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Assessing the global economic impacts of floods and their potential propagation through international trade

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The XIX World Water Congress

RS2 *Water Security and Water-related risks: 3.1 Water Disaster Management*

2025/12/02

Global Supply Chains: Economic Growth but Create Dependencies

Trade liberalization

Technological advancements

Interconnected economy with global supply chains (GSCs) linking suppliers and producers worldwide

CORPORATE | Together with Our Suppliers

Toyota Times

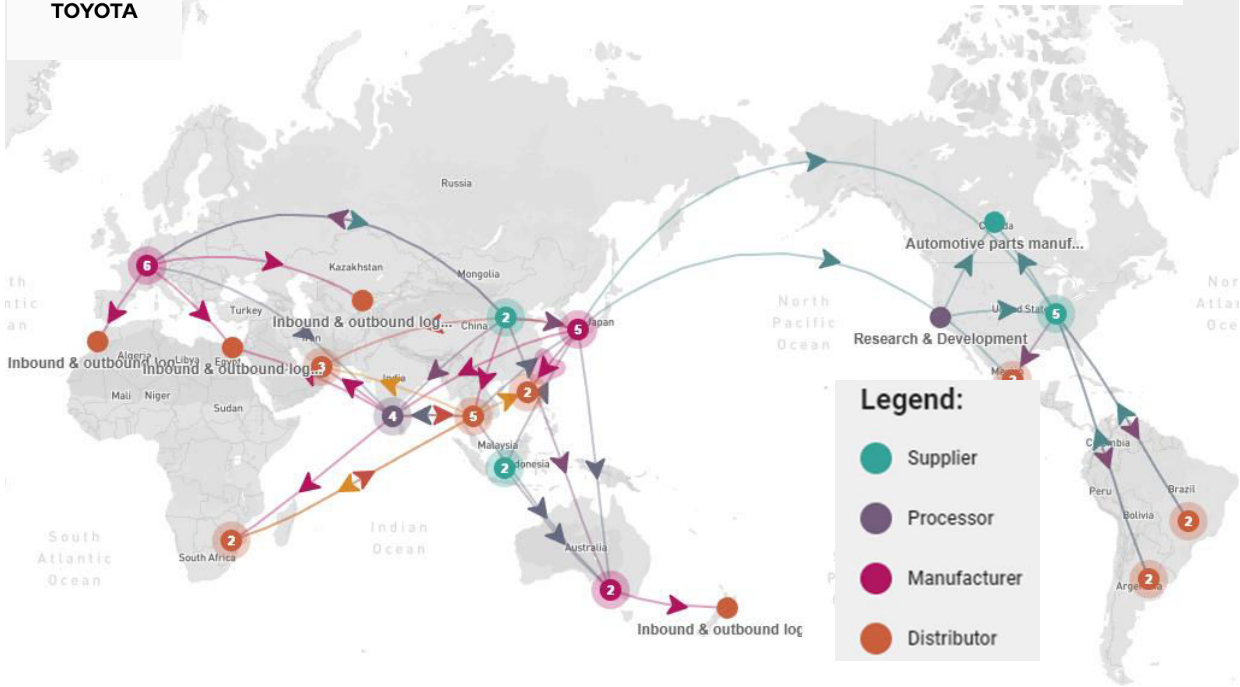
Suppliers, Not Subcontractors--Toyota's Commitment to Co-prosperity with 60,000 Companies

➔ *Seamless operations and growth*

➔ *High dependency !!!*

TOYOTA

Toyota Global Supply Chain network



Global Supply Chains: Vulnerable to Disruption

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Pandemics (COVID 19)

Geopolitical issues

Cyb

Supply Chain Dive

Extreme weather is 2024's top supply chain risk: Everstream

Extreme weather is 2024's top supply chain risk: Everstream. Wildfires, rains and droughts could cause shipping delays, while agricultural...

Trade policies & tariffs

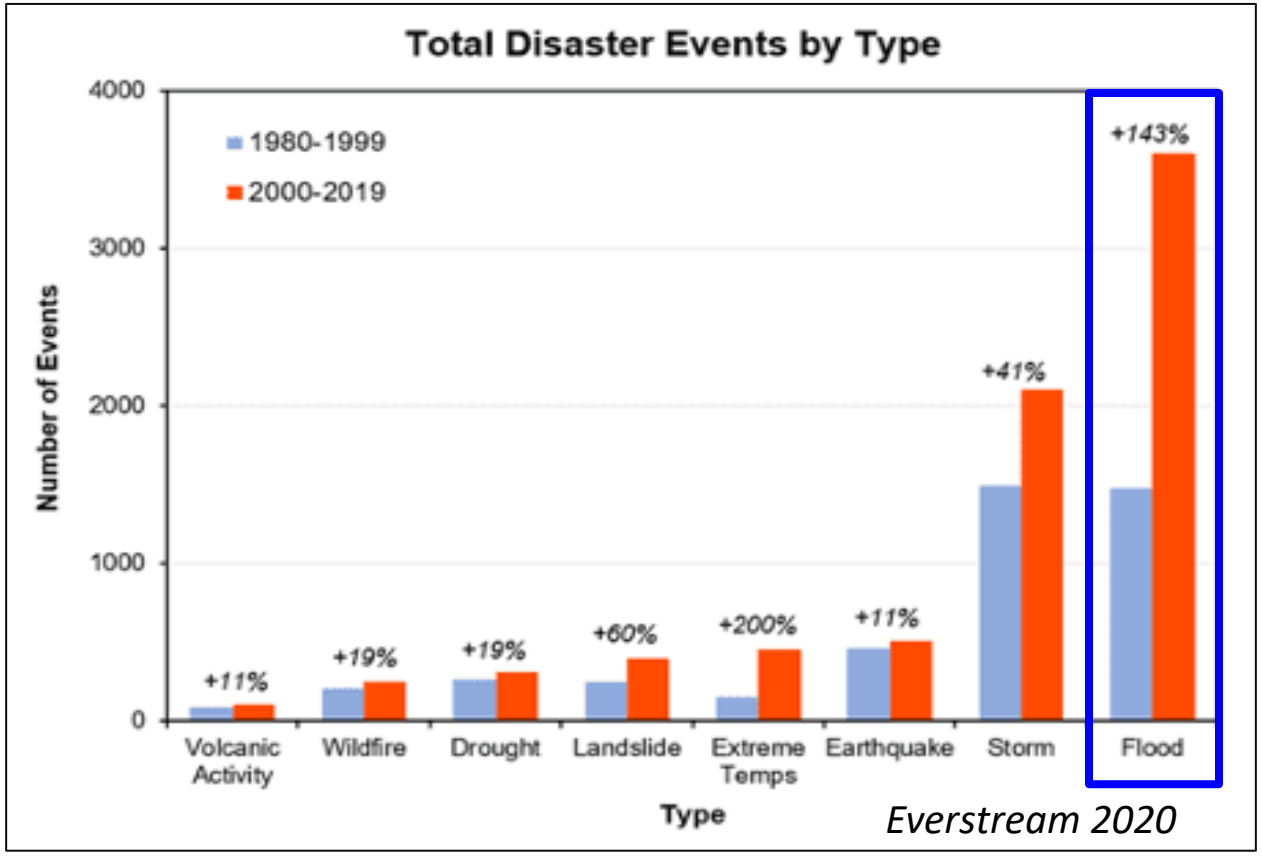
Climate-related disasters

Climate-related Disasters Disrupt Global Supply Chains

Climate change

➔ **More** frequent and severe **disasters**

➔ Increased **disruptions** & economic **losses**



Everstream 2020

Stats on flood events (2000–2019)

Most frequent:

44% of all disasters

Most impactful:

1.6 bn people affected globally

Second costliest

22 % of global disaster costs

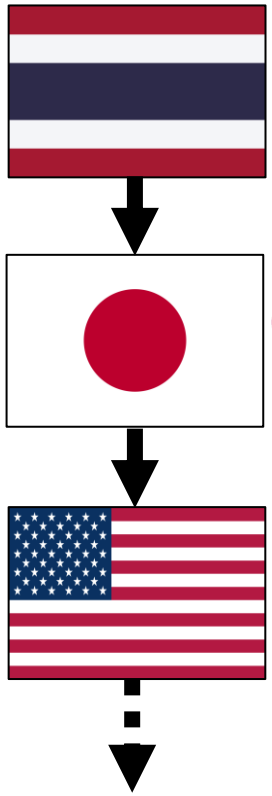
Bloomberg.com

Floods Are Top Risk to Supply Chains in 2025, Everstream Says

Flooding poses the greatest threat to supply chains this year, as warm ocean temperatures fuel more frequent and disruptive storms,...

Supply Chain Disruptions Trigger Cascading Economic Impacts

2011 floods in Thailand: Not only local (*direct*), but also ripple (*indirect*) effects



Business Interruption for weeks

+ Supply shortage of auto parts

Production suspension

Production shutdowns

***Ripple** effects propagating across borders and sectors*

Research Objective & Questions

Develop an assessment framework of *direct* economic impacts of floods and their potential *indirect* propagation through supply chains

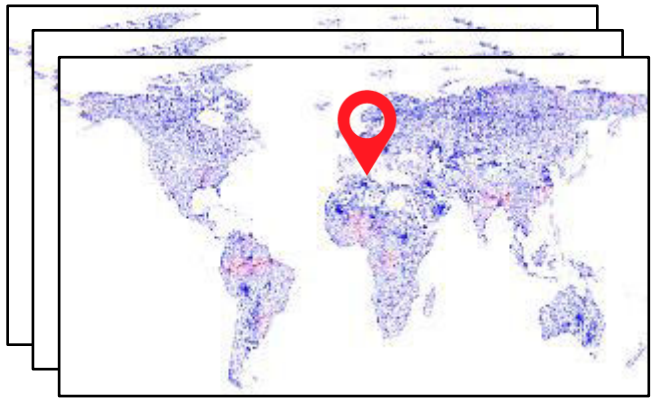
To reveal hidden disruption risks within supply chains ….

- ❑ **How significant are the *direct* economic impacts of floods on different economic sectors (Agriculture, Industry, Services)?**
- ❑ **To what extent can flood risk propagate *indirectly* through global supply chains?**

Methodology: Assessing Global Flood Risk

Where might loss occur?

Global flood hazard maps *(gridded flood depth)*

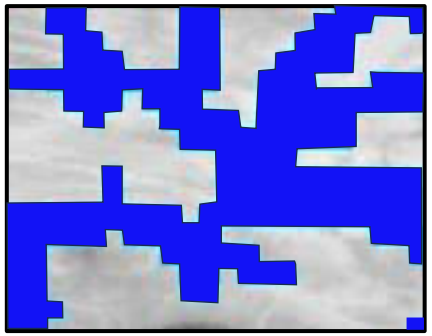


Different occurrence probabilities (1/5 … 1/1000)

Geospatial analysis
Big data analysis

National-level flooded area (flood depth > 0 m)

Flooded area



How much loss in different sectors?

Agriculture:

All potential products in flooded areas will be lost

Land-use-based value added estimation

Flooded agricultural area [km²] × **Value Added in agricultural area [US$/km²]**

Industry & Services:

Production capacity reduction during floods

Value Added *(industry/service)* **in the flooded area [US$/day]** × **Business interruption period [days]**

Population-based value added estimation

Satellite-based flood data (>4,900 events)

Methodology: Assessing Flood Risk Propagation

- International **trade flows** (export and import)➔ **supply chain** linkages
- **Herfindahl–Hirschman Index (HHI):** concentration of imports & diversity of exports (1/HHI)
- **Loss-Weighted HHI** (LHHI): HHI adjusted by flood losses in trade partners

Potential propagation of flood risk

$$LHHI_{export,\,r} = \left(\frac{1}{\sum_{n=1}^{n=134}(e_n^r)^2}\right) Loss^r$$

e_n^r : the share of **exports** from country r to country n

How much r affect its export partners n ?

➔ **Who gives flood risk?**

Exposure to indirect flood risk

$$LHHI_{import,\,r} = \sum_{n=1}^{n=134} (i_n^r)^2 Loss^n$$

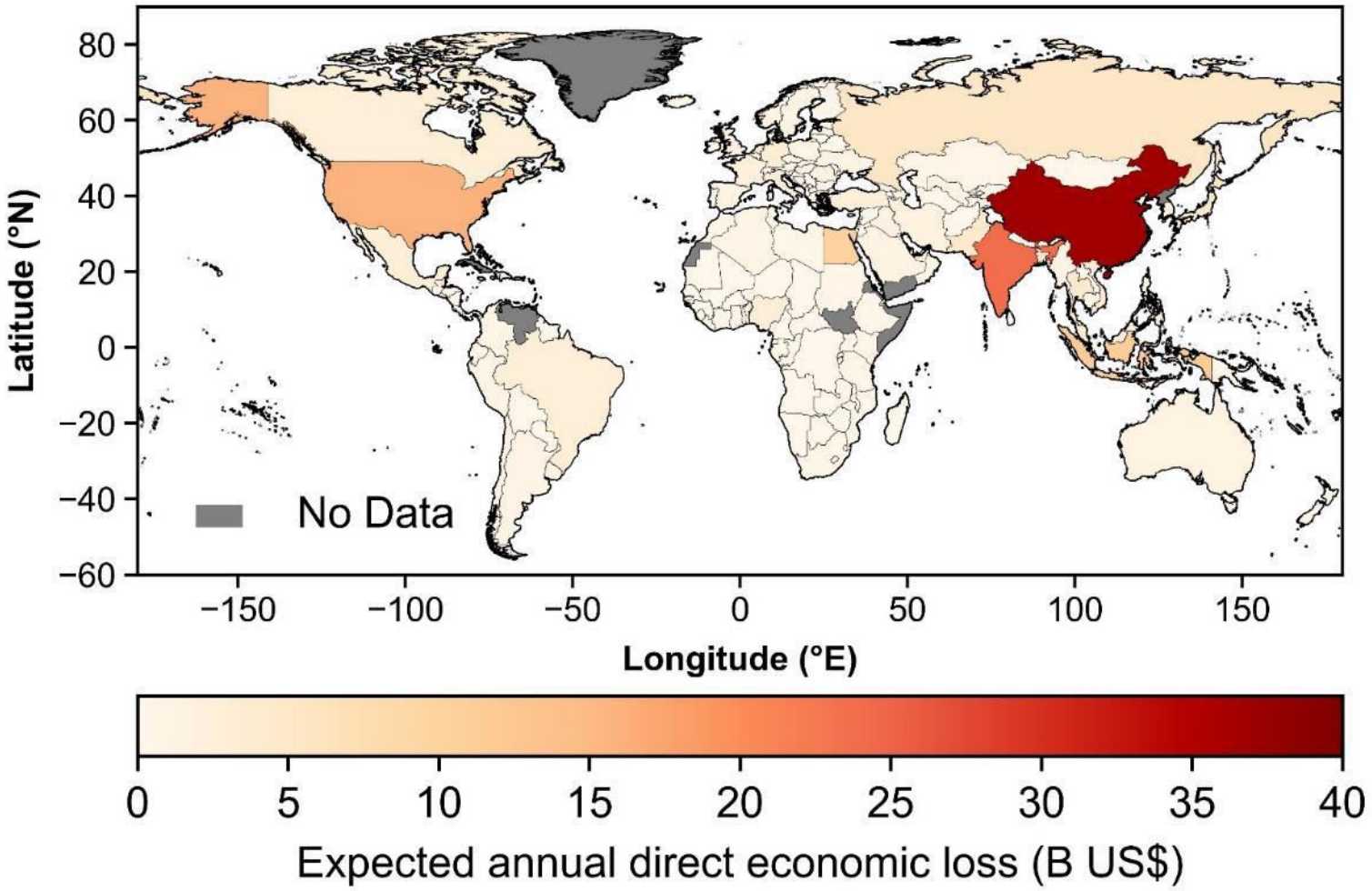
i_n^r : the share of **imports** from country n to country r

How much r is exposed to flood risk in import partners n ?

➔ **Who takes flood risk?**

Results: Total Direct Economic Loss by Floods

Global total direct economic loss = US$ 194 billion/year ➔ 0.14% of the Global GDP



	Billion $US	*% of global loss*	
	36.6	18.9	
	23.8	12.3	
	15.9	8.2	
	11.1	5.7	
	9.9	5.1	> 50%
	4.8	2.5	

Mtibaa et al., 2025

Results: Direct Economic Loss Vary by Sector

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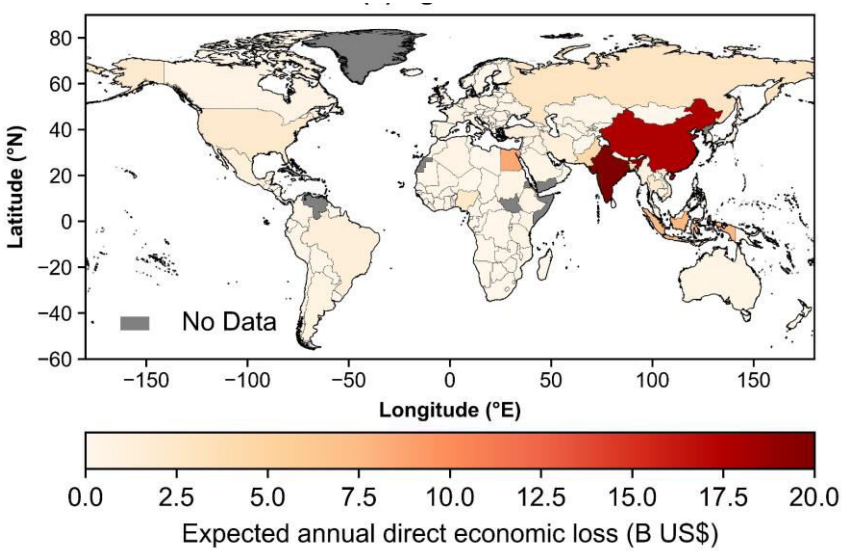
Economic loss in Agriculture — **54% of the total**

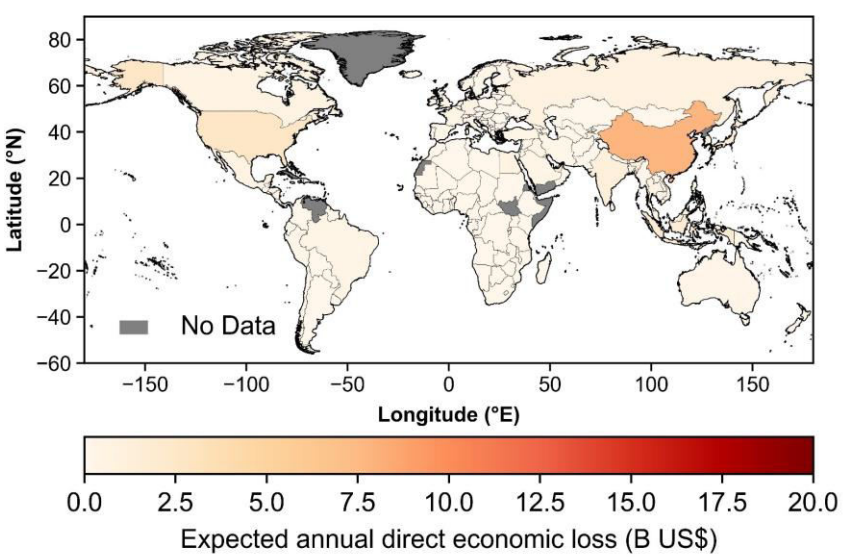


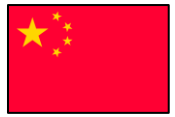

19.3%


8.1%

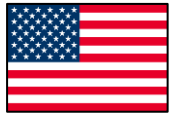

17.0%

Economic loss in Industry — **15% of the total**

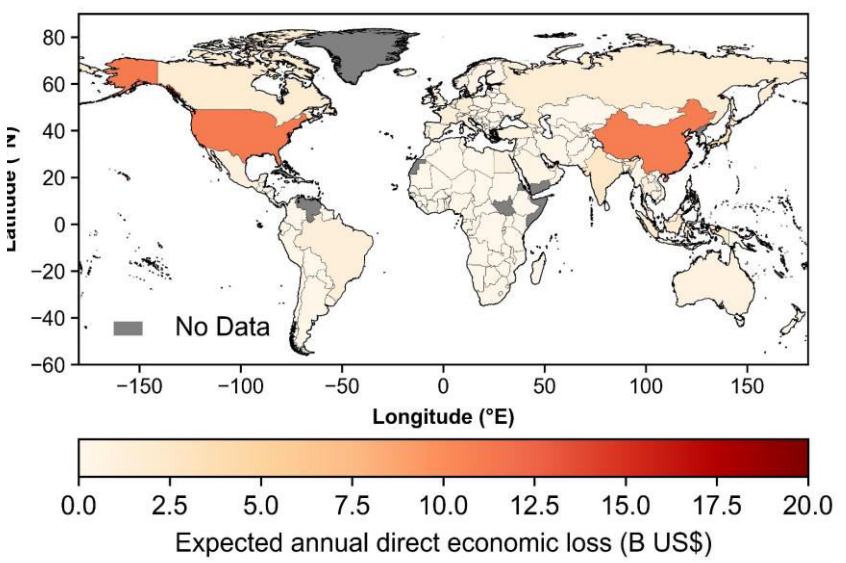



26.6%

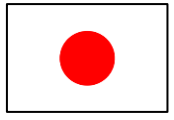

5.6%

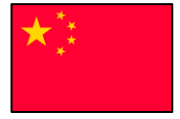

9.0%

Economic loss in Services — **31% of the total**




18.5%

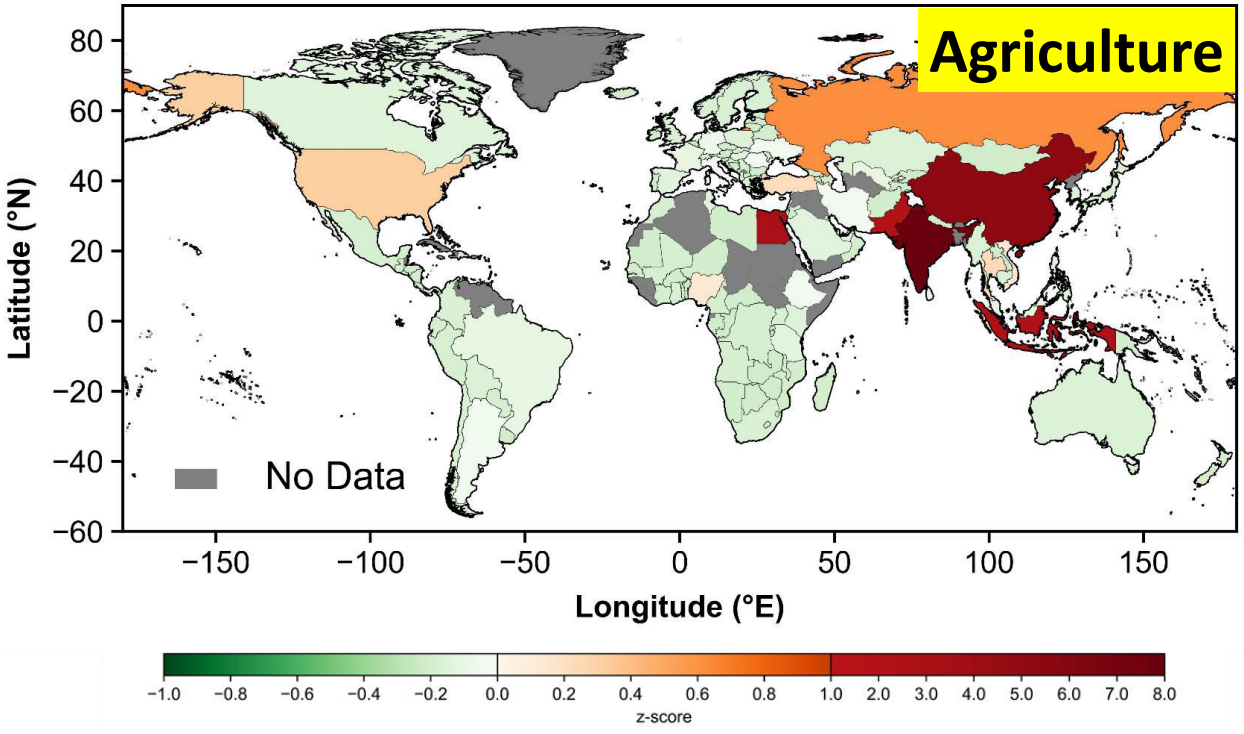

5.2%

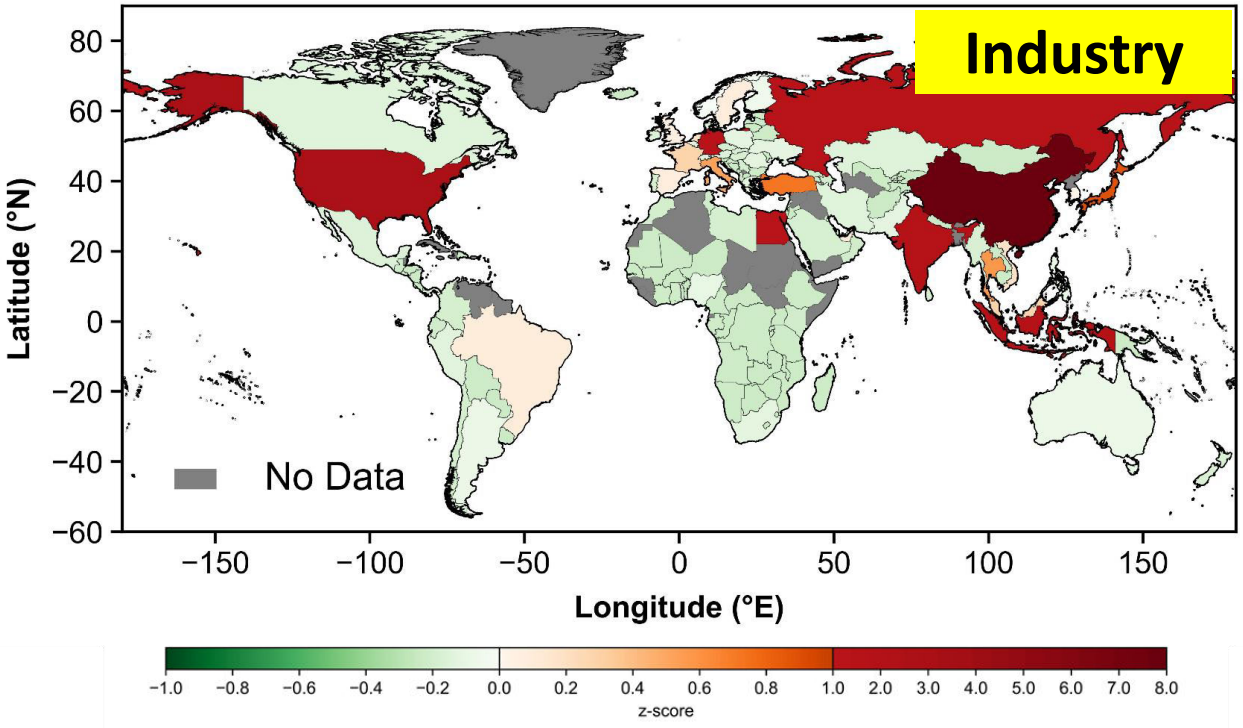

18.2%

Mtibaa et al., 2025

Results: $LHHI_{export}$ Reveals Who Gives Food Risk

Countries with high $LHHI_{export}$ z-scores: Potential transmitters of flood-related impacts via agricultural and industrial exports



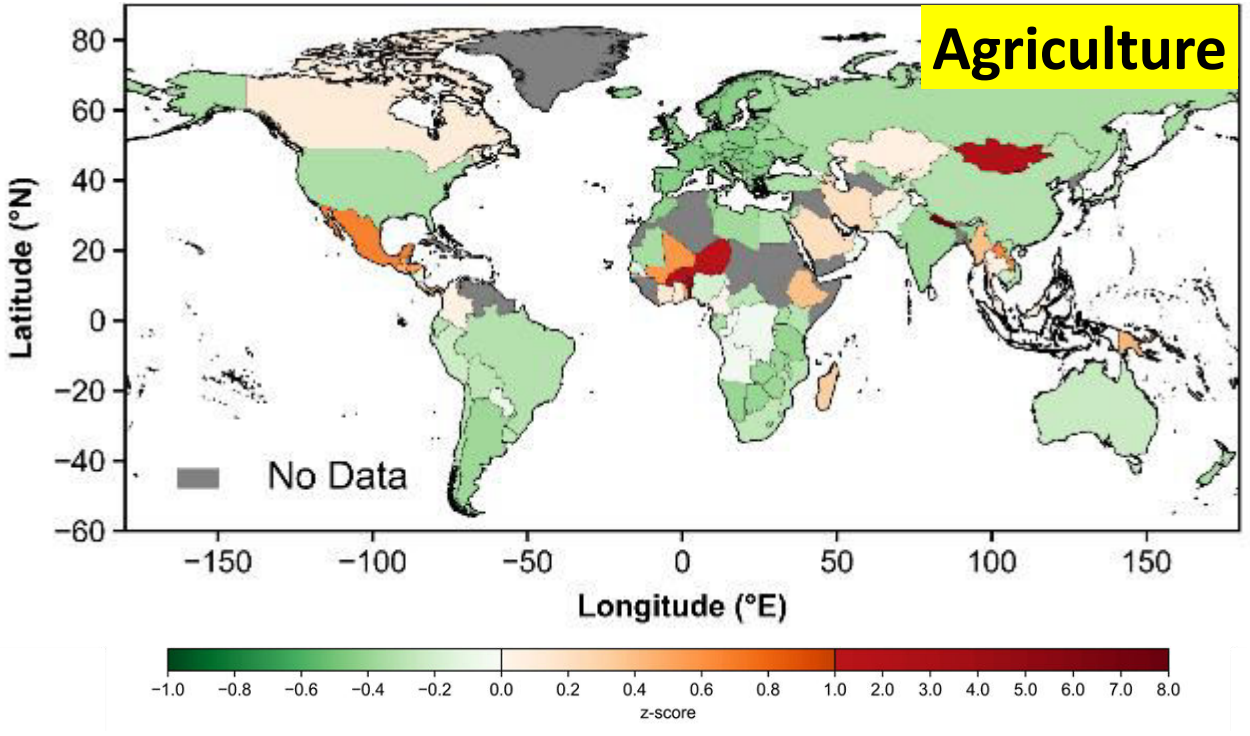


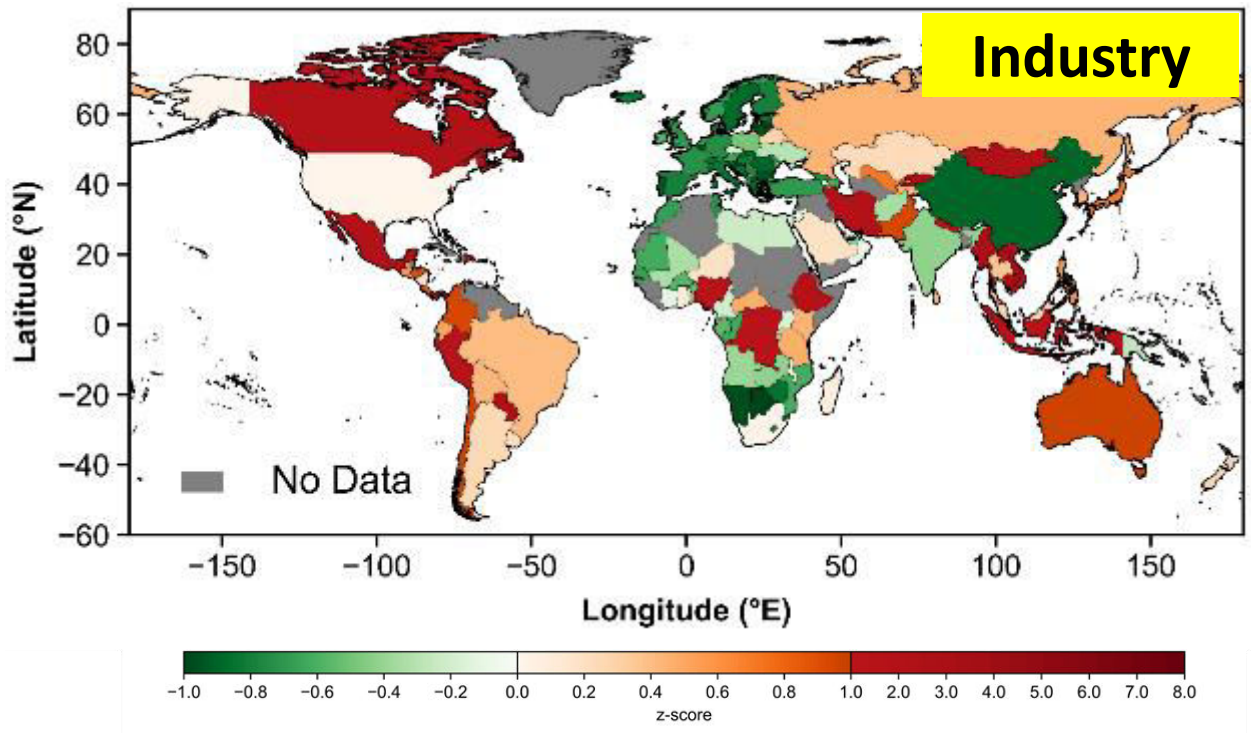
High direct losses and diverse exports ➔ Strong potential to transmit flood risk

- ❑ **Risk givers: China, USA, India, Egypt, …**
- ❑ **Can indirectly disrupt trade-dependent industries in export partners**

Results: $LHHI_{import}$ Reveals Who Takes Food Risk

Countries with high $LHHI_{import}$ z-scores: Increased indirect exposure to flood-related disruptions through agricultural and industrial imports





Heavy import reliance on flood-prone countries ➔ High vulnerability to indirect disruptions

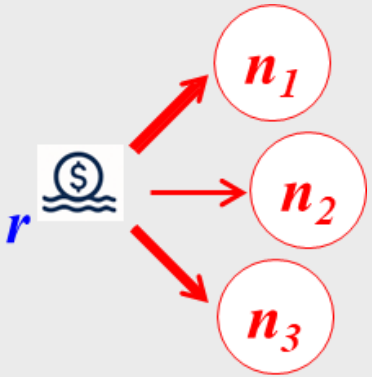
- ❑ **Risk takers: Sector-dependent; Europe is generally less vulnerable**
- ❑ **Indirect disruptions can cascade through industrial supply chains**

Key Takeaways

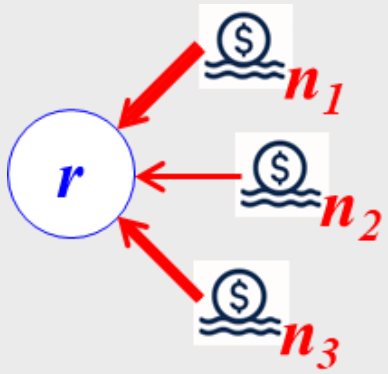
- **Sector-wise** assessment framework of global flood risk: **direct** economic losses from business interruptions across key sectors.
  ➔ Capture **potential business interruptions** by floods and **local** supply chain disruption risk, not just asset exposure.

- **New Risk Propagation Metric (LHHI)**: track flood risk **propagation** via international trade.

Risk Givers: Potential **spread** of **local impacts** to trade partners



Risk Takers: Potential **indirect** exposure to **disruptions** from trade partners



- Mitigation through Diversification: **Diversifying trade partners** and **reducing over-reliance on flood-prone suppliers** strengthens economic resilience.

ELSEVIER

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Research article

Potential risk by riverine floods in the global economy: Sector-wise assessment of direct and indirect impacts through international trade

Slim Mtibaa [a b] ✉, Keitaro Maeno [a b], Kamrul Islam [a b], Masaharu Motoshita [a b]

Thank you!

Methodology: Direct flood impact assessment

Agricultural sector: Lost value added (US$) in inundated agricultural and forested areas as proxy, assuming 100% loss.

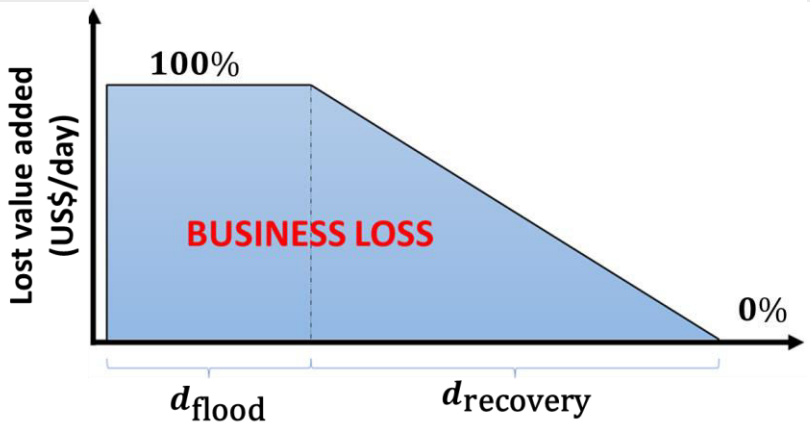
$$\text{Loss}_{\text{agri}} = N_{\text{inundated agri cells}} \times \left(\frac{\text{Value added}_{\text{agri}}}{N_{\text{agri cells}}} \right)$$

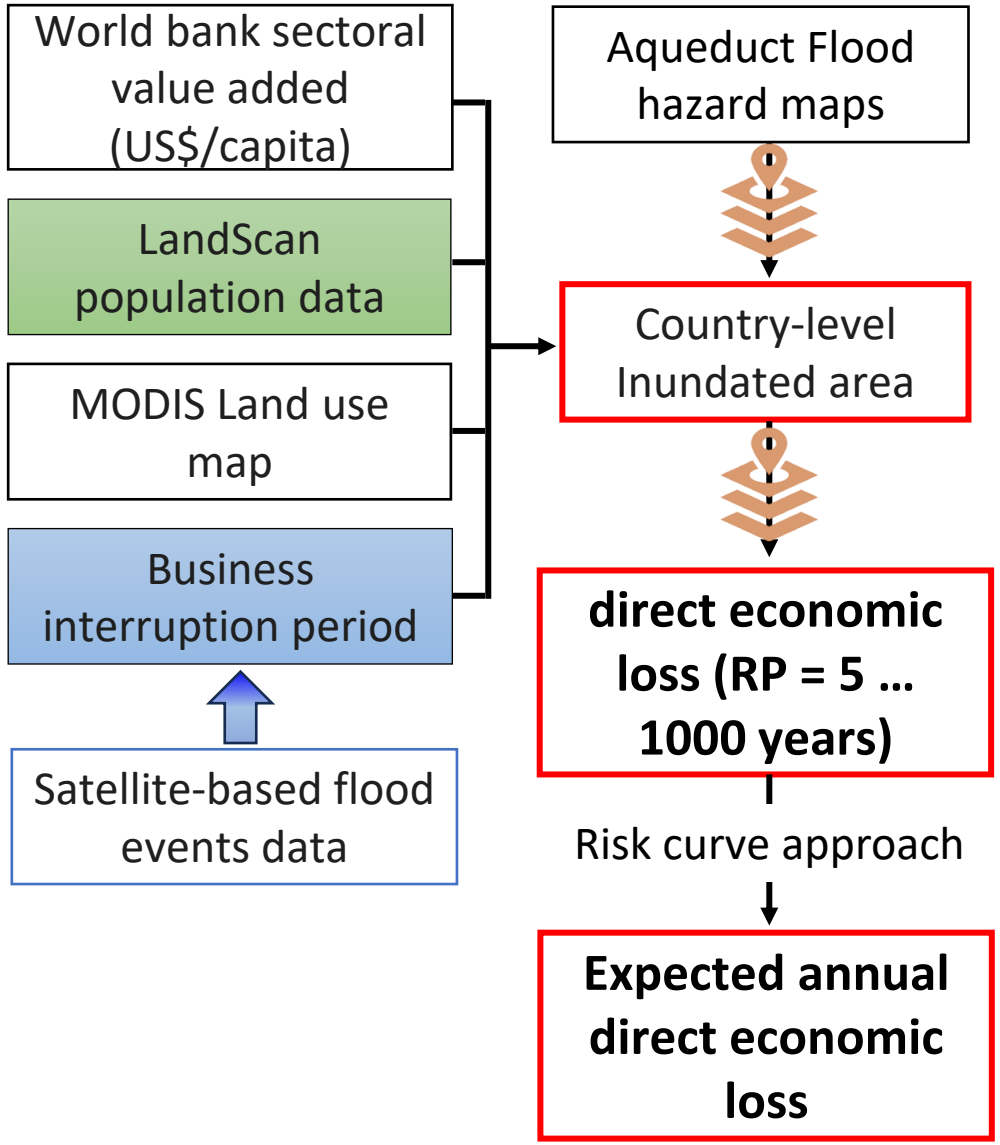
Industrial / Service sector: Reduced production capacity by affected people as proxy.

$$\text{Loss}_{\text{industry/service}} = \left(d_{\text{flood}} + \frac{d_{\text{recovery}}}{2} \right) \times N_{\text{exposed people}} \times \left(\frac{\text{GDP}_{\text{PPP}}}{365} \right) \times \beta_{\text{industry/service}}$$

Business interruption (Tanoue et al. 2020)

$d_{\text{recovery}} = 2 \times d_{\text{flood}}$
(MLIT, 2005)

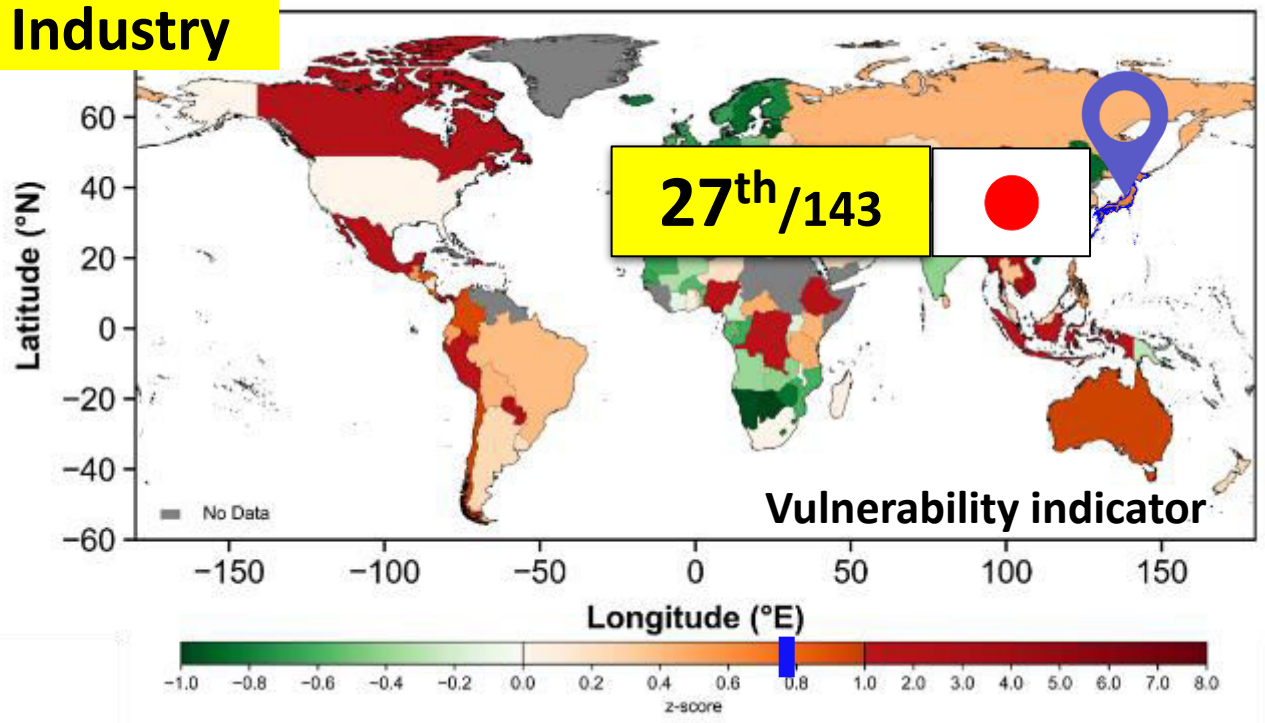




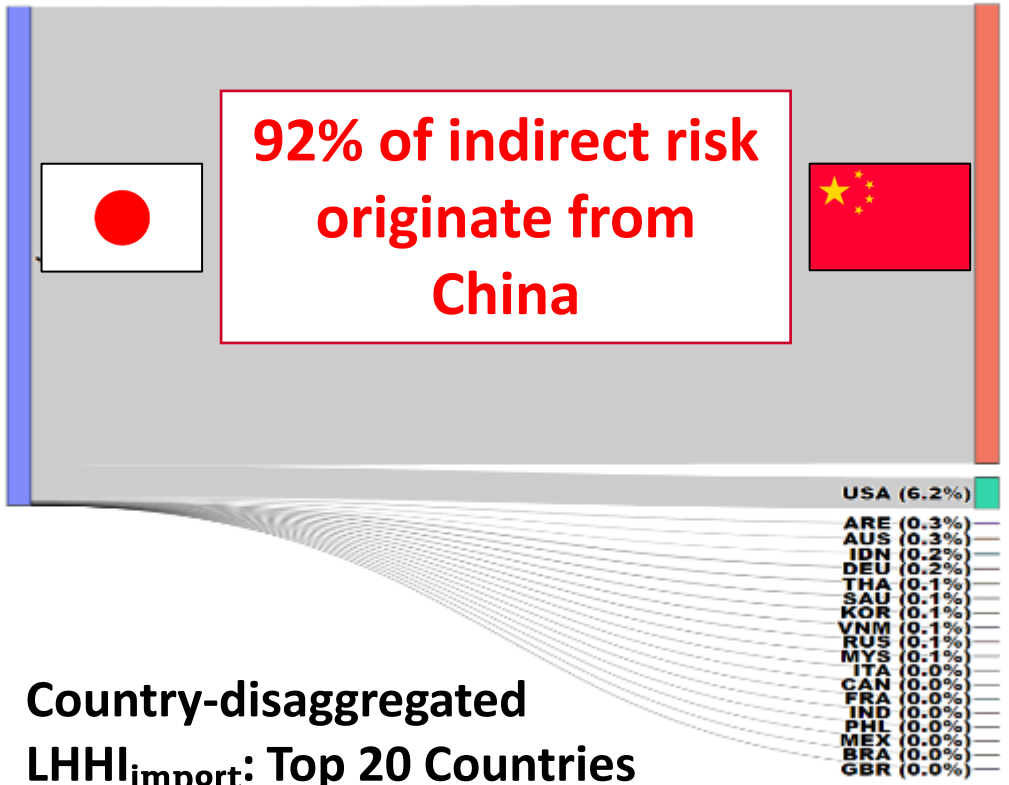
Simplified representation of our approach

Results: Case of Japanese Industry

Industry



Spatial distribution of $LHHI_{import}$



Country-disaggregated $LHHI_{import}$: Top 20 Countries

≈ 90% of Japan's indirect risk exposure originates from floods in China.

➔ The global supply chains of Japanese industries are highly vulnerable to indirect disruptions from flood-induced impacts in China.