2.4.1 Help from the Nature-Hard Rock Returns but for Good

The inflow of water due to the rains in the catchment area of the Dam was compensating for the small outflow, as a result, no substantial lowering of water levels. Due to a steady increase in the water level, the administration feared the overtopping of the dam. The water level had come down by 15 cm only in the last 30 hours.

The excavation was continued with the aim to deplete the reservoir. But the hard rock restricted the efforts to obtain the desired depth of the channel. However, this hard rock acted as a boon in disguise as it diverted the water flow in the channel towards the embankment and increase the speed of cutting the embankment. So, the machinery was withdrawn from the excavation and water started playing its own role by cutting the edges of the dam (Fig. 2-29).

Figure 2-29 : The breach in the dam embankment

Once the water flow started cutting the edges of the embankment, nobody had a clear idea about how fast the Dam would collapse and how rapid would be the flood. So, both the district teams rushed to the villages to confirm no one was left behind. By 6:00 PM, the loose or compacted sand wall was falling under the strength and might of flowing water. Command Control Centre, Bhopal was watching too, and had a video meeting immediately. The teams in the villages were alerted with all instructions repeated. The traffic at Agra-Bombay highway and all the roads on the Karam river was stopped. Finally, at 6:45 PM the breach widened and the water was discharged through the breach downstream (Figures below).

Figure 2-30 : The submerged camp site at dam due to the water

Figure 2-31 : Water discharge in river (almost touching AB-NH bridge)

Figure 2-32 : Water discharge in river at peak flow

2.4.2 The scenario of the Downstream Settlement of the last village (Lasangaon) at 7:30 PM

Due to the breach, the water level in Dam fell down rapidly. At 8:00 PM, Dam safety officials from the dam site called and informed us that the peak is over and flow has started decreasing. Taking 296.5 mt at 6:00 PM (14.5 mcm), more than 8 mcm of water had come out in 2 hours. Once the peak flow was reduced, the traffic was opened at 9:30 PM on AB road.

Around 10:00 PM, the water level went down in Jalakoti, the lowest downstream village in the Khargone district was received. In Dhar district, the flow level was reduced to normal around 11: 30 PM at the last village Lasangaon. Soon after announcements were made to declare villages safe to return and the situation was totally under control.

The restless combined efforts by both administrative and technical teams for more than 72 hours averted the disaster of the Karam dam breach and turned it into a best practice in disaster management.

Figure 2-33 : Happy Faces of successful aversion (14th Aug 11:30 PM, LasanGaon, Dhar District)

Figure 2-34 : Dinner in peace (at Jalkoti, last village on Khargone district)

Chapter 3

3.0 Introduction

Various resources/ disaster response forces were deployed well in time in a proactive mode for anticipated search - response, evacuatiory rescue and relief operations in event of a breach of Karam dam, Dhar district, Madhya Pradesh. The various disaster response forces, on being requisitioned, promptly reacted with great synergy with the central, state, and district authorities and all other stakeholders. The main focus of the operations was on preventing the loss of lives and livestock in event of a dam breach. An effective, timely, and coordinated multi-agency response is a pre-requisite to eliminate or reduce the risks of any disastrous situation. Under the visionary leadership of the hon'ble Chief minister, the state government's line departments were on their toes to attain the objective of zero casualty. Hon'ble WRD Minister, Chief Secretary, ACS (Home department), and ACS (Water Resources Department) shouldered with each other during the response to dam failure. The effective coordination at the top level facilitated timely decisions, communication, resource deployment (man and machine), and lighting arrangements to minimize the impacts of dam failure. The other esteemed agencies/ departments also played a crucial role during the response, including state SDERF, Home guards, Indian Army, Indian Air Force, IMD, CWC, State Police, and all state line departments. The evacuation, response and relief activities for the dam failure are discussed in detail in the sections below.

3.1 Role of Administration and Governance - Coordination, Supervision and Timely Directions for immediate Action

With the very first trigger of an impending disaster, which in this case was the leaking of water from the downstream face of Karam dam, the whole Government machinery led by Hon'ble Chief Minister (HCM) at the highest level swung into action immediately. Hon'ble Chief Minister, Sri Shivraj Singh Chouhan was keeping a close vigil online on the situation from VBRS, Bhopal along with Chief Secretary, ACS Home, and WRD as shown in Fig. 3-1

Figure 3-1 : HCM in action: Monitoring the situation from VBSR

Figure 3-2 : IG, Indore Division, DM Dhar, SP Dhar and SDM Kukshi inspecting dam site

Figure 3-3 : Ministers in action at Dam Site

By the evening of 11th August 2022, two ministers viz. State Water Resources Minister, Sri Tulsi Silawat and Industries Minister, Sri Rajyavardhan Singh Dattigaon visited the site. DM and SP, Dhar rushed to the Dam site immediately after hearing the news (Fig. 3-2 & 3-3). The technical team of WRD engineers started to repair the downstream face of the dam. The Executive Magistrate was assigned duty on the dam site for close observation. Immediate support from experts of the Central Water Commission (CWC) was sought. It was advised to dig up a side channel to drain out water from the reservoir to prevent the possibility of the dam from bursting. HCM termed the steps taken after the dam breach detection as the “finest example of disaster management”.

3.2 Evacuation, Response and Relief Operations by State Force & Home Guards

After the first information was received by the administration, the district administration alerted the state-level administration and requested help from the state response forces.

- The Home Guard team from Indore and Bhopal HQ were sent with the required materials to the Dam site on 12th August 2022 for the safety and maintenance of law & order at the spot.
- State Police and Home Guard (17 teams with 145 Officers/Staff/Jawan) were present at various spots with Motorboats with OBM and other related equipment & material related to the disaster for the safety point of view.

- Home guard, Bardwani team also reached Maheswar as per instruction of their Commandant.
- Home Guard teams were mainly engaged in the coordination with local administration at villages and required spots for safety, maintaining law & order, evacuation of villagers & cattle, etc.
- On 13th and 14th of August all the teams were engaged with technical teams for the safe passage of water by making the side channel with the use of JCB, Poklain.

3.3 Evacuation, Response and Relief Operations by State Disaster Emergency Response Force (SDERF)

After receiving the information regarding the Karam dam leakage at State Command Centre, Bhopal at 5:45 PM on 11th August 2022, the SDERF team and DRC, Dharampuri were asked to reach the site immediately. The same night, DRC, Dharampuri, and Manawar were stationed there and alerted from a security point of view. After the information on more water leakage and chances of the dam bursting on 12th August 2022 at 07:00 pm. The following teams were asked to reach the dam site.

Table 3-1 : Team details of SDERF, DCGH, PC/HC & HG

Teams	**DCHG**	**PC/HC**	**SDERF**	**HG**	**Total**
Dhar	01	01	14	14	30
Khargone	01	01	07	04	13
Indore	-	01	04	05	10
Badwani	-	01	08	02	11
Jhabua	-	-	05	04	9
NDRF					
CC	SI	ASI GD	HC	Constable	
01	02	01	07	15	03

The following teams also reached the spot:

- SDERF Khargone with 13 members reached Gujri village at 11:00 Hrs.
- SDERF Indore with 10 members reached the Dam site at 11:30 Hrs.
- SDERF Bardwani with 11 members started for the Dam site at 09:30 Hrs.
- SDERF Dhar with 30 members reached the Dam site at 08:45 Hrs.
- SDERF Jhabua with 09 members started for the Dam site at 13:25 Hrs.
- NDRF Bhopal with 29 members started for the Dam site at 09:10 Hrs.

All the above teams were engaged in downstream villages for the management of the safety of villagers and cattle. On 12th, 13th, and 14th of August, all the teams were engaged with technical teams for the safe passage of water by making the side channel with the use of JCB, Poklain, etc. along with the maintenance of law & order, safety of villagers & livestock, evacuation etc.

3.4 Evacuation, Response and Relief Operations by National Disaster Response Force (NDRF) and Indian Army

Teams of the Army and the National Disaster Response Force (NDRF) reached Dhar, Madhya Pradesh on Saturday, 13th August 2022. Around 200 Army personnel, including engineers, and three teams of the NDRF from Bhopal as well as from Gujarat's Vadodara and Surat had reached the Dam site at Dhar to tackle the emergency. Each team of NDRF had around 30 to 35 members. Army from 4 Mahar Border Regiment, Mhow and 56 Rapid (S) Engineer Regiment 36 Infantry Division, Sagar joined the operation. They were being engaged in safely draining out water from the reservoir to reduce pressure on its wall. In parallel, they were engaged with the local administration for the evacuation of villagers and cattle in the shelters which were arranged at Dhamnod. Two helicopters of the Indian Air Force (IAF) were put on standby to deal with any emergency (Figs. 3-4 & 3-5).

Figure 3-4: Helicopter as standby for emergency

Figure 3-5 : Rescue efforts by NDRF and Indian Army

On 13th and 14th of August, all the teams were engaged in the safe passage of water by making the side channel along with the maintenance of law & order, safety of villagers & livestock, evacuation etc. As a precautionary measure, people from 12 villages in the Dhar district and 6 villages in the Khargone district have been shifted to safer places adding that these settlements were downstream of the dam. (Fig. 3-6).

Figure 3-6 : Shelter at Kankariya village

3.5 Role of Volunteer Organizations and NGOs

Voluntary organizations and NGOs play a significant role in disaster response, mitigation reduction and in coordination activities as well. During the Karam dam breach also, the local NGO (Seva Samaj) played a crucial role in providing relief to the people. The team visited one of the safe shelters in Dhamanodh (Fig. 3-7).

The shelter was a huge marriage hall having the capacity to accommodate hundreds of people. The people were evacuated in 2 hrs from their respective villages and moved to safe shelters. The coordination between the administration and NGOs played a key role in makeshift the marriage hall a relief shelter. The NGOs also helped in arranging basic needs like food, clothes, etc. Based on the interactions with the Patidar Samaj at Dhamanodh, the contribution and associated things received from the community helped the management to arrange it in a very short time. During the crucial period, the NGOs collected the food from the households and distributed it to the people at the shelters and to the people involved in the operations. Apart from the NGOs, the administration with the help of local communities took care of the people who were shifted to the high-elevation areas. Proper care regarding the availability of feed to the livestock was also taken. The Collector, Dhar highlighted the support received from the communities and NGOs in reducing the additional pressure on the administration in the decision-making process both physically and financially. This showcased one of the best examples set for the coordinated effort between NGOs, communities and administration.

Figure 3-7 : The team visited one of the safe shelters in Dhamanodh

3.6 Role of Media

The backbone of any democracy is independent, professional and responsible media. Their role is to inform correctly, criticize and stimulate debate. The social responsibility of the media is to communicate the right information to the public. In this case of Karam dam breaches, Media disseminated all the correct information related to Karam dam breaches in an effective manner. The media management from the administration was excellent. The information released by the HCM from time to time helped in avoiding any sort of rumors/ panic in the communities (Fig. 3-8). The archive of news items apart from the data collected from the authority helped a lot in the preparation of the documentation.

Figure 3-8 : Continuous updates from HCM in Media

3.7 Public/Community Participation

Public and Community participation is considered to be one of the cornerstones of effective DRR&R. Public participation in DRR ensures shared responsibility and transparency in DRR planning and implementation. It also allows decision-makers to make communities aware of the risks which they faced while informing the community about their understanding of such risks. During the Karam dam breach also, the understanding and cooperation with the administration resulted in zero causality and the economic losses to a minimum value.

On 11th August 2022, after the identification of the seepage in the dam wall, alerts were issued to the downstream communities to evacuate and move to safe shelters. At first, people were reluctant and ignored the alerts and stayed in the villages. After the observation of the first breach and slacking of soil on the bund around 7.00 AM on 12th August 2022, the district administration formalized the disaster response and within 2 hours the villagers agreed to move to the elevated area from 12 villages of the district Dhar and 6 villages of district Khargone. The rapid evacuation is evidence of the cooperation and coordination between the district administration.

Chapter 4

4.0 Loss/ Damages and Needs Assessment

Dam failures may cause flash flood and consequently, causes immense property damage, environmental damage and even loss of lives and livestock. Additionally, there may be public health risks as well.

The peak discharge from the side channel created at the Karam dam site passed at around 5:30 PM. The flood wave inundated (low-intensity submergence) very few parcels (Tables 4.1 & 4.2). A small bridge in the village was found inundated. The flood level remained almost 2 ft. below the deck level of a bridge on Agra-Bombay Road.

4.1 Loss and Damages in Dhar district

Since the villages were evacuated and animals were shifted from the villages, no casualties were reported. The submergence was in the agricultural land, brick kiln, culverts, etc. One temple was also submerged for some time. Traffic was halted on AB Road and Nagda-Gujri state highway for five hours as a precautionary measure. The perfect risk assessment and subsequent management by administrations resulted in zero loss of lives and livestock. High alertness of all stakeholders since Day zero and proper counselling to the villagers saved them from a catastrophic situation. The heavy flow of flood water after the breaches of the Karam dam washed away the soil in a few parcels (Fig. 4.5) of certain villages (Table 4.1). In some places, crop damage was also reported. The status of compensation for the affected farmers is shown in (Table 4.2).

Table 4.1 : Village parcels affected at Dhar district due to breach of Karam dam.

Sl.No.	Village name	Total no. of survey affected	Survey numbers
1	Simrali	10	224/1, 224/2, 224/3, 224/4, 224/5, 223/1/1, 223/1/2, 223/2/1, 229, 221/2, 221/3, 199
2	Jahangirpura	16	134/1, 134/2, 136/1, 136/2, 136/3, 136/4, 176, 177, 205/1, 208/2, 173/4, 173/2, 173/3, 173/1, 178/1, 201
3	Faraspura	4	47, 48, 53/3, 53/4
4	Kothida	31	64/1, 62/2, 66, 67, 24/3, 58, 26, 25,59, 22/3, 23/3, 77/1, 76/2, 81/2,69, 79/2, 68/2, 76/1/3, 86/1/2, 76/1/1, 86/1/2 ,82/2, 81/1, 18,68/1, 76/1/2, 61, 62, 63, 21/1, 19
5	Imlipura	3	75/3,75/1,76
6	Choki (Bharudpura)	1	123
7	Bhandakho	21	75, 74/3, 132, 130, 129, 135/1, 123, 120/2, 122, 135/2, 120/1, 117, 124, 131, 134/1/2, 133, 126, 127, 128, 74/4
8	Dahivar	1	37
9	Mangbayda	10	107, 108, 109, 126, 125, 127, 128, 247, 252, 253
10	Sirsodiya	2	253, 256
11	Lalbagh	1	363
12	Basvi	1	134/1/8
13	Balwari	4	770, 466, 467, 580
14	Gujari	6	63/1 , 65/1, 65/2, 64/1, 61, 63/2
15	Dehriya	1	23\1\10

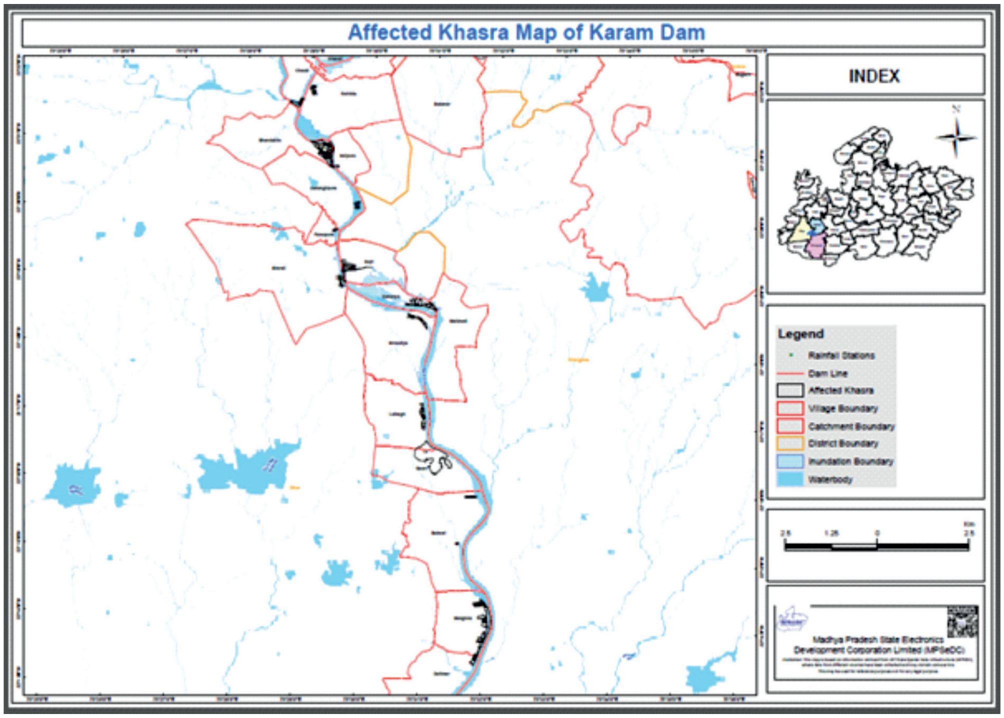


Figure 4-1 : Affected parcels due to breaches of Karam dam.

4.2 Loss and Damages in Khargone district

The breach in the dam affected six villages in the Khargone district. In this area most of these villages are tribal dominated. In villages of Khargone district surrounding Karam River falls in Maheswar Tahsil, where limited parcels of land were affected (Table 4.3) by flood due to dam breaches. In some places, soil was washed away but no major loss had been reported. There were no major crop damages as per the status of the Revenue department of the district.

Table 4.2 : Damage and Losses due to Dam breach

Office of Tehsil- Dharampuri, District- Dhar (Madhya Pradesh)

Madhya Pradesh Administration, Revenue Department (Relief wing)
revenue book circular section- 06, serial number- 4 as amended (Enact from 01 March, 2018)

Damage sheet

Sl. No.	Main Village	Majra include in the Village	Damage sheet			Agriculture land soil loss		Animal house damage		Amount (Revenue Book Circular Volume-6, Number-4)	Kutcha house, utensils and food grains	Amount (Revenue Book Circular Volume -6, Number -4)	Damaged brick Potter kiln	According to R. B. C. 6 (4) Amount
			Farmers Number	Damaged corp in Hectare	Total amount of crop damaged (In Rupees)	The number of farmers affected by the rapid flow of water causing soil erosion and the deposition of stones in agricultural land with fertile soil due to flash floods	Affected Area in Hectares	Amount in Rupees	Number	Amount	Number	Amount	Number	Amount
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Faras pura	Simrali	7	1.215	42537	7	1.096	19776	_	_	_	_	_	_
		Faraspura	2	0.240	10000	2	0.200	2440	_	_	_	_	1	10000

		Jahangirpura	17	6.041	136978	5	1.860	22692	_	_	_	_	_	_
2	Gujari	Deharia	1	0.118	5000	_	_	_	_	_	_	_	14	140000
		Gujari	4	3.031	49844	_	_	_	_	_	_	_	1	10000
3	Sirsodia	Sirsodia	2	0.805	12075	_	_	_	_	_	_	_	7	70000
		Lalbagh	1	0.175	5000	_	_	_	_	_	_	_	_	_
4	Dahiwar	Dahiwar	1	0.150	5000	_	_	_	_	_	_	_	_	_
		Mangabyada	15	1.908	75000	_	_	_	_	_	_	_	_	_
5	Kothida	Kothida	30	12.490	316472	17	6.916	88401	2	4200	2	98000	_	_
6	Imalipura	Dugani	_	_	_	_	_	_	_	_	_	_	_	_
		Imlipura	3	1.045	20262	1	0.410	5002	_	_	_	_	_	_
7	Chowki (Bhorudpura)	Chowki (Bhorudpura)	1	0.759	12144	1	0.759	9260	_	_	_	_	_	_
		Bhaunda akhau	16	8.028	210367	12	3.840	46848	1	2100	1	11000	_	_
8	Basvi	Basvi	2	0.200	10000	_	_	_	_	_	_	_	_	_
9	Balwari	Balwari	4	0.300	20000	_	_	_	_	_	_	_	_	_
10	Baiganda	Uchavad Viran Village	_	_	_	_	_	_	_	_	_	_	_	_
		Baiganda	_	_	_	_	_	_	_	_	_	_	_	_
11	Lasangaon	Lasan gaon	_	_	_		_	_	_	_	_	_	_	_
Grand total			106	36.505	930679	45	15.081	194419	3	6300	3	109000	23	230000
Total					**930679/-**			**194419/-**		**6300/-**		**109000/-**		**230000/-**

Table 4.3 : Village parcels affected at Khargone district due to breach of Karam dam

	Village name	Total survey no. affected	Survey numbers
1	Kakdada	Nil	Nil
2	Kakriya	3	130/1 , 124/3 , 124/4
3	Badvi	3	2/1 , 2/2 , 4
4	Jalkota	1	22/1/1,
5	Mohida	Nil	Nil
6	Melkhedi	Nil	Nil

Figure 4-2 : Deposit of sediment in farms adjacent to riverbank

Figure 4-3 : Sedimentation at farms in Simrali

Chapter 5

5.0 Disaster Management Plan and Emergency Action Plan

The Karam dam breach again proved the need for a disaster management plan for effective planning and utilization of resources available in the region. Along with the Disaster Management Plan, the need for an Emergency Action Plan of the dam to estimate the discharge velocities and the probable inundation areas in case of dam fails. In this chapter, the measures which can be adopted for this kind of scenario were explained.

5.1 About Disaster Management (DM) Plan

Preparation of a "Disaster Management Plan" for any Dam/reservoir is a prerequisite, as catastrophic situation, which is highly unpredictable, may occur at any time in the life span of the project. To tackle the catastrophic situation development of an effective "DMP" is imperative to establish coordination between District Administration and Project Authority. Line/Assisting agencies from the district administration side are Fire Services, Police Department, Medical Services, Consumer Affairs and Public Distribution Department, Transport Department, Communication Department, Meteorology Department, Irrigation and Flood Control Department, Civil Defence Forces and Voluntary Organizations. Coordination and close cooperation among all the agencies involved is essential for the timely and successful implementation of "DMP" to provide relief to the affected in their time of need. Furthermore, the DM Plan on Dam breach cannot be a standalone plan. It should be integrated with SDMP, DDMP and Departmental DM Plan.

Well-defined role and responsibilities of assisting agencies in "DMP" is required, so that proper planning, according to the intensity of the disaster could be made by agencies. Therefore, DMP for dam breach should include specific and time-bound action points with specific responsibilities. Identification of the event and its intensity in the affected area is assessed by the Chief Coordinator. He should be authorized to declare a "disastrous situation" based on detailed information available so that assisting agencies to swing into action to mobilize their resources in the affected area. Based on the intensity of the disaster in the project a proper relief programme may be implemented by District Administration with the help of assisting/line agencies.

5.1.1 Hazard, Vulnerability, Capacity & Risk Analysis (HVCRA)

Every element of Disaster Management planning is built upon the fundamental scientific methodology of HVCRA. Understanding our strengths, weaknesses, and potential dangers is crucial and the first step. So, as part of the plan, we must first do a Hazard, Vulnerability, Capacity and Risk Analysis. This analysis goal is to anticipate issues and think about workable solutions to help save lives, protect property, and lessen the damage.

5.1.2 Preparation of Inundation Map

The selected dam break flood for this purpose corresponds to the extreme conditions that yield the maximum possible flow storage at the downstream locations. The extreme condition is estimated from various parameters like breach width, and minimum time of failure. The inundation map has been prepared with the help of the water surface elevation profile, which has been computed for maximum flood discharge elevation at various downstream locations.

Given the topographic characteristics, the flood will be confined generally within the narrow valley sections barring low-lying areas of Simrali, Jahangirpura, Faraspura, Kothida, Imlipura, Choki(Bharudpura), Bhandakho, Dahivar, Mangbayda, Sirsodiya, Lalbagh, Basvi, Balwari, Gujari and Dehriya villages of Dhar district as well as Kakadda, Mohida, Melkhedi, Bhedlyabada, Jalkota, Mohida and Kakariya villages of Khargone district.

The map would serve as a guide for working out the details of these vulnerable areas. The inundation map would be displayed at all the downstream flood-prone locations depicting the maximum water level that would be attained. The elevations together with other geographical details could be marked on the ground of the downstream areas.

Keeping because of the gradient between the Dam site and the last village the flood wave is expected to inundate some low-lying areas in the first twenty-five km downstream of the dam site approximately in 02 to 03 hours. This means that very little time would be available for the execution of any rescue and/or evacuation plan. Therefore, the Disaster Management Plan has been devised mostly for preventive measures. As a first measure of the management plan, it is suggested that surveillance and monitoring schemes be implemented simultaneously with the design and detailed engineering stage of the project. It should continue during the construction phase through the impoundment of the reservoir, early operation period, and operation and maintenance phases during the life of the dam.

5.1.3 Mitigation Measures/ Dam Safety Measures

The following measures should be taken to avoid loss of lives and property.

5.1.3.1 Monitoring

As the dam safety plan is most important, the Dam authorities need to prepare detailed effective dam safety surveillance and monitoring scheme, which should include rapid analysis and interpretation of instrumentation and different observation data along with periodic inspection, safety reviews and evaluation. The Dam Safety Plan is implemented during the following five phases covering the life of the dam.

a) Design and investigation phase

b) Construction Phase

c) First reservoir impoundment

d) Early operation period, and

e) Operation and maintenance phase

5.1.3.2 Strengthening of river banks downstream of the dam

The slopes of the low-lying areas of the Simrali, Jahangirpura, Faraspura, Kothida, Imlipura, Choki (Bharudpura), Bhandakho, Dahivar, Mangbayda, Sirsodiya, Lalbagh, Basvi, Balwari, Gujari and Dehriya villages of Dhar district as well as Kakadda, Mohida, Melkhedi, Bhedlyabada, Jalkota, Mohida and Kakariya villages of Khargone district shall get inundated thus be provided with protection measures viz; construction of gabions/wire mesh crates. These structures may be raised to the level of danger mark.

5.1.3.3 Provisions for Emergency Action Plan (EAP)

The formulation of an emergency action plan would depend upon the expected levels of emergency. The specific safety plans for different levels of emergency would have to be prepared for tackling the dam break situation and chalk out appropriate warning procedures to be followed in case of failure and/or potential failure of the dam. The main emphasis should be issuing timely warnings to the people at risk and alerting the officials responsible for taking action in case of an emergency.

5.1.3.4 Administrative setup

The administrative and procedural aspects of an Emergency Action Plan consist of a flow chart depicting the names and addresses of the designated officials appointed for the purpose. In case the failure is imminent, or the failure has occurred or a potential emergency condition is developing, the observer at the site should report to the Engineer-in-Charge through a wireless system or by any fastest available communication system. The Engineer-in-Charge would in turn be responsible for informing the Civil Administration, viz; District Magistrate about the developing situation.

For the implementation of the "Disaster Management Plan" at the time of emergency, setting up a control room as a nodal point to monitor the ground situation is essential. The control room should be in close vicinity of the Dam and equipped with the following:

a) Copy of Disaster Management Plan.

b) Resource Plan prepared by the District Administration.

c) Map indicating evacuation points for the affected population at the time of emergency and their shelter areas etc.

d) Area map showing topographic, demographic and infrastructure details, i.e. hospitals, roads, helipads, schools etc.

e) Telephone directory to contact various assisting agencies and communication systems such as telephones, VHF sets etc.

Each person should be made aware of his/her responsibilities/duties and the importance of the work assigned under the Emergency Action Plan. All villages falling under the flood-prone zone or on margins should be connected through a wireless communication system with a backup of standby telephone lines. A centralized siren alert system should be installed at the entire village "Panchayet Bhavan" so that in the event of a warning all villagers can be alerted through sirens.

5.1.3.5 Maintenance measures

The personnel responsible for preventive measures would identify equipment that needs repairs and the materials needed for the purpose, laborer and expertise for use during an emergency. The amount and type of material required for emergency repairs should be determined for the dam, depending on its characteristics and design. Sufficient and suitable construction materials should be stockpiled near the dam site. The anticipated need for equipment should be evaluated and if these were not available at the dam site, the exact location and availability of this equipment should be determined and specified. The sources/agencies be provided with necessary information/instruction or assistance in case of emergencies.

Dry mock runs, drills and exercises should be conducted from time to time simulating the emergencies to evaluate and assess the effectiveness of various preventive actions that should be framed to tackle emergencies.

A plan for regular inspection of the dam should be drawn. The overflow and non-overflow sections be properly illuminated. Whenever sinkholes, boils increase in leakage, movement of soil, gate failure, rapid rise or fall of the level in the reservoir or wave over the run of the dam crest are observed, the personnel on patrol should immediately inform the Engineer-in-Charge. He should inform the local administration authority about the situation. The downstream population should be warned about the imminent danger using a siren or other warning systems available.

5.1.3.6 Communication system

An efficient downstream warning and communication system is essential for the success of the Emergency Preparedness Plan. The population living downstream should be educated about the difference between a high flood and a dam break situation. In case of emergencies, telecommunication plays a critical and crucial role in mitigating the problems faced by people during and after calamity. Any efficient communication system in disaster management should have the following characteristics:

a) Reliability

b) Ease of maintenance

c) Quick deployment

d) High tolerance to extremely adverse conditions

e) Compatibility with alternative power sources, and

f) Fast transportability and easy deployment

The traditional communication facilities such as telephones, microwave links, telex services, mobile phones, etc. should be installed simultaneously with project initiation. Besides, the project authority should install a modern suitable communication system in the project impact area.

5.1.3.7 Communication Components

The communication system, in general, consists of: (a) a Strong Mobile network with dedicated towers for efficient network availability throughout the entire project earlier, (b) a Transmitter; (c) a Receiver, and (d) a network management system. A single communication unit may have both transmitter and a receiver on a single platform. In addition, there has to be a medium for messages and data to travel. Keeping various factors in mind, the basic medium would be radio waves as other mediums such as copper or fibre optic cable are likely to be distorted during the disaster. In far-flung areas, such terrestrial links are either not existing or are extremely expensive and time-consuming. The foremost requirement of a communication system is to support voice, fax and data services to enable the transmission of any type of data from one site to other.

5.1.3.8 Evacuation Plan

The Emergency Action Plan also includes evacuation of people at risk and procedures for implementation are based on local needs. Generally, the following procedure forms the basis of the plan:

a) Demarcation and prioritization of areas to be evacuated

b) Notification procedures and evacuation instructions

c) Safe routes, transport and traffic control

d) Safe areas and shelters, and

e) Functions and responsibilities of members of the evacuation team

The identified low-level zone from the dam should be delineated and the entire zone should be assigned an adequate factor of safety. As the flood wave would take about two to three hours up to 23 Km, the people living in downstream areas namely Simrali, Jahangirpura, Faraspura, Kothida, Imlipura, Choki (Bharudpura), Bhandakho, Dahivar, Mangbayda, Sirsodiya, Lalbagh, Basvi, Balwari, Gujari and Dehriya villages of Dhar district as well as Kakadda, Mohida, Melkhedi, Bhedlyabada, Jalkota, Mohida and Kakariya villages of Khargone district should be informed well in time through wireless, alerted through sirens, etc. The flood zone should be marked at all the inhabited areas downstream.

5.1.3.9 Notification

Notification procedure forms an integral part of any Emergency Action Plan. Different procedures are suggested to establish different situations in the process of dam break. Two types of notifications should be issued. The first one should include communication of an alert situation indicating that although failure or flooding is not imminent, a more serious situation could occur unless conditions improve. The second type of notification should include an alert situation followed by a warning situation. A warning situation should indicate that flooding is imminent due to expected dam failure. It should normally include an order for the evacuation of delineated inundation areas.

The copies of the Emergency Action Plan also include the above-described inundation map. This map should be made available to the persons responsible for the execution of the plan. Besides, copies of the map should be displayed at prominent locations and in the offices of the authorities concerned. Inundation maps should be displayed in the Village Panchayat Ghars in the project impact area. For a regular watch on the flood level situation, two or more people should man the flood cells so that an alternative person is available for notification around the clock. For speedy and efficient communication, a wireless system would be a preferable mode of communication. Telephones and mobile phones should also be used as and when required. All the critical points in the project impact area including the dam component should be provided with wireless/cordless communication systems.

The guidelines to be observed by the inhabitants in the event of a dam break, formulated under the public awareness for disaster mitigation in the Disaster Management Plan are:

a) Listen to the radio/TV for advance information and advice,

b) Disconnect all electrical appliances and move all valuable personal and household belongings out of reach of the flood impact area,

c) Move vehicles, farm animals and movable goods to nearby safer places,

d) Prevent dangerous pollution by moving all insecticides out of reach of water,

e) Turn off electricity and gas,

f) Lock all outside doors and windows in case of evacuation, and

g) Do not enter flood water.

5.2 Public Awareness Programme

The people living around the Dam area can play a vital role in the event of a disaster due to a dam break. For this purpose, Public Awareness Programs should be conducted regularly to make the general public aware of potential hazards likely to occur in the project area. Emphasis may be given to the following aspects:

a) Pamphlets and booklets containing details about the hazards associated with the hydropower project may be prepared and distributed among the general public.

b) Permanent notice boards may be fixed at all the suitable places in the area displaying information related to assisting agencies, their telephone numbers etc.

c) Help from local youth organizations, voluntary organizations, and educational institutions may be sought to conduct educational sessions to make people aware of the safety measures and rescue operations in the event of a disaster, and

d) Teachers in these areas can educate the students about preparedness in the event of any eventuality in case of a dam break.

A monitoring committee should be constituted in consultation with the District Administration to ensure preparedness for the implementation of the "Disaster Management Plan". The committee shall review the effectiveness of the plan at regular intervals and call for a mock drill as per requirement in the project area. The committee may also suggest improvement in the action plan as may be deemed fit by it based on its observations through time.

5.3 Setting up of the Seismic Observatory

The area falls in the seismic Zone –III as per the Seismic Zonation Map of India published by the Bureau of Indian Standards (BIS), all the characteristics related to seismicity, tectonics, seismo-tectonics, and associated matters are needed to be dealt with in detail. Therefore, a plan for seismic surveillance of the area by establishing a seismic monitoring station is recommended. The setting of the seismic observatory and installation of the equipment should coincide with the commencement of project execution to gather micro details and refine the already collected data:

a) Concerning neo-tectonic activity prevailing if any in the area, and

b) To judge the effect of reservoir impoundment on the seismic status of the area.

Chapter 6

6.0 Lesson learnt and Recommendations

There has been a very creditable sign in the approach to avert the disaster. The successful risk reduction strategy which was followed in the Karam dam breaches could not take into outburst and the way the reservoir was made empty irrespective of several hazards taken place during the period when bypass channel work was in the process is also one of those.

The Karam Dam breach taught us so many lessons in response to and recovery from disasters. This breach brought again our strengths and weaknesses related to disaster management under the spotlight and the need to rethink and adopt certain measures for better performance in these kinds of unprecedented hazards.

Strengths

- Multi level coordination
- Complex decision making
- Effective media management
- Civic response
- Support from NGOs

Weakness

- Fear of unknown
- Resource allocation
- Communication systems
- Moniting and Alert mechnaism
- Leveraging technology
- Rainfall data

Oppurtunities

- Strengthening SDMA and DDMA
- Regular mockdrills
- Awareness generation on Disaster Risk Management
- Community engagement

Challenges

- Addressing the masses
- Quality of construction
- Psycho social aspects
- Inflow and outflow alerts for small dams
- Dam safety aspects

6.1 Lessons learnt

The Karam dam breach highlighted some major valuable lessons to remember for the future and challenges to be addressed in the present to deal with this kind of known unknown disaster shortly. The lessons learnt and challenges faced during the Karam dam breach were enumerated below.

6.1.1 The Known Unknown Hazard situation

The state and district administration were aware of the hazard profile of the state, but they neither anticipated nor experienced this kind of scenario earlier. The district administration and the technical teams failed to assess the risk and the vulnerable areas to the exact. During the incident, there were several unsolved answers about the probability of the occurrence of a breach due to the seepage. Even though, it was their first experience the district administration puts the maximum effort to minimize the risk to the maximum extent with guidance from the technical and higher-level administration. Instead of waiting for the accurate analysis, the administration evacuated the areas by taking the discharge flow of 9200 cumecs which is almost double the designed outflow of the dam. The out-of-the-box thinking practice proved very effective in achieving zero causality.

6.1.2 The Multi-level Coordination of Administration

The deployment and management of officials in the response mechanism played a crucial role in the Karam dam breach management. The combined interventions and efforts of all concerned stakeholders averted the disaster. Deployment of higher officials to the ground level to increase the level of alert and seriousness of the incident. The continuous sharing of information from the dam site to the officials through a common messaging group and the flow of instructions resulted in reducing the loss to zero.

6.1.3 Effective Media Management

During the period of a dam breach, the downstream people don’t have any idea about the exact situation. The source of information for the locals is the information from the officials. However, the sharing of some false information from the people at the dam site through social media created panic in the communities. The approach followed in this incident, the timely updates of the breach incident directly from the chief minister of the state through live media and the updates in social media prevented the circulation of false information and averted the panic condition in the communities.

6.1.4 The Community Response

The evacuation of 18 villages was not possible without support from the communities. The information is simultaneously passed on to the village head and requested to coordinate with the officials. At first, the villagers were reluctant to shift from their villages but later the efforts of the administration and the presence of the army and air force made them understand the severity. Few incidents where the people were revolted to vacate the areas where the force majeures were followed to leave no one behind.

“The administration also encountered the situation of dealing with the cremation where religious practices followed. The people moved the corpse to the Karam riverbank and refused to go back to the village when the officials stopped to do so. Thereafter, the Dhar district magistrate himself consoled and explained the situation to the village people and made alternative arrangements for the other village which is away from the dam site.”

This dam breach incident taught a lesson on the handling of these kinds of small aspects related to religious, and psychological matters and the acceptance from society.

6.1.5 Support from NGOs

Evacuating the people from 18 villages within hours and providing the basic necessities was very difficult. However, in the case of the Karam dam breach, the district administration successfully evacuated and provide all the necessities withwithinrs. This won't be possible with the help of NGOs. The district administration approached the NGOs for their support in the relief facilities like shelter accommodation and food for the villagers. Upon receiving the call, the NGOs made all the arrangements for the people at marriage halls and collected the food from crowd kitchens, packed and distributed it to all the people including the villagers and the people working at the site also.

The DM and ADM, Dhar highlighted the NGO's help in arranging the food and shelters which resulted in the timely supply of food and zero-fiscal liability for the administration. This was also a key lesson we should highlight in utilizing the local resources efficiently.

6.1.6 The Dam Construction-Quality and Monitoring

The core reason for the failure of the Karam dam was technical in nature. The construction of any dam should be as per the design standards and follow the methodology. In the Karam dam breach, there was a clear deviation from the established engineering design and methodology of the construction which endanger the dam and the downstream population.

The practice related to the closure of the dam was also not followed in this case where the closure should be done once the dam is raised to a safe elevation and with completion of the spillway and the dam is safe with all respects to its functional operations. The protocols were ignored in this dam construction.

The quality of the construction and deviation from the protocols will pose a threat to the dam and the communities around the dam.

6.1.7 Alert and Communication Mechanism

The Karam dam was an under construction minor dam which does not have any alert systems. As per the WRD, there were 35 upstream projects in the catchment area still there was no proper rainfall measuring mechanism established which created panic in the administration about inflow from the catchment into the Karam reservoir.

Secondly, the communication network was very poor on the dam site. The mobile phone of SDM, Kukshi was the only point of contact between the headquarter and the dam top. He used to run between the spillway and the cutting channel to pass the information.

The delay in the establishment of proper communications delayed the action in the case of the Karam dam to some extent.

6.1.8 Awareness of Disaster Risk Reduction

The Karam dam breach pinpointed the need for disaster management at various levels. The district administration had no experience in dealing with these kinds of disasters and awareness of the standard operating procedures which can reduce complexity in controlling the situation.

Secondly, the District Disaster Management Plan which would be of very helpful in identifying the resources was not considered for the mobilization of resources because of the outdated data. Although, the district administration controlled the situation effectively. The gaps were still visible and need to be strengthened by the robust and active disaster management structure at the district level.

6.1.9 Psychosocial Aspects

During the evacuation of people from the villages started on the second day (i.e. 12th August 2022) itself. After several efforts by the administration, the people evacuated the villages and moved to safer areas. Over a period, the behavioral aspects of the people made them move back to their houses and in some villages, people were advised to return to their homes after necessary directions from the administration and for the purpose of security of their belongings, the houses were locked from outside.

The long awaits for the dam breach news combined with the wrong information about dam breaches at the individual level changed their behavioral aspects and made to move back from the safe areas. The administration utilized the patrolling forces to prevent from reentering into villages and arranged some activities at safe shelters to keep them engaged.

6.2 Suggestions and Recommendations

The suggestions and recommendations enumerated below concerning the increasing vulnerability of low-lying areas to floods due to dam safety issues and improving upon the current state of preparedness, response capabilities and the evolution of the long-term and short-term disaster risk reduction strategies.

6.2.1 Towards Dam Safety

- The Dam Safety Act is to provide for surveillance, inspection, operation, and maintenance of the specified dam for the prevention of dam failure-related disasters and to provide for an institutional mechanism to ensure their safe functioning and for matters connected therewith or incidental thereto. In brief, the mechanism of Central & State Government provided in the aforesaid Act is as follows.
  - a) Constitution of the National Committee on Dam Safety (NCDS)
  - b) Establishment of the National Dam Safety Authority (NDSA)
  - c) Constitution of the State Committee on Dam Safety (SCDS) by the State Governments.
  - d) Establishment of the State Dam Safety Organization (SDSO) in States

    In the case of the state of Madhya Pradesh having 5238 dams, it's highly recommended to follow the mechanism provided by per Dam Safety Act 2021.
- A detailed audit should be carried out in all major and minor dams in the state including old and new dams regarding the stability and safety aspects to prevent the reoccurrence of this kind of situation in the state.
- BIS norms and guidelines should be utilized and not bypassed/deviated, as has been done in the instant case. Strict penalties should be imposed for any such deviation without authorization.
- Special attention should be given to the quality and construction practices during the construction of the dam. Moisture content and compaction of embankment fill material must be carefully monitored for acceptance during construction.
- Regular inspections of dams should be carried out at prescribed intervals by dam owners/State Dam Safety Organizations as envisaged in the Dam Safety Act-2021. If any deviations are found, remedial measures as required for the safety of the dams need to be carried out timely. Particularly, dams should be inspected and monitored during and/or after large rainfall, seismic, or other unusual loading events.
- Emergency Action Plan (EAP) should be prepared for all dams based on the expected levels of emergency. The specific safety plans for different levels of emergency would have to be prepared for tackling the eventuality of a dam break situation and chalk out appropriate warning procedures to be followed in case of failure and/or potential failure of the dam. The primary focus should be on providing a prompt warning

to those in danger and alerting the authorities in case of an emergency.

- The inundation maps based on the Dam break analysis to demarcate the extent of the likely affected area, and downstream reservoir should be prepared for all dams and information should be made available to the local administrative authorities to use as a decision support tool.
- The rain gauges should be established in the major catchment areas and a dynamic rainfall analysis system should be adopted for the early interpretation of the inflow into the reservoirs.
- The flood risk management: Suggested policy and advocacy interventions developed by NIDM can be adopted at the state level. (Parkash, 2022)
- Dam owners, engineers, and regulators need to address public safety issues during the construction of dams. An emergency alarm/warning system can be an effective means of providing warning to downstream residents located in close proximity to a dam where the warning time is short.
- Remote sensing/controls should have redundancy, preferably via a system of a separate nature, such as visual (camera) reconnaissance to confirm reported conditions.
- High and significant hazard dams should be designed to pass an appropriate amount of flood water. Dams constructed prior to the availability of extreme rainfall data should be assessed to make sure they have adequate spillway capacity.
- Dams may overtop floods more frequently than the design flood if the spillway capacity is reduced (due to debris plugging or gate malfunction).
- The benefits of EAP exercises are best realized when both dam owners and emergency responders are involved so that weaknesses in protocol procedures and duty assignments can be exposed and corrected before a real emergency occurs.
- Common Alert Protocol (CAP) should be instituted in critical infrastructure projects. Any blind spots in communication in the vicinity of such critical infrastructure should be immediately taken care of.
- The necessity to incorporate DRR in all development-related initiatives is reiterated at all DRR platforms. Mitigation and prevention should be incorporated into the development process to ensure the sustainability of the developmental benefits of dam construction-like projects.

6.2.2 Administrative/Organizational suggestions

The Major problem observed during the Karam dam breach was the lack of sensitization to this kind of disaster in the administration. The suggestions/ recommendations for strengthening the administration were enumerated below.

- The sensitization programs like training or hazard-specific mock drills should be carried out at regular intervals to enhance the capacities of administration at various levels.
- As per the DM Act 2005, the District Management Authorities should be in a place where it is missing in the state of MP. The SDMA and DDMA should be strengthened.
- The District Disaster Management Plan (DDMP) should be updated at periodic intervals which can be very useful in the identification of resources at the need of the hour.
- The Inventory details should be updated in the India Disaster Resources Network (IDRN) and capacity enhancement should be carried out on the utilization of the resource information.
- Incident Response System is a management tool that constitutes an important part of the Disaster Response at State and District level. The administration should develop their capacities on this tool.

At the State level, the funding window shall be exclusively utilized for preparedness and capacity building of State Disaster Management Authorities (SDMAs), State Institutes of Disaster Management (SIDM), training and capacity-building activities,

- Purchase of emergency equipment and emergency response facilities under State Disaster Response Fund (SDRF).
- A satellite Communication phone/ VSAT facility for emergency communication should be provided at the district level.

6.2.3 Community Level

The community plays a crucial role in any success/ failure of disaster risk practices. The knowledge of disaster risk reduction should be inculcated at the community level. The suggestions/ recommendations for strengthening the communities were enumerated below

- Community-Based Disaster Risk Management (CBDRM) is a way of analyzing risks and conducting DRM that both originates from and is organized by, local communities. The CBDRM develops knowledge of disaster/vulnerability risk assessment, risk reduction planning, early warning systems, post-disaster relief, and participatory monitoring and evaluation. The CBDRM activities should be implemented at the village level and effective disaster risk management.
- Stockpiling the emergency inventory and resources data at the village level which can be utilized by first responders in the golden hours.
- Develop a pool of community volunteers who can be a helping hand to the administration in emergency situations like Aapda Mitra implemented by NDMA.
- The hazard-specific awareness activities involving the communities should be carried out at regular intervals to develop exposure to disaster risk management.

6.3 Conclusion:

The Karam dam breach gave a wake-up call to rethink about the safety of the dams (both old & newly constructed) thus resulting in the people. The story of the Karam dam breach was one of the best examples of command and coordination to deal with disasters. Although the officials who are engaged in this incident were not experienced it earlier the approach and the time-to-time guidance from the resources lead them to successfully avert the disaster. However, there are certain questions that are left behind about the breached dam probably about the reconstruction of the dam.

Undoubtfully, the dam was proposed and constructed to promote irrigation in the Dhar and Khargone districts. The government should conduct a detailed analysis of reconstruction and the mistakes related to the quality of construction should be avoided like in the past.

As per the proverb "Expect the worst and prepare to your best", the capacities of the communities as well as the administration should be strengthened their capacities further to deal with these kinds of unforeseen events. Ultimately, the Karam dam breach was marked as one of the success stories where the ticking bomb of 15 MCM of storage water behind the dam was safely discharged into the Narmada river with zero causality. The dedication, and power of the administration combined with the support from Communities turned the uncertainty into a controlled situation.

Annexure-1

About Dam

- Karam 1 Medium Project is located on the Karam River sub-basin in Dhar Taluka of Dhar district.
- The proposed reservoir is located at Latitude 22° 22' 4.766" N & Longitude 75°29' 3.474" E.
- The nature of the catchment is hilly and there are 35 upstream projects, Total catchment area of the Projects is 342.50 sqkm.
- An Earth Dam of Maximum Height 52.09 m and length 331.68 m on the Right Flank and 23.36 m on the Left flank.
- Ogee Type Side Spillway 96 m in length and 41 m in height (measured from foundation RL of 251.30 m) having capacity to pass the flood discharge of 5234.82 cumecs with flood lift 1.5 m is proposed.
- Karam Medium project is proposed to provide irrigation facility to 8750.00 Ha of CCA.

Dam data

Peak Flood	: 5234.82 cumecs
Routed Flood	: 4776.87 cumecs

Overflow Dam

Crest Level of Weir	: 302.00 m
Length of Spillway	: 96.00 m
No. of Gates	: 5 (1 Standby)
Size of Gate	: 15 m X 10 m
Top Width of Dam	: 6.00 m
Deepest Foundation Level	: 275.00 m
Maximum Height above foundation	: 27.00 m
Length of Dam	: 564 m

Non Overflow Dam

Maximum Height above foundation	: 41.00 m
Length (L/R Flank)	: 50.00 m / 60.00 m

Earth Dam

Length of Dam	: 355.04 m
Maximum height of Dam	: 52.00 m

Sluice

Type of Sluice	: R.C.C. Barrel Type
Numbers : 1	
Location : Left Flank	
Size of barrel	: (2.30 x 2.00) m

Principal Levels

(a)	Nalla Bed Level (NBL)	: 264.00 m
(b)	Lowest Sill Level (LSL)	: 284.00 m
(c)	Min Draw Down Level (MDDL)	: 286.00 m
(d)	Full reservoir Level (FRL)	: 312.00 m
(e)	Maximum Water Level (MWL)	: 313.20 m
(f)	Top Bund Level (TBL)	: 316.00 m
(g)	Dead Storage (Capacity at LSL)	: 3.44 MCM
(h)	Gross Storage (Capacity at FRL)	: 43.98 MCM
(i)	Live Storage	: 40.53 MCM
(j)	Capacity at LSL (Revised after Sedimentation)	: 1.09 MCM
(k)	Capacity at FRL (Revised after Sedimentation)	: 39.54MCM
(l)	Submergence at FRL	: 252.71 Ha

Canal System

Main Canal

(a)	Distributary	: 02
(b)	Total no. of Minors	: 12
(c)	Length of LDC and RDC	: 35200m / 24500m
(d)	Total GCA	: 15605 Ha
(e)	Total CCA	: 10500 Ha
(f)	Head discharge required	: 3.83 cumecs
(g)	Head discharge designed	: 3.83 cumecs
(h)	No. of villages benefited	: 52

Submergence

(a)	Private Land (Irrigated land)	: 72.764 Ha
	Private Land (Unirrigated land)	:13.530 Ha
(b)	Government Land	: 112.60 Ha
(c)	Forest land	: 119.25 Ha
(d)	Total submergence area	: 318.144 Ha
(e)	Villages Affected	: BhaisakhoKhurd, Bhaisakho BujurgUtawali, Chowki, Lalgarh, Saray, Kothida, Jamanda

Annexure-2

Rainfall status near Karam dam

			Rainguage Station	
Sl no	Month	Year	Dharampuri	Nalchha
1	June	2018	149.00	218.60
2	July	2018	188.00	195.40
3	August	2018	255.00	128.00
4	September	2018	102.00	178.20
5	October	2018	0.00	0.00
1	June	2019	0.00	8.60
2	July	2019	3.00	9.80
3	August	2019	0.00	0.00
4	September	2019	22.00	5.20
1	June	2020	156.00	238.60
2	July	2020	101.00	153.20
3	August	2020	200.00	408.00
4	September	2020	143,0	223.40
1	June	2021	57.00	165.40
2	July	2021	142.00	221.60
3	August	2021	43.00	127.20
4	September	2021	136.00	264.00
1	June	2022	14.00	79.40
2	July	2022	217.00	244.00
3	August	2022	150.00	270.00

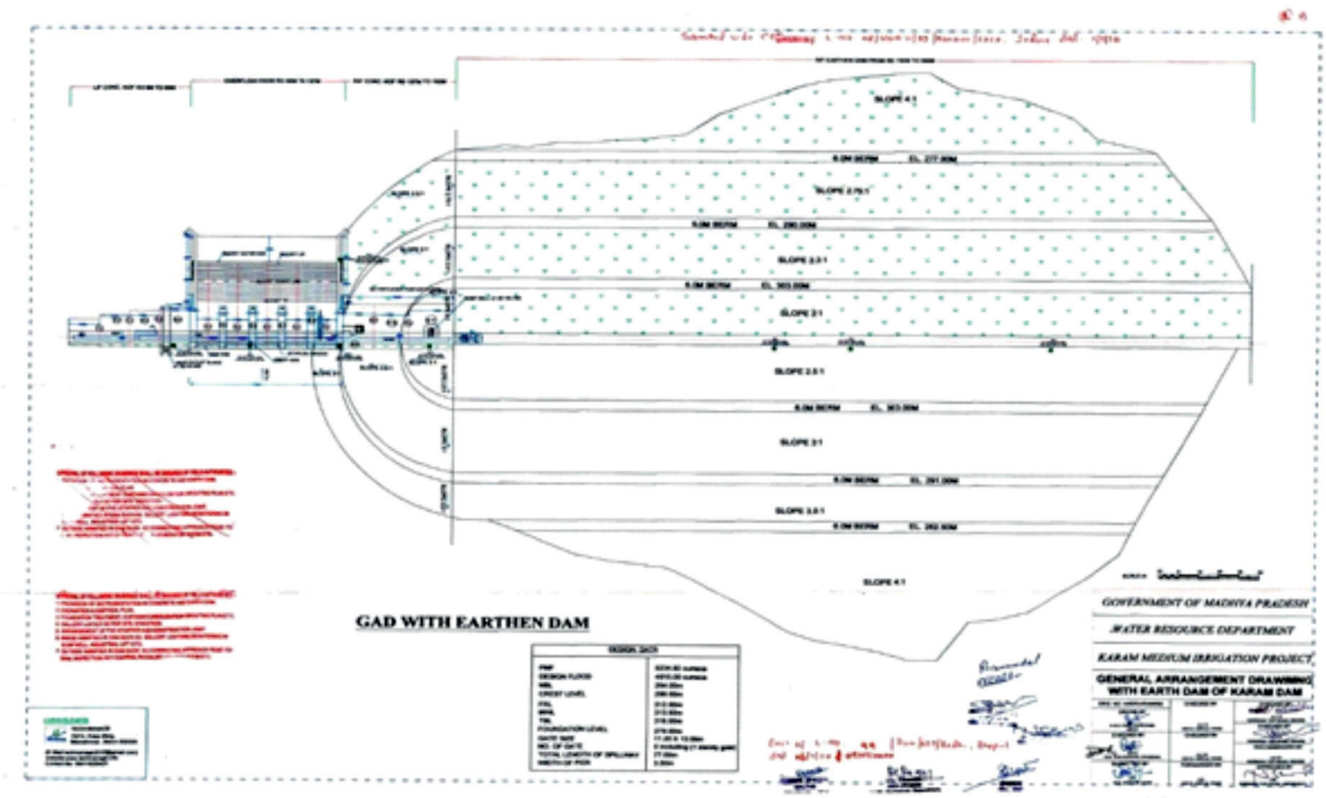
Annexure-3

Water Level (Max. and Min) at Karam river, Dahiwar water gauge station from year 2019 -2022

Sl.No.	Year level	Max. water	Date	Time level	Min. Water	Date	Time
1	2019-2020	166.925	22-08-2019	18:00	164.820	11-04-2019	08:00
2	2020-2021	166.930	22-08-2020	18:00	164.820	06-01-2020	08:00
3	2021-2022	166.410	16-07-2021	15:00	164.850	29-05-2021	08:00
4	2022-2023	166.110	12-08-2022	21:00	164.820	01-06-2022	01:00

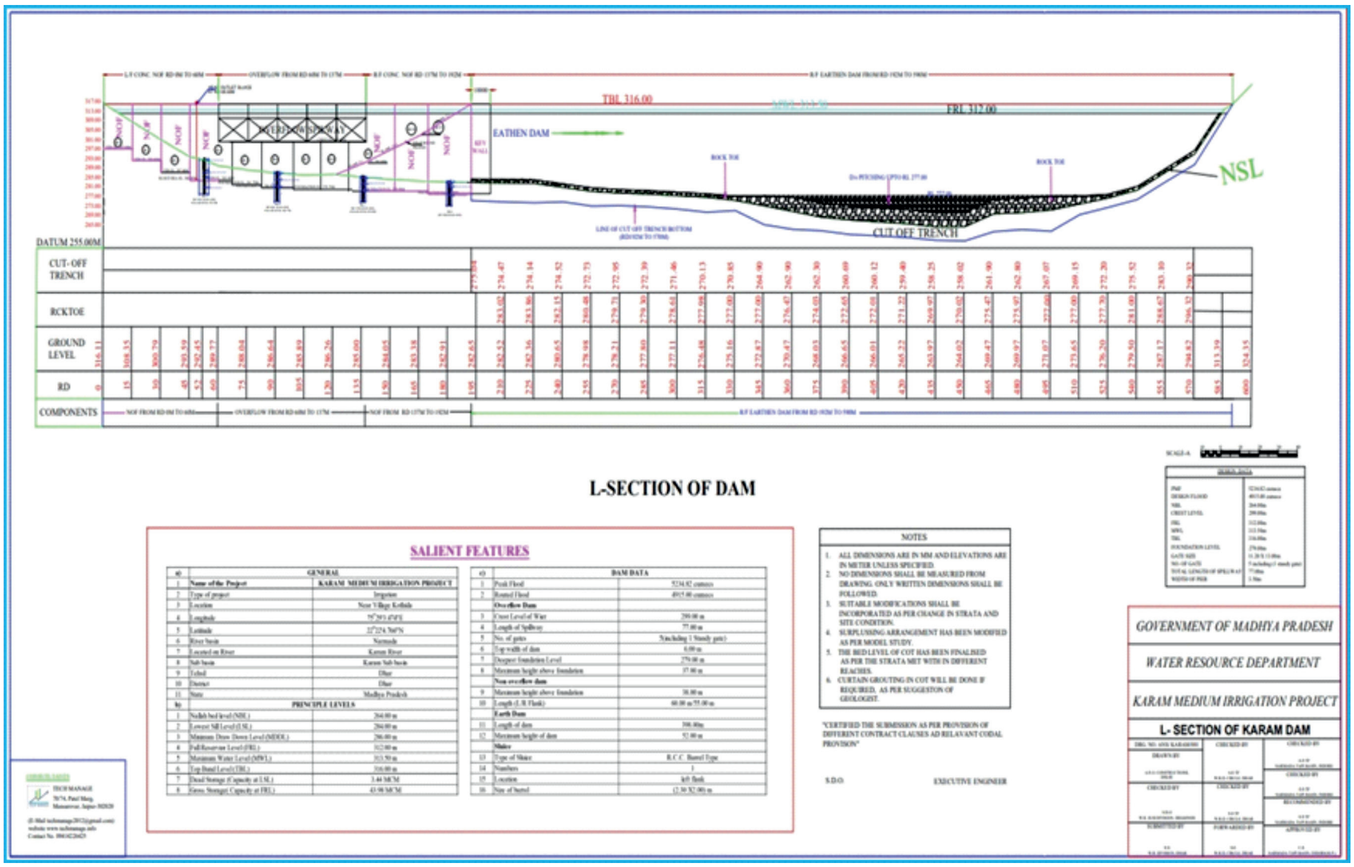
Source: Revenue Department, Madhya Pradesh

Appendix-I



General Arrangement Drawing of Karam Dam

Appendix-II



Longitudinal Section of the Dam

Appendix-III

Madhya Pradesh State Disaster Management Authority
Government of Madhya Pradesh, Mantralay, Vallabh Bhavan, Bhopal.

No: 822... D-84 / SDMA/2022 Date 16/08/2022

To,

Shri Taj Hassan, IPS
Executive Director
National Institute of Disaster Management (NIDM)
Ministry of Home Affairs, Govt of India
Plot No -15, Pocket-3, Block-B, Sector-29
Rohini, Delhi-110042

Sub: Documentation of Kaaram Dam breach disaster management in Dist Dhar, MP during 11th to 14th August 2022.

As you might be aware that an unprecedented event of Kaaram Earthern Dam Breach (Under Construction) has taken place on August, 11th 2022 at village Kothida, Tehsil Dharampuri, Dist Dhar which was successfully managed by August 14th 2022 without any loss of human or cattle life and without loss to any private property. The earthen dam was 52 m high and 550m wide and its breach had endangered 14,000 villagers residing in 18 villages in Dhar and Khargone districts.

Soon after the receipt of first information of seepage in the dam and preliminary situation report, the entire state machinery sprung into action under the leadership of hon'ble Chief Minister. The disaster response and management carried out by Home, Water Resources and Revenue departments of State Govt, district administrations of Dhar and Khargone, SDERF, Police, Home Guards, the National Disaster Response Force, Indian Air Force, Indian Army, experts of Central Water Commission & National Dam Safety Authority needs to be documented for records, training, capacity building and case study.

In this regard Honble Chief Minister, Madhya Pradesh and Additional Chief Secretary, Home Department had spoken to senior faculty of National institute of Disaster Management Prof Dr. Surya Prakash on August 14th 2022.

You are requested to kindly depute a team at the earliest to get the event of disaster of national level documented in scientific and appropriate manner. The state government will extend all logistic support at Bhopal and at dam site and in 18 villages. All the cost incurred in this documentation by NIDM will be borne by SDMA. Dr Dilip Singh, Deputy Director, MP State Disaster Management Authority (Cell Number-9425377504) will coordinate with your deputed team. Thanking you in anticipation.

(Ravindra Singh)
Secretary (Home)

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Photo Gallery

Photo-1 : Interaction with Dr Pavan Jain DG-Home Guards

Photo-2 : Interaction with ACS- WRD & officials

Photo-3 : Interaction with officials from VBSR

Photo-4 : Visit to Dam site

Photo-5 : Interaction with WRD officials

Photo-6 : Interaction with the communities

Photo-7 : Interaction with Dist. Officials

Photo-8 : Visit to Downstream Villages

Photo-9 : Dam condition after Breach

Photo-10 : Downstream situation after breach

Photo-11 : Flow water level indication Marks at Dahiwar

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About the institute

The National Institute of Disaster Management (NIDM) was constituted under an Act of Parliament with a vision to play the role of a premier institute for capacity development in India and the region. The efforts in this direction that began with the formation of the National Centre for Disaster Management (NCDM) in 1995 gained impetus with its redesignation as the National Institute of Disaster Management (NIDM) for training and capacity development. Under the Disaster Management Act 2005, NIDM has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation and policy advocacy in the field of disaster management.

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