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Q7

**Dam failures are always catastrophic, especially on the downstream side, resulting in a colossal loss of life and property. Analyze the various causes of dam failures. Give two examples of large dam failures.**

UPSC Civil Services Mains 2023 · GS III · 10 marks · Indian Economy

Indian Economy and issues relating to planning, mobilization of resources, growth, development and employment.

**Core demand of the question**

- **Analyse causes of dam failures:** hydrological, structural, foundation, operation, seismic
- **Give two well-known large failures:** Banqiao 1975 and Machhu II 1979
- State why the downstream loss is catastrophic

**Revision summary**

Common causes are overtopping in extreme rain, piping, foundation failure, design error, earthquakes, and gates that do not work.

Banqiao in China in 1975 failed in typhoon rain; deaths were in the tens of thousands in a cascade of breaches.

Machhu II at Morbi in 1979 failed in monsoon inflow; official deaths were in the low thousands.

Teton 1976 and Panshet-Khadakwasla 1961 are other documented large failures.

Downstream loss is huge because the reservoir empties as a sudden wave onto towns that grew below the dam.

**Introduction**

A large dam holds a **reservoir against gravity**. When the structure, the foundation, or the spillway fails, that water becomes a flood with almost no warning on the **downstream** side. The loss of life and property is therefore out of proportion to a normal river flood.

**Body****Causes of dam failures**

- **Overtopping:** the inflow from extreme rain or a failed upstream dam exceeds spillway capacity; water flows over an earth or rockfill crest and erodes it. This is among the most common causes worldwide.
- **Piping and seepage:** internal erosion through the embankment or along conduits opens a tunnel; the dam collapses inward.
- **Foundation failure:** weak, karst, or poorly grouted rock; settlement or sliding of the base.

- **Structural and design faults:** inadequate freeboard, poorly designed spillways, or materials that do not match the design.
- **Seismic loading:** shaking, liquefaction, or seiche in the reservoir; also induced seismicity in some large reservoirs.
- **Operation and maintenance:** gates that do not open, silted spillways, missing instrumentation, and flood forecasts that never reach the operator.
- **Upstream cascade:** one breach loads the next dam, as in some Chinese 1975 failures.
- **Age and conflict damage** are rarer Indian peacetime causes but matter in old masonry dams.

## Two large failures

- **Banqiao Dam, Henan, China, August 1975:** Typhoon Nina dropped extreme rain; Banqiao and other dams in the Shimantan cascade overtopped and breached. **Downstream plains** flooded for many kilometres. Deaths ran into **tens of thousands** (official and later estimates differ; the event is among the deadliest dam disasters on record).
- **Machhu II Dam, Morbi, Gujarat, 11 August 1979:** an earthen dam on the Machhu river failed in extreme monsoon inflow; the wall of water hit Morbi town. Official deaths were in the **low thousands**; unofficial counts were higher. The cause combined hydrological load, embankment design, and insufficient spillway capacity.

(Other well-documented cases used in the same literature include **Teton Dam, Idaho, United States, 1976**, a piping/foundation failure, and the **Panshet-Khadakwasla** floods at Pune in **1961**.)

## Why downstream loss is colossal

- Stored potential energy is released in **minutes**, not days.
- Settlements below a dam often grew after the dam, in the false safety of a regulated river.
- Warning time is short; silt and debris raise the killing power of the wave.

## Flow diagram

Causes -> Overtopping  
Causes -> Piping seepage  
Causes -> Foundation seismic  
Causes -> Poor operation  
Overtopping -> Breach  
Piping seepage -> Breach  
Breach -> Downstream flood  
Downstream flood -> Life and property loss

## Conclusion

Dam failures come from overtopping, piping, foundations, design, seismic load and poor operation. **Banqiao 1975** and **Machhu II 1979** show how a breached reservoir becomes a night-time flood. Instrumentation, spillway capacity and downstream evacuation plans are the only honest mitigation.

## Facts & figures

**Banqiao 1975**

Henan, China: Typhoon Nina; Banqiao and related dams overtopped; one of the deadliest dam disasters, with deaths in the tens of thousands.

**Machhu II 1979**

Morbi, Gujarat: earthen dam breach on 11 August 1979; official deaths in the low thousands.

**Teton 1976**

Idaho, United States: piping and foundation failure of a new earth dam; a textbook structural case.

**Panshet 1961**

Pune: Panshet failure and Khadakwasla overtopping flooded the city; a major Indian urban dam disaster.

**Dam Safety Act 2021**

Union law and a Dam Safety Authority framework for surveillance of specified dams in India.

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