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Q8

Explain the mechanism and occurrence of cloudburst in the context of the Indian subcontinent. Discuss two recent examples.

UPSC Civil Services Mains 2022 · 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

- Explain the mechanism and occurrence of cloudbursts in the Indian subcontinent
- Give two recent well-known examples

Revision summary

A **cloudburst** is an extreme short downpour over a small area, often ~100 mm in an hour on a steep slope.

In the Indian subcontinent it is mainly orographic convection in the Himalaya during monsoon or western disturbances.

A slow-moving cell plus a narrow catchment turns rain into flash flood and landslide.

Kedarnath June 2013 and Leh 6 August 2010 are well-documented cases; Amarnath 8 July 2022 is a later yatra-route example.

Nowcasts, radar and keeping settlements off debris fans are the response.

Introduction

A **cloudburst** is an extreme, short-lived downpour over a small area-conventionally of the order of **100 mm in an hour**-often on a steep Himalayan slope. The cloud does not 'burst' like a bag; rain falls faster than the ground or the drainage can take. In the Indian subcontinent this is mainly an **orographic plus convective** monsoon hazard.

Body**Mechanism**

- Moist monsoon or western-disturbance air is forced **up a steep hill**. Rapid ascent cools the parcel, condensation is intense, and a deep **cumulonimbus** grows.
- A local **convergence** or a mesoscale vortex can stack more moisture into the same valley.
- If a **weak steering wind** holds the cell over one catchment, rain accumulates in minutes rather than being spread along a track.
- **Orographic lift** plus **warm-cloud collision-coalescence** yields large drops; the rainfall rate becomes extreme.
- On a slope, the same water becomes **flash flood, debris flow and landslide**. The disaster is hydrology and geology as much as meteorology.

Occurrence in the subcontinent

- **Western and Central Himalaya** (Jammu and Kashmir, Himachal, Uttarakhand) in the monsoon, and sometimes with western disturbances.
- **North-eastern hills** and steep Western Ghat pockets can see similar extreme cells.
- Plains can have very heavy convective rain; the term **cloudburst** is used most strictly for **concentrated mountain downpours**.
- Climate warming loads more moisture into the air (Clausius-Clapeyron), which can raise the intensity of such cells; attribution of one event still needs care.

Two well-known examples

- **Kedarnath, Uttarakhand, June 2013:** extreme rain and glacial-lake / debris-laden flood in the Mandakini catchment destroyed the shrine town and killed large numbers of pilgrims and residents. It is the benchmark Himalayan hydro-meteorological disaster of that decade.
- **Leh, Ladakh, 6 August 2010:** a **cloudburst** and flash flood on a high-altitude cold desert, unusual for a rain-shadow town, caused heavy loss of life and damage to the airfield and settlements.
- **Amarnath, Jammu and Kashmir, 8 July 2022** is another documented **cloudburst**-related flash flood on the yatra route (use this if a 'more recent' second example is needed beside Kedarnath). Do not invent dates.

Preparedness (brief)

- Doppler weather radar in the hills, nowcasts, restricted building on fans and channels, and pilgrimage caps on forecast days.

Flow diagram

Moist monsoon air -> Orographic lift
Orographic lift -> Deep cumulonimbus
Deep cumulonimbus -> Extreme rain small area
Extreme rain small area -> Flash flood debris flow
Kedarnath 2013 -> Flash flood debris flow
Leh 2010 -> Flash flood debris flow

Conclusion

Cloudbursts in the subcontinent are orographic-convective extreme rains held over a small Himalayan catchment. Mechanism is rapid ascent, a stationary cell, and torrents on steep debris. **Kedarnath 2013** and **Leh 2010** (and **Amarnath 2022**) are the public memory of that physics. Warning and land-use are the only practical shields.

Facts & figures

Cloudburst (working sense)

Very high rainfall intensity over a few square kilometres in a short time; often cited near 100 mm per hour.

Kedarnath 2013

June 2013 extreme rain and debris flood in the Mandakini valley, Uttarakhand; major pilgrimage disaster.

Leh 2010

Cloudburst and flash flood on 6 August 2010 in the Ladakh rain shadow.

Amarnath 2022

8 July 2022 cloudburst-related flash flood on the Amarnath yatra route.

Orographic lift

Forced ascent of moist air against a mountain, the main Himalayan trigger for such cells.

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