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Ice-flood risk mitigation measures

LAURA BĒRTIŅA | MODELLING EXPERT

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OBJECTIVE OF THE MEASURES

- Ensure safe ice passage in spring.
- Reduce the formation of ice jams.
- Mitigate flood risk in populated areas.
- Integrate with overall flood risk management.

TWO MAIN CATEGORIES OF FLOOD RISK MITIGATION

1. Structural Measures	2. Non-Structural Measures
Structures that include infrastructure for ice formation control, flow pattern modification, or flood risk mitigation	Actions based on forecasting, management, and emergency response plans.

The difference between these categories is based on whether the mitigation measure involves permanent physical infrastructure or flexible operational strategies.

STRUCTURAL MEASURES

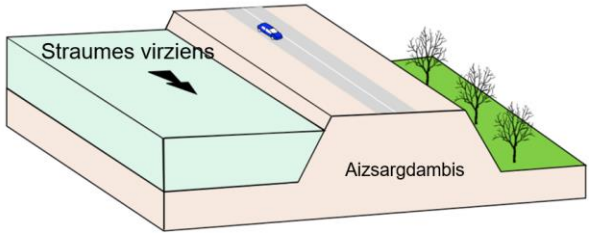
Structures intended for controlling ice formation, modifying flow, or mitigating flood risk associated with ice jams.

Common examples:

- Ice control structures: weirs, reservoirs, dams, sluices, levees.
- Ice retention barriers and pier structures.
- Channel modifications, including widening and deepening.
- Modification of bridges and culverts to improve ice passage.

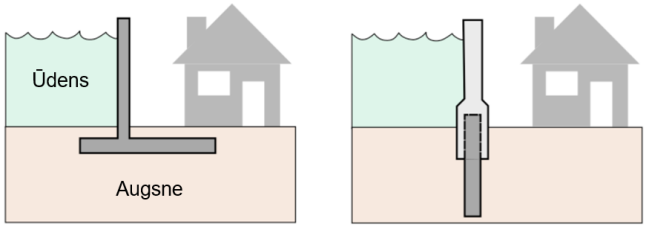
Important considerations: Although structural interventions can prove highly effective, the costs associated with design and implementation can be significant. Depending on the solution, they may also have significant consequences for river ecosystems.

STRUCTURAL MEASURES



Levees or protective dams: Earth embankments extending for miles along river banks to protect large adjacent land areas.

Dams: Similar to levees, but they connect both banks of the river. Built to prevent water from entering certain flood-prone areas.



Flood walls: Relatively small concrete or steel structures that are effective for protecting limited land areas.

STRUCTURAL MEASURES

Ice control sluices: These structures retain ice accumulation in the upstream part of the river and reduce the ice supply downstream to problematic areas.

Large dams: Significantly reduce the formation of ice jams, but they are capital-intensive projects with a significant environmental impact. Reservoirs behind dams can create a stable ice cover to stop ice flows and collect small ice during freezing.

Pier structures: Help to create a stable ice jam behind the piers and divert water flow along the adjacent floodplain or channel (if one exists).

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NON-STRUCTURAL MEASURES

Considerations: Although they are increasingly recognized as valuable tools for ice jam flood risk mitigation, a significant knowledge gap still exists regarding their actual effectiveness. These measures can be used in conjunction with structural interventions for comprehensive protection.

Measures:

Monitoring and Forecasting: Ice monitoring systems, jam modeling, risk mapping.	**Emergency Response:** Evacuation planning, use of sandbags, mechanical ice breaking.
Pre-season ice weakening	
Communication: Public warning systems and community information.	**Land Use Planning:** Zoning restrictions in flood-prone areas.

MONITORING AND FORECASTING

Objective: To forecast, monitor, and prepare for potential ice jams before they occur.

Main goals:

- Flood protection.
- Reduce ice supply.

MONITORING AND FORECASTING

Modeling and mapping: Includes ice jam modeling, risk mapping, weather forecasting, and satellite remote sensing technologies.

Detection systems: Ice movement detectors provide automated early warning of ice movement, allowing for timely flood response.

Visual monitoring: Webcams provide real-time data and retrospective analysis. Unmanned aerial vehicles (drones) supplement visual information if satellite data is unavailable.

Human observers: Trained observers, including students and NGOs, conduct valuable on-site observations and documentation.

Ice measurement: Manual measurement or the use of sonar and ground-penetrating radar is used to assess ice thickness and conditions.

Warning: All these activities are combined into public warning systems and communication plans to ensure timely informing of residents.

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PRE-SEASON ICE WEAKENING

Ice breaking: Involves the use of specialized vessels or equipment to fracture the ice cover and prevent accumulation.

Ice cutting and perforation: Creating cracks and drilling holes in the ice to weaken it and promote controlled breakup.

Dusting: Coating the ice surface with dark substances (carbon dust, ash, soil, sand) to increase solar radiation absorption and cause faster melting

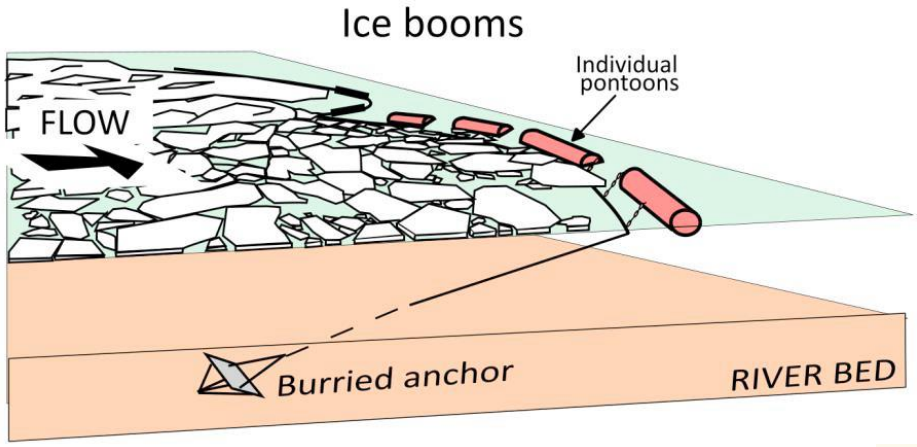
Use of salt: Chemical ice weakening by spreading salt on its surface.

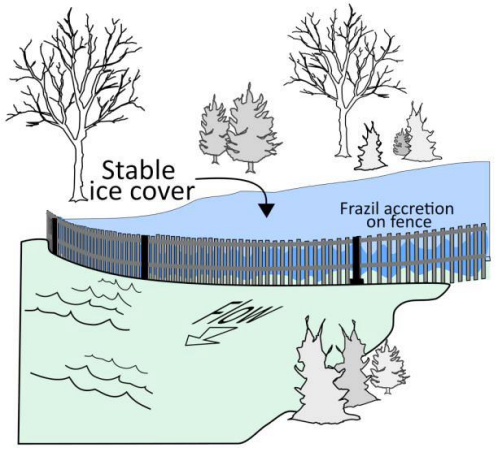
Thermal discharge: Delays or prevents the formation of ice cover in critical areas by introducing warm water upstream. Warm water sources can include industrial cooling ponds, power plant cooling systems, or water from the deep layers of lakes/reservoirs raised by pumps.

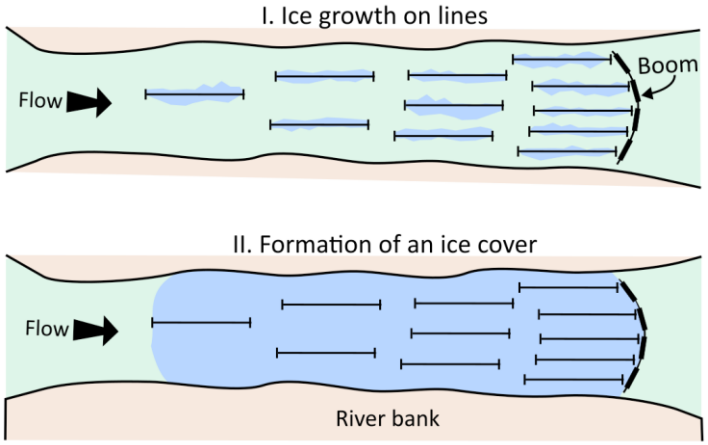
MECHANICAL INTERVENTION FOR ICE WEAKENING BEFORE ICE RUN

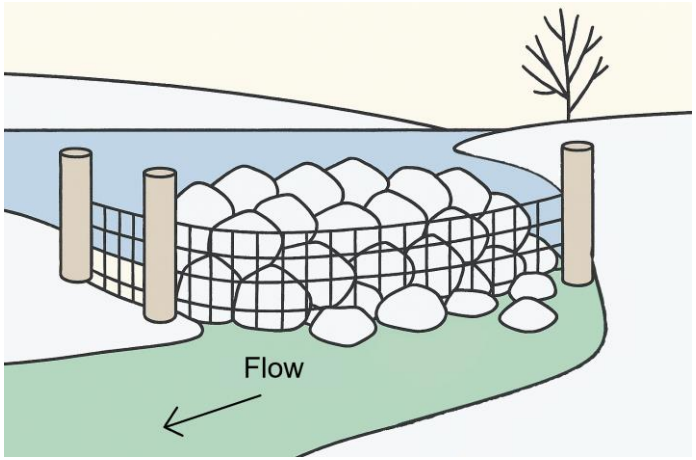
Booms, nets, and seasonal barriers

Purpose: To collect ice in a safe upstream area, thereby reducing ice supply to downstream problem zones, primarily under freezing conditions.









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EMERGENCY RESPONSE

Objective: Rapid response to ice jams that have already formed or are causing active flooding.

Dredging / excavation: Use of excavators and bulldozers for channel cleaning and relocation of major ice blocks (e.g., Jēkabpils ice floods in 2023).

Blasting:
Use of explosives to break up ice jams.

Water management:
Controlled release of water from dams or reservoirs.

Evacuation and flood protection:
Evacuation, use of sandbags, temporary dikes.

EMERGENCY RESPONSE

Tactical approach: Destabilize the ice jam downstream to release floodwater. Blasting often provides the fastest results but requires careful planning and expertise.

Optimal conditions:

- Explosives are placed under the ice.
- Placement before the stage drop.
- A significant number of charges for success.

Limitations:

- Logistically difficult to execute.
- Dangerous operations.
- Not suitable for urban areas.

Ice blasting at Pļaviņas on 25 March 2010 on the Daugava River near Pļaviņas, Bebruleja.

FLOOD CONTROL

Evacuation plans	Use of sandbags	Temporary dams
Coordinated emergency evacuation for residents at risk.	Rapid deployment of sandbag barriers to protect critical infrastructure and property.	Rapid construction of temporary flood barriers using available materials.

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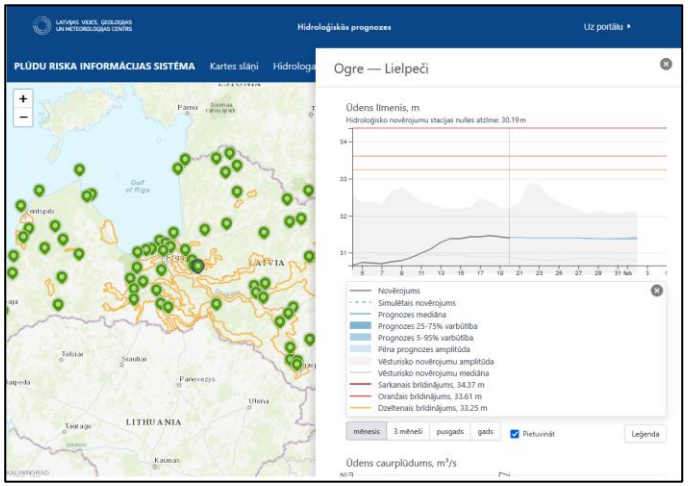
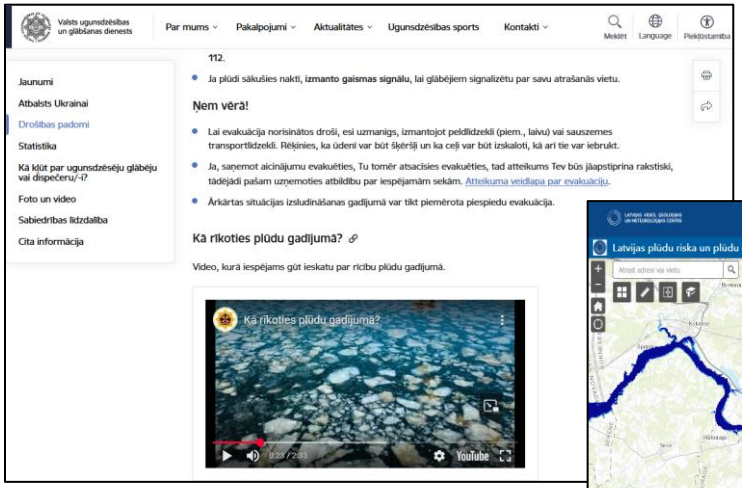
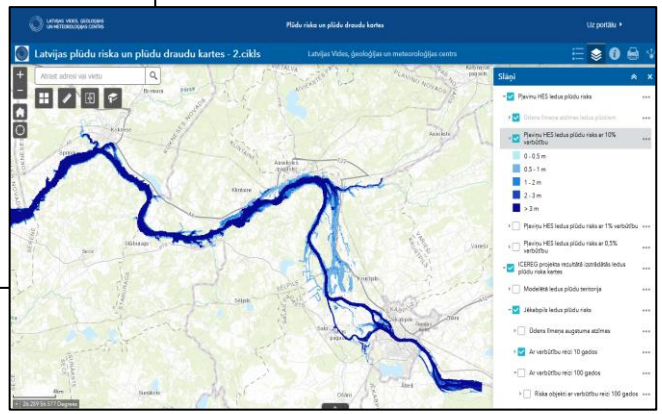
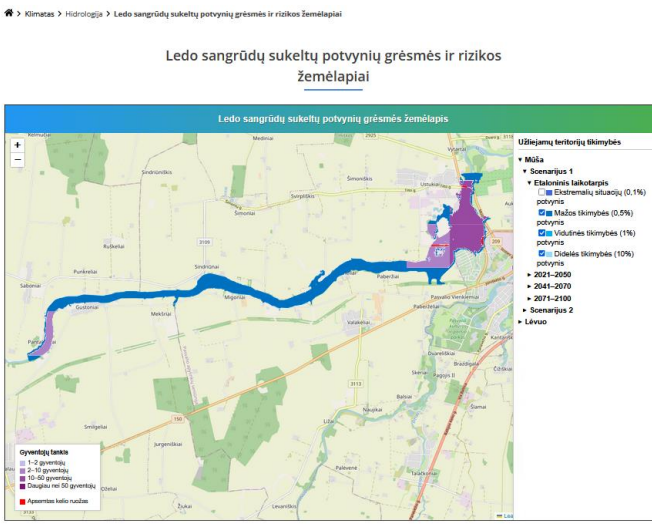
ICE-JAM FLOOD COMMUNICATION

- Hydrological forecast and warning (https://videscentrs.lvgmc.lv/iebuvets/hidrologiskas-prognozes; https://www.meteo.lt/en/currently/hydrological-information)
- Ice-jam flood risk maps (https://videscentrs.lvgmc.lv/iebuvets/pludu-riska-un-pludu-draudu-kartes; https://www.meteo.lt/klimatas/hidrologija/ledo-sangrudu-sukeltu-potvyniu-gresmes-ir-rizikos-zemelapiai/)
- State Resque Service information (https://www.vugd.gov.lv/lv/pludi; https://pagd.lrv.lt/)









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Best practice

Best practice is to use a combined strategy – prevention where possible (ice control, monitoring) and strong emergency readiness in case jams break unpredictably.

1. River ice management like 1) Ice booms; 2) Ice breaking with specialized equipment; 3) Managed ice cutting

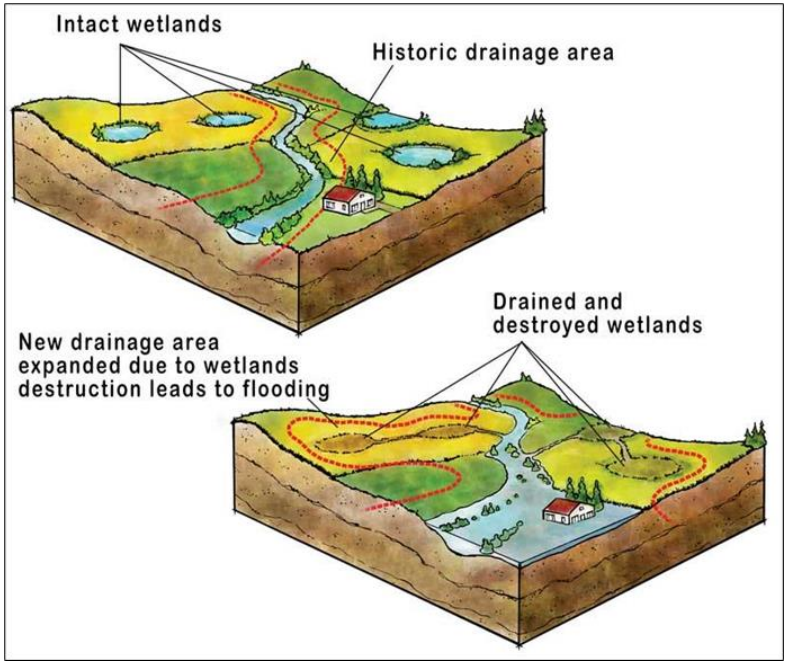
2. Floodplain and land-use planning like 1) Floodplain zoning to limit new construction; 2) Maintain or restore wetlands and riparian buffers to absorb floodwaters.

3. Real-time monitoring & Early Warning Systems

Tools:

- Remote sensors and gauges to track river heights and temperature;
- Satellite or aerial imagery to spot developing ice packs;
- Automated alerts to authorities and communities.

4. Ecological and Nature-Based Solutions like 1) Set back or remove levees; 2) Excavate or regrade the floodplain; 3) Reopen historical side channels; 4) Plant native trees and shrubs with strong root systems; 5) Maintain gradual bank slopes (avoid vertical walls).



When to "Do Nothing": Strategic Inaction

In certain circumstances, monitoring without intervention may be the most appropriate response.

Thin, weak ice conditions: If the ice strength is insufficient to create significant ice jams.

Reduced ice inflow: When most of the ice has already melted or dispersed.

Favorable weather forecast: Moderate temperatures and no precipitation are expected, which will accelerate natural breakup.

Rapid jam dynamics: Ice jams can form and release quickly (<1 day), making emergency measure mobilization impossible.

Cost-Benefit Analysis Principles in Ice Jam Mitigation

Cost-Benefit Analysis (CBA) compares the total expected benefits of mitigation measures – **primarily reduced flood damage, avoided emergency costs, and improved public resilience** – **with the costs of implementation and maintenance**. Typical benefits are quantified using depth-damage relationships, which assess potential property and infrastructure losses in ice jam scenarios with and without mitigation measures.

What Measures Could be Implemented in the Studied River Basins?

Pre-season measures:

- Early flood forecasting and public warning systems. ☺
- Monitoring (gauges, webcams, drones, trained observers). ☺
- Mechanical weakening: dusting. ?

  In Pļaviņas, peat was once applied using helicopters. However, it must be considered where the peat ends up afterward. Sunny weather is required for the ice to melt.

Emergency measures:

- Water management: controlled water release from dams or reservoirs. !?

  Jēkabpils and Pļaviņas sometimes disagree over gate opening, causing delays. In 2023, flooding was mainly due to snow and slush ice, making the effectiveness of gate opening uncertain.

- Evacuation planning; use of sandbags, temporary dams. !?

  To reinforce the dike in Jēkabpils, residents extensively used sandbags. A shortage of 'big bag' sacks required deliveries from Vidzeme and Kurzeme. The method is old-fashioned but highly effective.

Permanent measures:

- Flood modeling, risk mapping. ☺
- Strategic land use planning, regulations, financial penalties for development in flood-prone areas. !?

  Participants noted that while all measures are used, some residents choose to remain in flood-prone areas despite regulations and oppose both dikes and rescue efforts. Flood risk zones are being identified through territorial planning.

- Installation of ice retention barriers. ?

  Residents have proposed installing cables across the river. Whether this would work is currently unclear.

- Design improvements to bridges or culverts for better ice passage. ?

  Some mitigation may be possible, as wedge-shaped piers and remaining submerged old piers can promote slush ice accumulation.

Thank you for your attention!

CONTACTS:
laura.bertina@lvgmc.lv