CEC Flood Costing Project

Third Virtual Expert Workshop

Analysis and Synthesis Findings

Xin Wen, Ph.D.
Pacific Water Research Centre,Simon Fraser University

25 March 2021

Outline

Results

- Flood events characteristics (2013 - 2017)
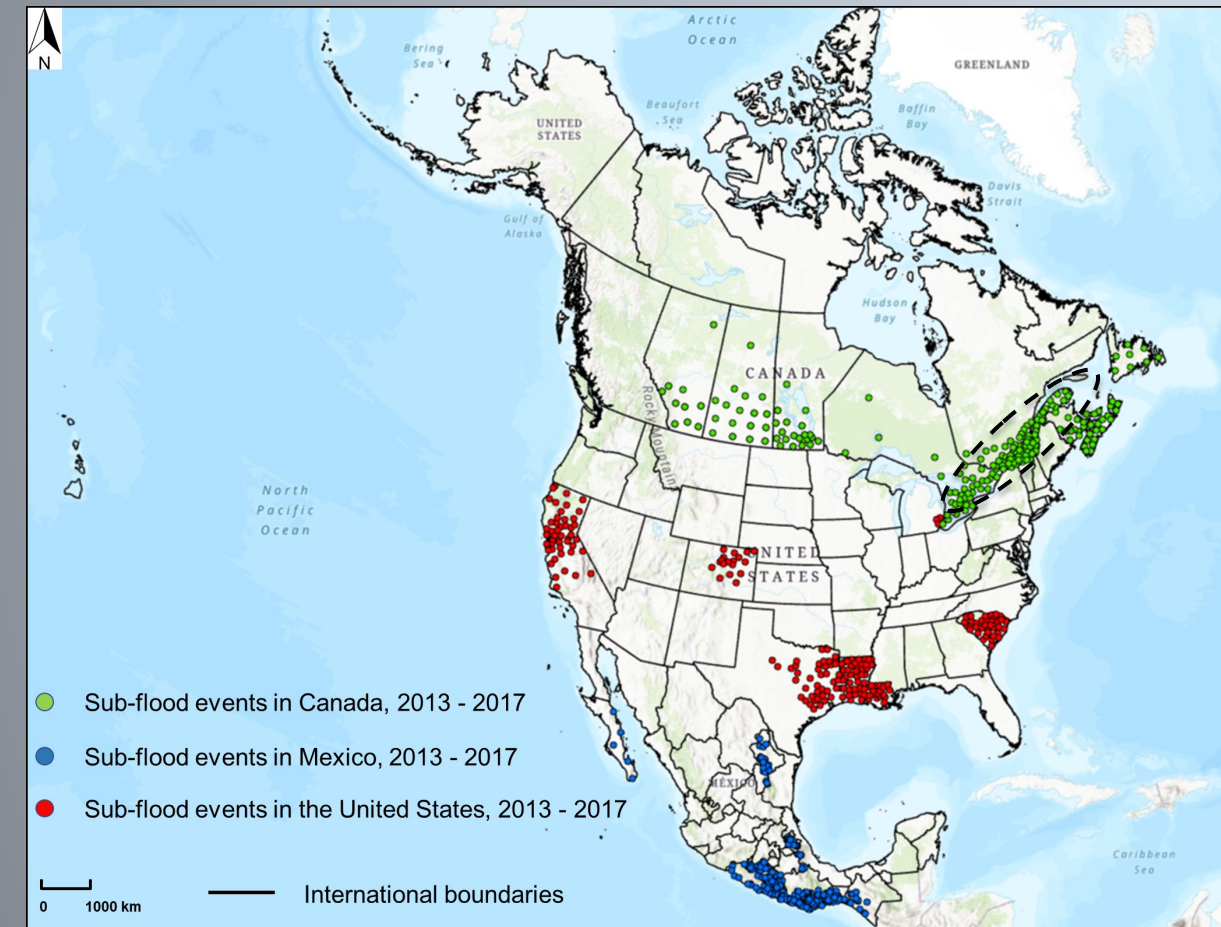
- Flood data characteristics (2013 - 2017)

Discussion

- Common features in flood cost damages

Conclusions

Flood events characteristics (2013 - 2017)

1. Large-scale impacts

Figure 1. Spatial distribution of sub-flood events across Canada, Mexico, and the United States, 2013 - 2017.

22 significant flood events and 826 sub-flood events

- 8 flood events in Canada, affected 300 census divisions
- 7 flood events in Mexico, affected 321 municipalities
- 7 flood events in the U.S., affected 205 counties

Multiple driving force factors:
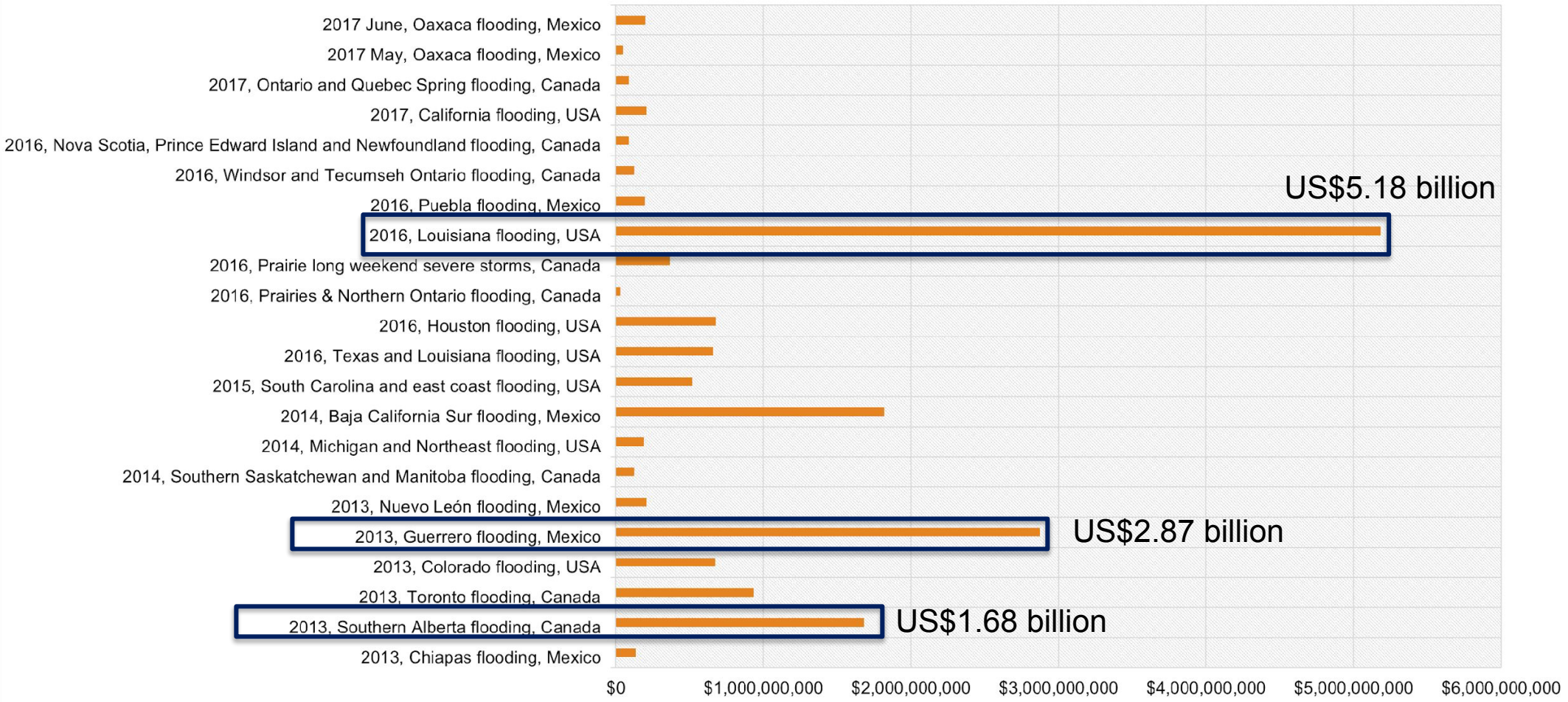
- Hurricanes
- Storm systems
- Rapid snowmelt
- …

Flood events characteristics (2013 - 2017)

2. Significant economic damages

Total flood economic damages across Canada, Mexico, and the United States, 2013 - 2017
(Unit: adjusted USD, 2020)

22 flood events:

Total CPI-adjusted damage was estimated approximately US$**17 billion**

US$5.18 billion

US$2.87 billion

US$1.68 billion

Figure 2. Total costs of flood events across Canada, Mexico, and the United States, 2013 – 2017 (Consumer price index(CPI)-adjusted).

Flood events characteristics (2013 - 2017)

3. Border flooding / international flooding

The United States
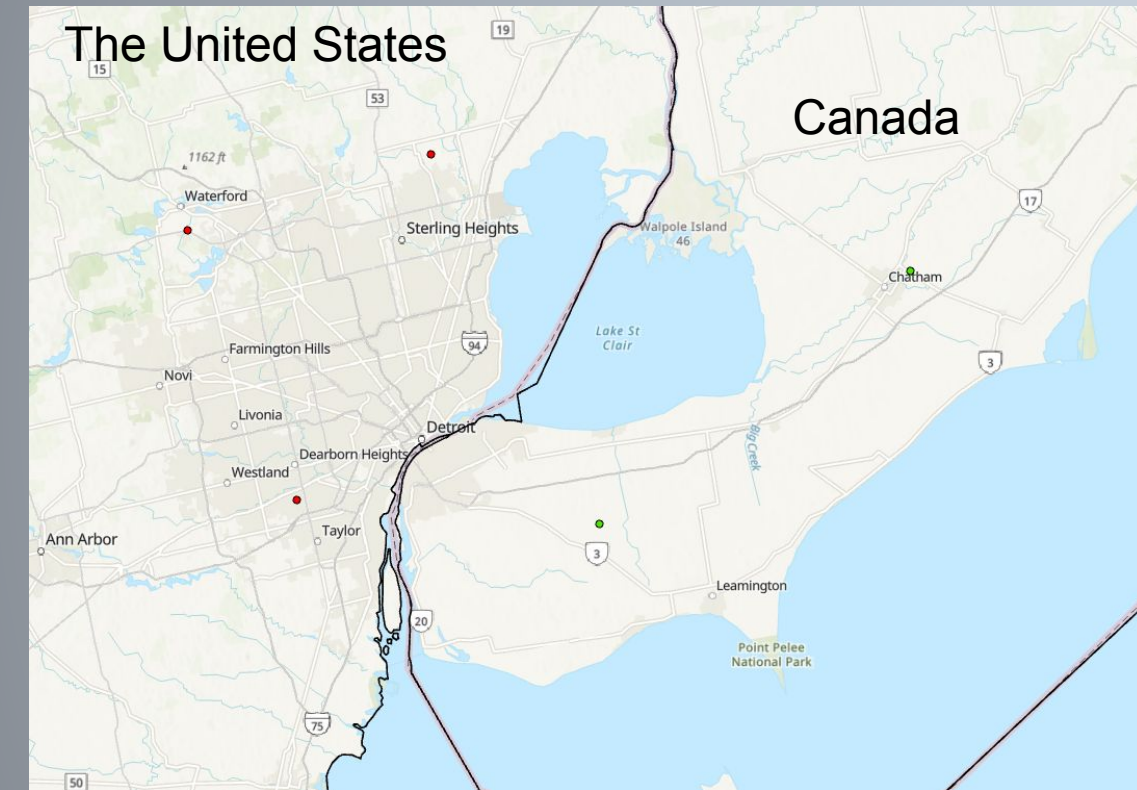
Canada

🔴 2014 Michigan and Northeast flooding, the United States
🟢 2016 Windsor and Tecumseh flooding, Ontario, Canada

🔴 2011 Souris River flood events, Canada

🟢 2011 Souris River flood events, the United States

— Watershed boundaries   — Souris River Basin   – – – International boundaries
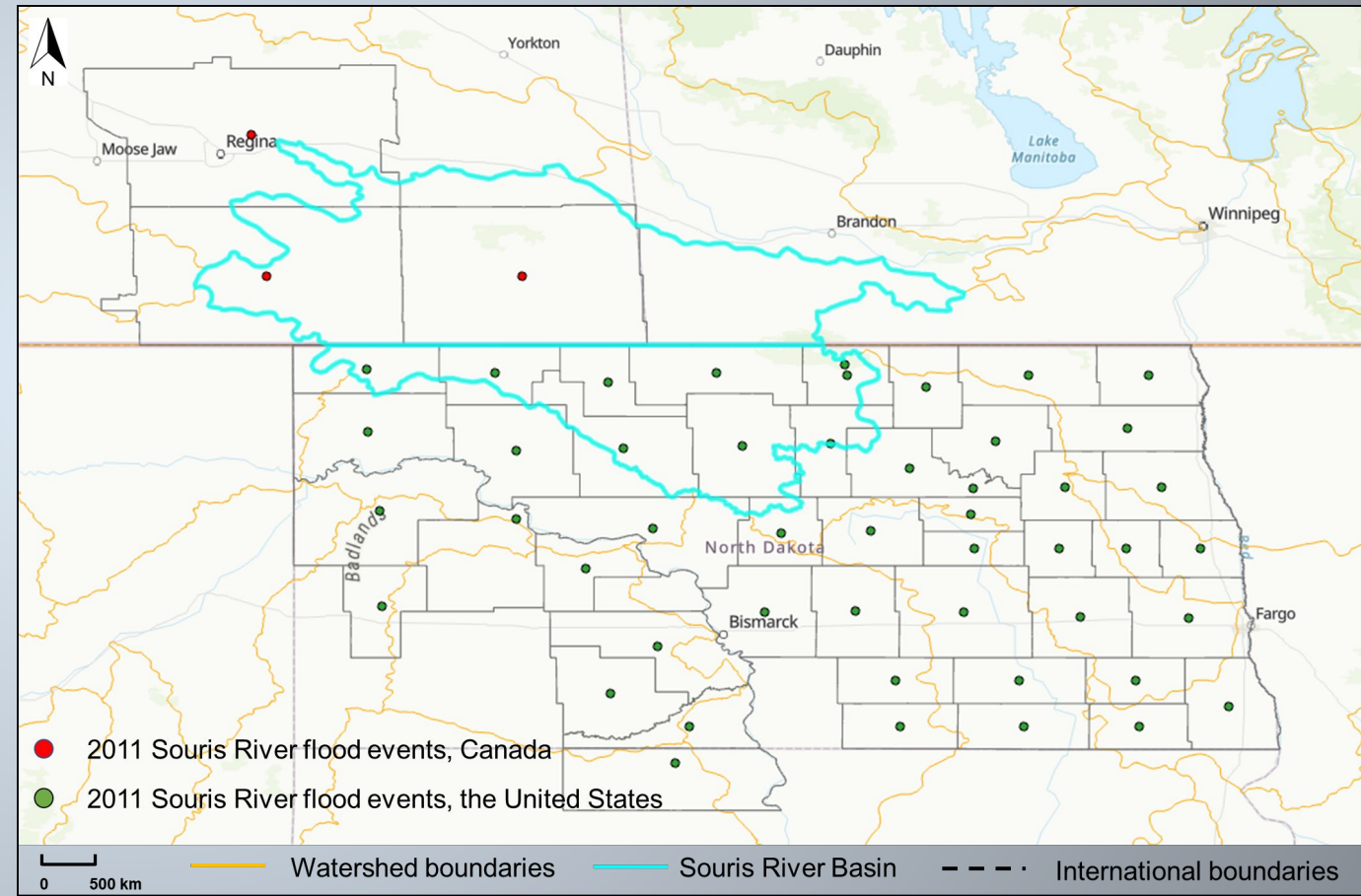
0   500 km

Figure 3. Geographical locations of the 2011 Souris River flooding in Saskatchewan, Canada and North Dakota, the United States.

Flood events characteristics (2013 - 2017)

4. Most severe damage on the metropolitan areas

Example:

Dwelling damages
Toronto, Ontario: US$ 355
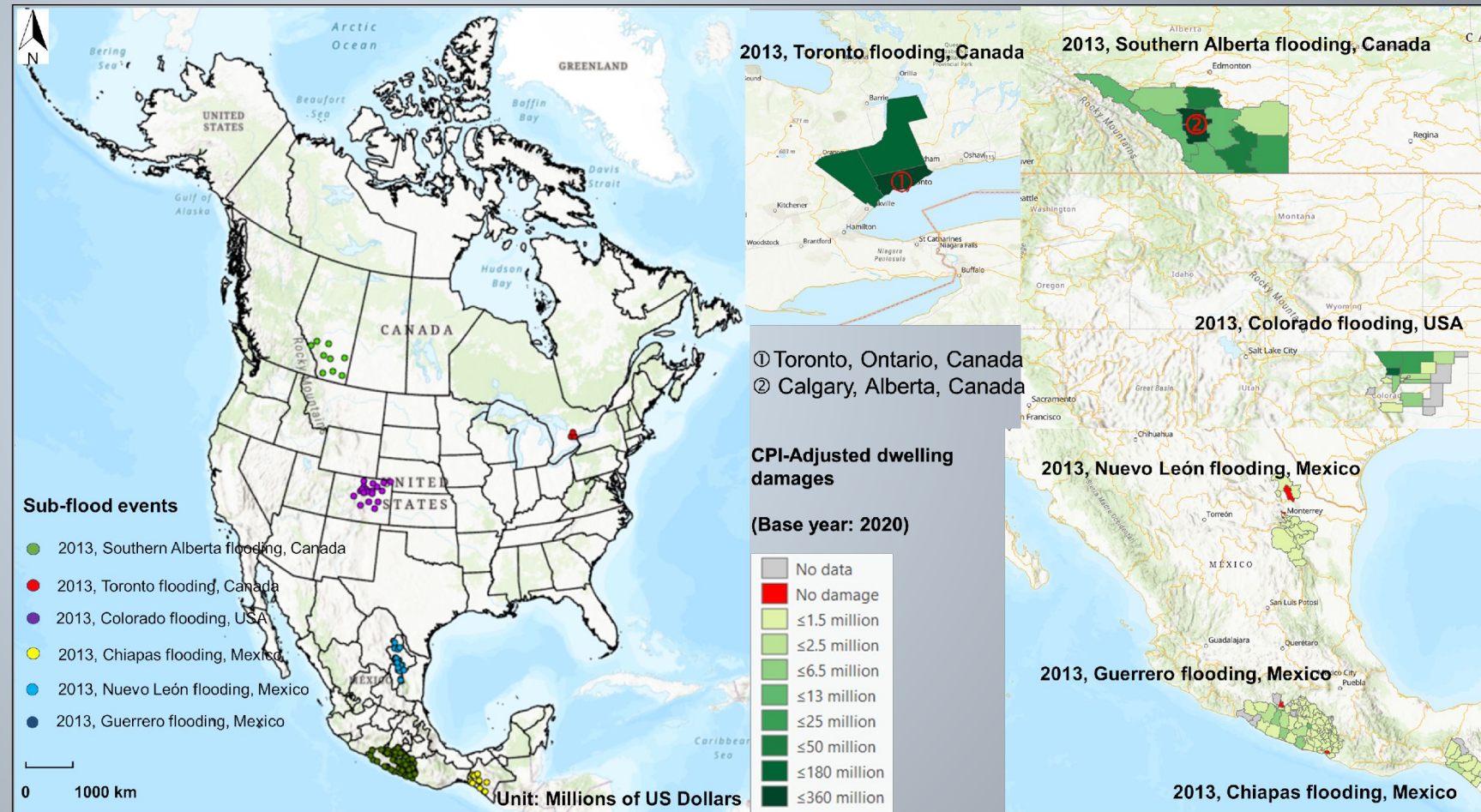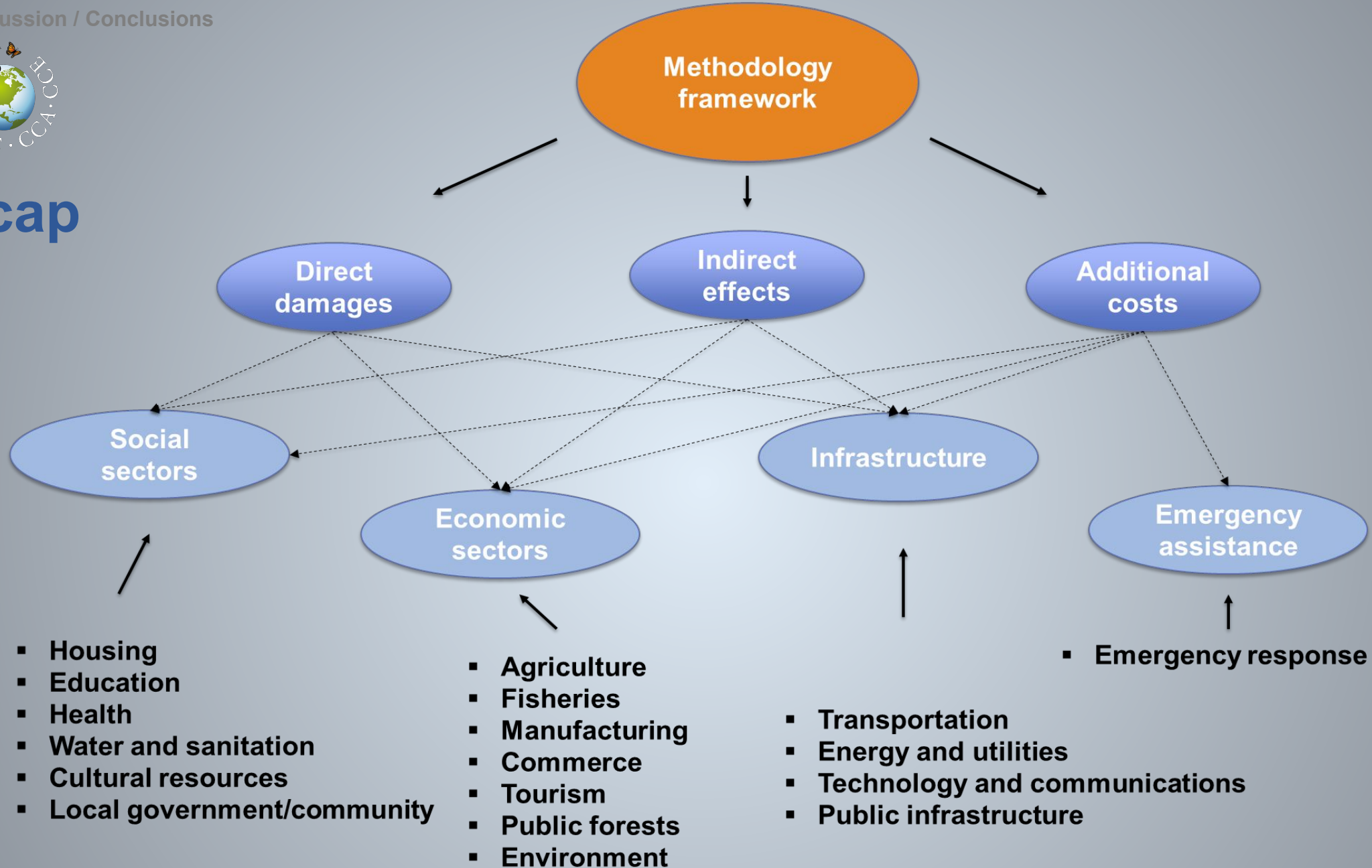million (CPI-adjusted, USD 2020)

2.7 million population (2016)*

Figure 4. Spatial distribution of dwelling damages caused by flooding across Canada, Mexico, and the United States in 2013.

Re-cap

Direct damage indicators (total number =55)	Indirect damage indicators (total number =15)	Additional cost indicators (total number =35)

Flood data characteristics (2013 - 2017)

1. Data availability by country and category:

o The best completeness among the three countries: Mexico > the United States > Canada
o Data availability across the three countries: direct damages > additional cost > indirect damages

Table 1 The CEC flood-costing methodology data availability for each country

Country	Data available for the number of			Data available for total number of indicators
	Direct damage Indicators (total number =55)	**Indirect damage Indicators (total number =15)**	**Additional cost Indicators (total number =35)**	
Canada	3	1	1	5
Mexico	[41 - 55]	8	[19 - 30]	[61 - 93]
The United States	[8 - 11]	0	[2- 3]	[10 - 14]

Flood data characteristics (2013 - 2017)

2. Data availability by sector:

o <u>Housing sector</u> is the most comprehensive of data available in the CEC flood damage categories.

o All flood events have data on the damages of <u>household items, dwellings/properties</u>, and <u>temporary accommodation</u>.

o Data for the cost of <u>commercial buildings and facilities</u> are also available for all three countries.

Table 2 Flood direct damage data availability

A blue light represents data available for this indicator and a red light represents data unavailable for this indicator

Direct damage categories	Direct damage indicators	Data collection		
		Canada	Mexico	The United States
House	Household items	🔵	🔵	🔵
	Dwelling	🔵	🔵	🔵
	Cleaning	🔴	🔵	🔴
Education	Building	🔴	🔵	🔴
	Classroom	🔴	🔵	🔴
	Cleaning	🔴	🔵	🔴
Health	Death toll	🔴	🔵	🔵
	Physical damage	🔴	🔵	🔴
	Medical equipment	🔴	🔵	🔴
Water and Sanitation	Storage tank	🔴	🔵	🔴
	Distribution network / treatment plant	🔴	🔵	🔴
	Rebuilding	🔴	🔵	🔵
Cultural Resources	Place of worship	🔴	🔵	🔵
	Recreation area	🔴	🔵	🔵

Table 2 Flood direct damage data (Continued)

A blue light represents data available for this indicator and a red light represents data unavailable for this indicator

Direct damage categories	Direct damage indicators	Data collection		
		Canada	Mexico	The United States
Cultural Resources	Sacred burial place	🔴	🔵	🔴
	Cultural artifact	🔴	🔵	🔴
	Museum collection	🔴	🔵	🔴
	Culturally-relevant historic structure	🔴	🔵	🔴
	Damaged zone	🔴	🔵	🔴
Local Government/Community	Local infrastructure and services	🔴	🔵	🔵
Transportation	Railroad	🔴	🔵	🔴
	Airport	🔴	🔵	🔴
	Port	🔴	🔵	🔴
	Road	🔴	🔵	🔵
	Protection wall/dyke	🔴	🔵	🔴
	Restore the infrastructure	🔴	🔵	🔴
	Restore the services	🔴	🔵	🔴
Energy & Utilities	Power generation plant	🔴	🔵	🔵
	Substation	🔴	🔵	🔴
	Transmission line and distribution grid	🔴	🔵	🔴
	Dispatch center	🔴	🔵	🔴
Technology & Communications	Service tower	🔴	🔵	🔴
	Communication infrastructure	🔴	🔵	🔴

Direct damage categories	Direct damage indicators	Data collection		
		Canada	Mexico	The United States
Agriculture	Road or bridge	🔴	🔵	🔴
	Storage space	🔴	🔵	🔴
	Infrastructure used in farming	🔴	🔵	🔵
	Infrastructure used in livestock	🔴	🔵	🔴
	Infrastructure used in poultry	🔴	🔵	🔴
	Infrastructure used in private forestry activity	🔴	🔵	🔴
Fisheries	Storage space	🔴	🔵	🔴
Manufacturing	Building and facility	🔴	🔵	🔴
	Machinery and equipment	🔴	🔵	🔴
	Inventory of goods	🔴	🔵	🔴
Commerce	Building and facility	🔵	🔵	🔵
	Machinery and equipment	🔴	🔵	🔴
	Inventory of goods	🔴	🔵	🔴
Tourism	Tourism area	🔴	🔵	🔴
	Property	🔴	🔵	🔴
Public Forest	Employee	🔴	🔵	🔴
	Road or bridge	🔴	🔵	🔴
	Infrastructure used in the park	🔴	🔵	🔴
Environment	Erosion and sedimentation	🔴	🔵	🔴
	Wildlife and aquatic species health	🔴	🔵	🔴
	Dispersal of nutrients and pollutants	🔴	🔵	🔴
	Local landscapes and habitats	🔴	🔵	🔴

Table 3 Flood indirect damage data availability

A blue light represents data available for this indicator, a red light represents data unavailable for this indicator, and a yellow light indicates data partially fit with the CEC flood-costing indicators

Indirect damage categories	Indirect damage indicators	Data collection		
		Canada	Mexico	The United States
House	House rental	🔴	🔵	🔴
Education	Missing workdays due to school closure	🔴	🔴	🔴
Health	Patient	🔴	🔴	🔴
	Workdays lost. Missing workdays due to psychological impacts, stress, and anxiety	🔴	🔴	🔴
Local Government/Community	Workdays lost (Unemployment increases)	🔴	🔴	🔴
Transportation	Loss of revenue at ports	🔴	🔵	🔴
Energy & Utilities	Spills damage	🔴	🔵	🔴
Technology & Communications	Revenue (manufacturing)	🔴	🔵	🔴
	Revenue (commerce)	🔴	🔵	🔴
Public infrastructure	Non-market value of public space	🔴	🔵	🔴
Manufacturing	R&D impacts	🔴	🔵	🔴
	Loss of wages, including temporary jobs	🔴	🔴	🔴
Commerce	Credit. Decreased credit scores and bond downgrades for businesses	🟡	🔴	🔴
Tourism	Loss of wages	🔴	🔴	🔴
Public Forest	Workday lost	🔴	🔵	🔴

Table 4 Flood losses and additional cost data availability

A blue light represents data available for this indicator and a red light represents data unavailable for this indicator

Losses & Additional Costs	Losses & Additional cost indicators	Data collection		
		Canada	Mexico	The United States
House	Temporary accommodation	🔵	🔵	🔵
	Relocation	🔴	🔵	🔴
Education	Temporary classroom	🔴	🔵	🔴
	Reset service	🔴	🔵	🔴
Health	Post-disaster epidemic	🔴	🔵	🔴
	Hospital-related costs	🔴	🔵	🔴
	Structure-related costs	🔴	🔵	🔴
Water and Sanitation	Temporary water needs	🔴	🔵	🔴
Cultural Resources	Revenue (cultural resources) Loss of revenue to religious/cultural organizations	🔴	🔵	🔴
	Recreation. Loss of recreation services (non-market values)	🔴	🔵	🔴
Local Government/Community	Revenue	🔴	🔴	🔴
	Loans and bonds	🔴	🔴	🔴
	GDP	🔴	🔴	🔴
Transportation	Cost for transporting freight	🔴	🔵	🔴
	Loss of tolls	🔴	🔴	🔴
	Cost for passengers	🔴	🔴	🔴
	Additional costs for crews	🔴	🔵	🔴

# Table 4 Flood losses and additional cost data availability (continued)

A blue light represents data available for this indicator and a red light represents data unavailable for this indicator

Losses & Additional Costs	Losses & Additional cost indicators	Data collection		
		Canada	Mexico	The United States
Energy & Utilities	Revenue	red	blue	red
	Rehabilitation/ reconstruction	red	blue	red
Public infrastructure	Cleaning	red	blue	blue
	Rescheduling public events' costs	red	blue	red
Agriculture	Market value of crop	red	blue	blue
	Income	red	blue	red
	Market value of livestock	red	blue	red
	Market value of poultry	red	blue	red
	Market value of private forest product	red	blue	red
Fisheries	Market value of fish	red	blue	red
	Market value of crustaceans	red	blue	red
	Income	red	blue	red
Tourism	Service flow	red	blue	red
Public Forest	Market value	red	blue	red
Emergency Response	Transporting the wounded or other emergency evacuations	red	blue	red
	Equipment	red	blue	red
	Temporary shelters	red	blue	red
	Search for people	red	blue	red

Common features in flood costs damages

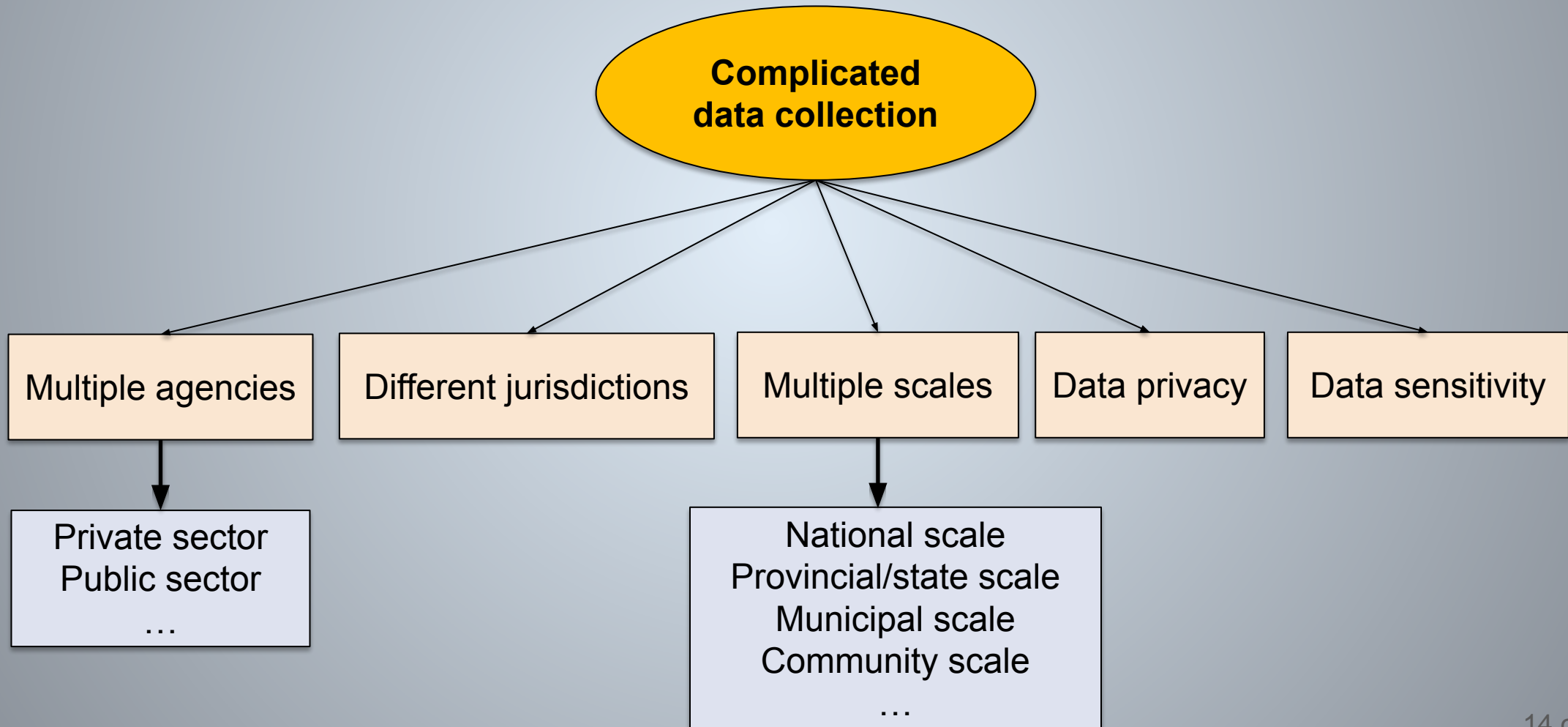o Flood cost data in Mexico are comprehensive, closely matching the CEC flood-costing methodology
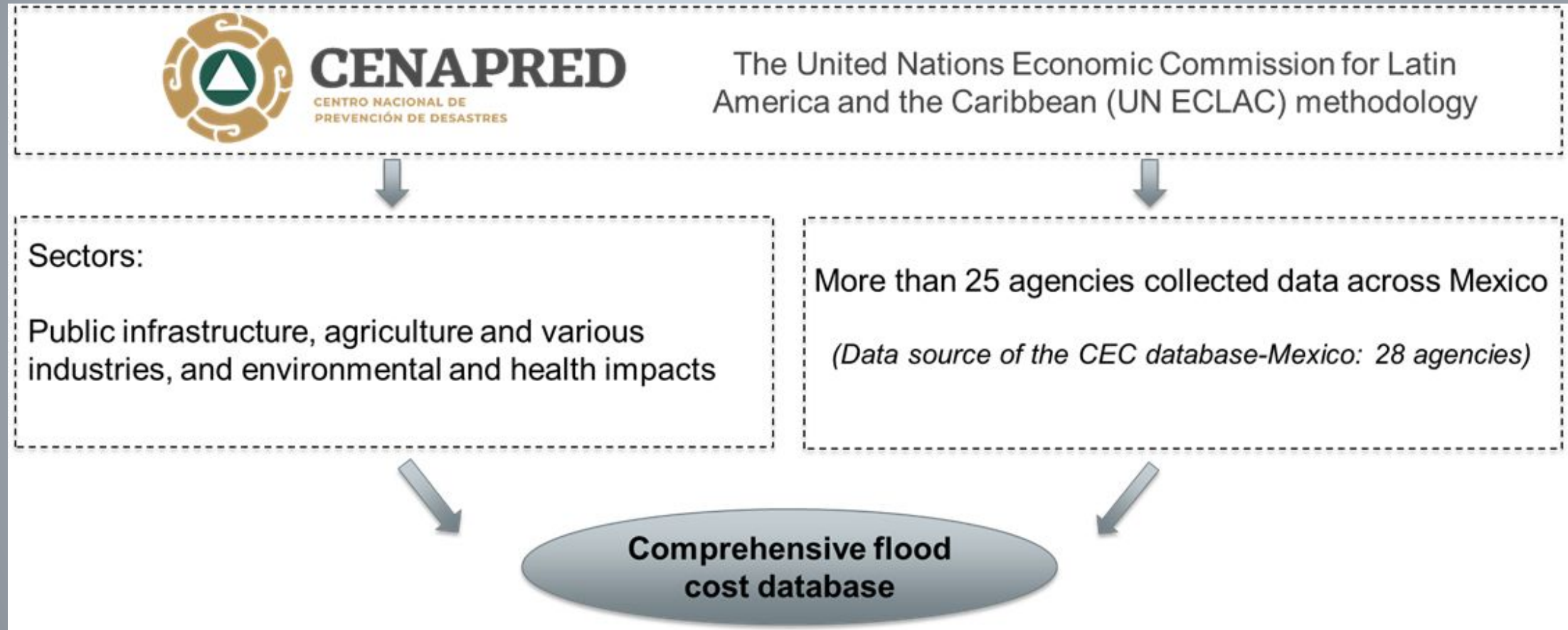
o More participation is needed from actors in **local** and **Indigenous communities (Canada and U.S.)**, to strengthen Mexico's assessment of studies.

Common features in flood costs damages

o Most of the records from Canada and the United States far from exhaustively populate the defined CEC flood cost categories.

Complicated data collection

Multiple agencies	Different jurisdictions	Multiple scales	Data privacy	Data sensitivity

Private sector
Public sector

…

National scale
Provincial/state scale
Municipal scale
Community scale

…

Common features in flood costs damages

o Flood cost data in Canada

<div style="background-color:orange">

The CEC- Canadian database:

Catastrophe Indices and Quantification Inc. (CatIQ) insured data

</div>

<div>

Other data source:

Canadian Disaster Database (CDD)
Provincial Disaster Assistance Program (PDAP)

</div>

→

CDD (2013 – 2017): open-access

o 22 flood events

o Only describe a total cost

o Data availability:12 out of the 22 events

PDAP (2013 – 2017): requested

o Saskatchewan PDAP

o New Brunswick PDAP

Common features in flood costs damages

o Multiple flood events recorded by different agencies for the same period

o Multiple data source for one flood event (Canada and U.S.)

Table 5 Comparison between CDD event estimate and CatIQ event estimate

No.	Flood events	CDD Estimated Total Cost	Federal DFAA Payments	Provincial Department Payments	Insurance Payments	CatIQ Estimated Total Cost
1	Windsor, ON, 2017	$173,000,000			$173,000,000	
2	Eastern Canada, 2017	$116,000,000			$116,000,000	$113,866,000
3	Nova Scotia, Prince Edward Island and Newfoundland, 2017	$30,350,000	$30,350,000			$104,179,000
4	Windsor and Tecumseh ON, 2016					$153,461,000
5	Fort McMurray AB, 2016	$462,528,000			$462,528,000	$422,368,000
6	Kenora ON, 2016					$14,910,000
7	Northeastern British Columbia, 2016	$65,132,000	$65,132,000			
8	Southern Manitoba, 2014	$1,164,679,000	$164,679,000		$1,000,000,000	$15,528,000
9	Southern Saskatchewan, 2014	$19,387,000	$19,387,000			$105,253,000
10	New Brunswick, 2014	$29,603,000	$13,603,000	$16,000,000		
11	Southern Quebec, 2014	$13,064,000	$13,064,000			
12	Toronto ON, 2013	$940,000,000			$940,000,000	$889,695,000
13	Southern Alberta, 2013	$2,715,742,000	$1,015,742,000		$1,700,000,000	$1,541,691,000
14	Cumberland House SK, 2013	$43,309,000	$43,309,000			
	Total cost (local cost)	$5,772,794,000				$3,360,951,000

Prairie Long Weekend Severe Storms, CatIQ, excluded data from SK and MB   Prairie & Northern Ontario Severe Storms, CatIQ, excluded data from SK and MB

Multiple data source for one flood event (Canada and U.S.)

Saskatchewan PDAP event estimate: 2014 Heavy Rain June

Claim Category	Actual Paid
1 Boards / Cooperatives	$239,781
2 Charitable Organization	$726,715
3 Displacement/ Temp Relocation	$538,820
4 First nations	$415,790
5 Municipal	$39,981,080
6 Other	$303,472
7 Primary Agricultural Enterprise	$3,756,861
8 Principal Residence	$18,808,681
9 Regional Park Authority	$1,449,567
10 Renter	$268,405
11 Small Business	$1,217,921
Total cost (local cost)	$67,707,092

Three types of cost data for 2014 Southern Saskatchewan:

CatIQ, CDD, and Saskatchewan PDAP

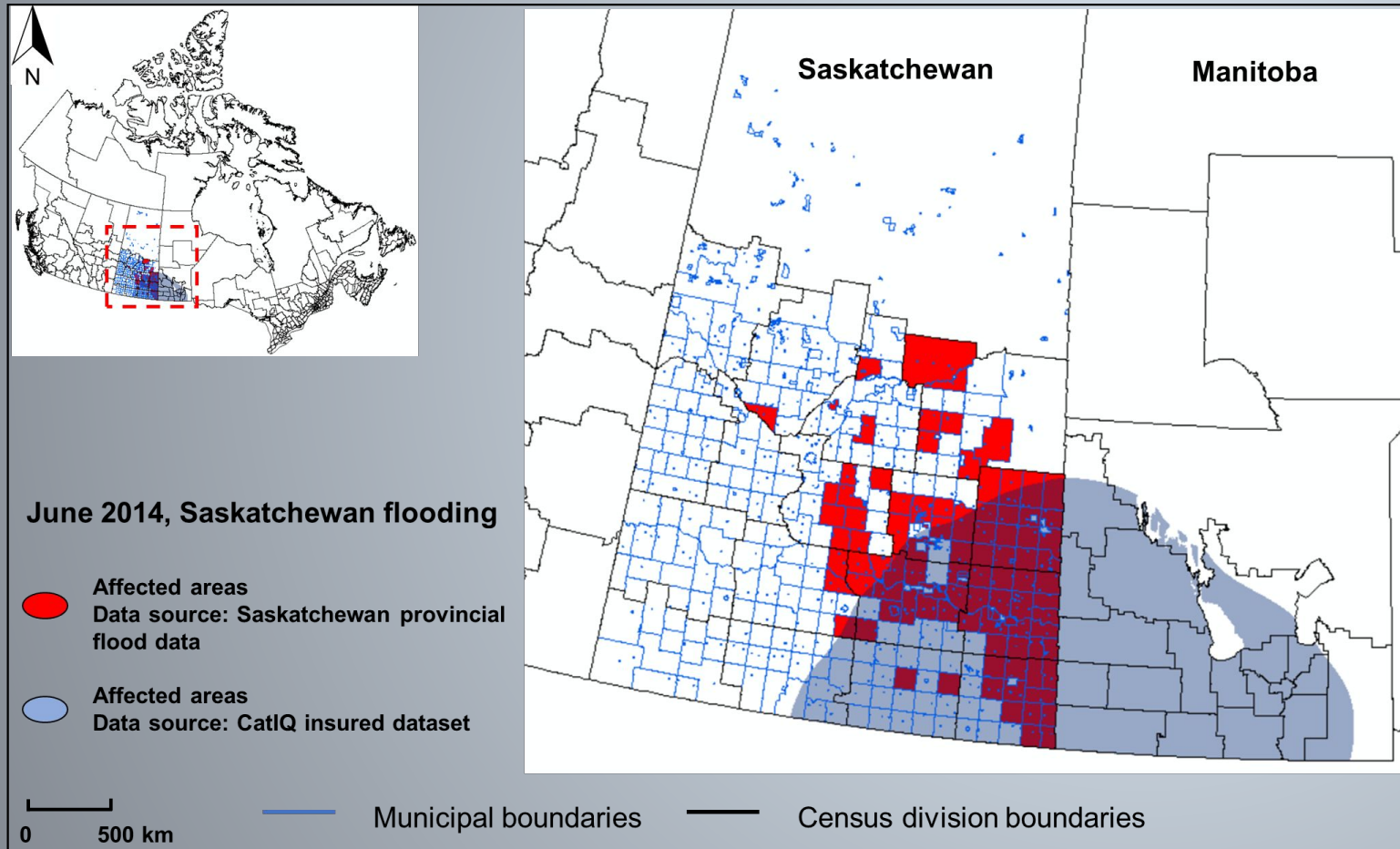U.S. multiple data source for one flood event: (for example)

2013 Colorado flooding, household item damage data offered by FEMA and Small Business Administration (SBA) (*Integrated*)

Common features in flood costs damages

o Geographic and spatial differences for the same flood event (Canada and U.S.)

June 2014, Saskatchewan flooding

Affected areas
Data source: Saskatchewan provincial flood data

Affected areas
Data source: CatIQ insured dataset

Municipal boundaries   Census division boundaries

2017 California flood event:

Affected counties provided by FEMA and NOAA are different

Figure 5. The example of geographic and spatial differences for the same flood event (June 2014 Saskatchewan flooding).

Common features in flood costs damages

Table 6 Comparison between **Saskatchewan PDAP** claim category and the **CEC flood-costing sector**

Saskatchewan Provincial Disaster Assistance Program (PDAP, SK) claim category for the 2014 Heavy Rain	PDAP, SK claim category possibly link to flood-costing indicator
Boards / Cooperatives	N/A
Charitable Organization	N/A
Displacement/ Temp Relocation	Temporary accommodation costs
Municipal	Local infrastructure and services
Primary Agricultural Enterprise	☐ Storage space ☐ Infrastructure used in farming ☐ Infrastructure used in livestock ☐ Infrastructure used in poultry ☐ Infrastructure used in private forestry activity
Principal Residence	Dwelling
Regional Park Authority	Tourism area
Renter	House rental
Small Business	☐ Building and facility ☐ Machinery and equipment ☐ Inventory of goods

Common features in flood costs damages

o Flood cost data in the United States

The CEC- U.S. database:

Federal government-generated open-access datasets

FEMA-based products, NOAA, SBA, and USDA

Other data source:

State, local, or tribal governments, non-governmental organizations, or private entity source

Common features in flood costs damages

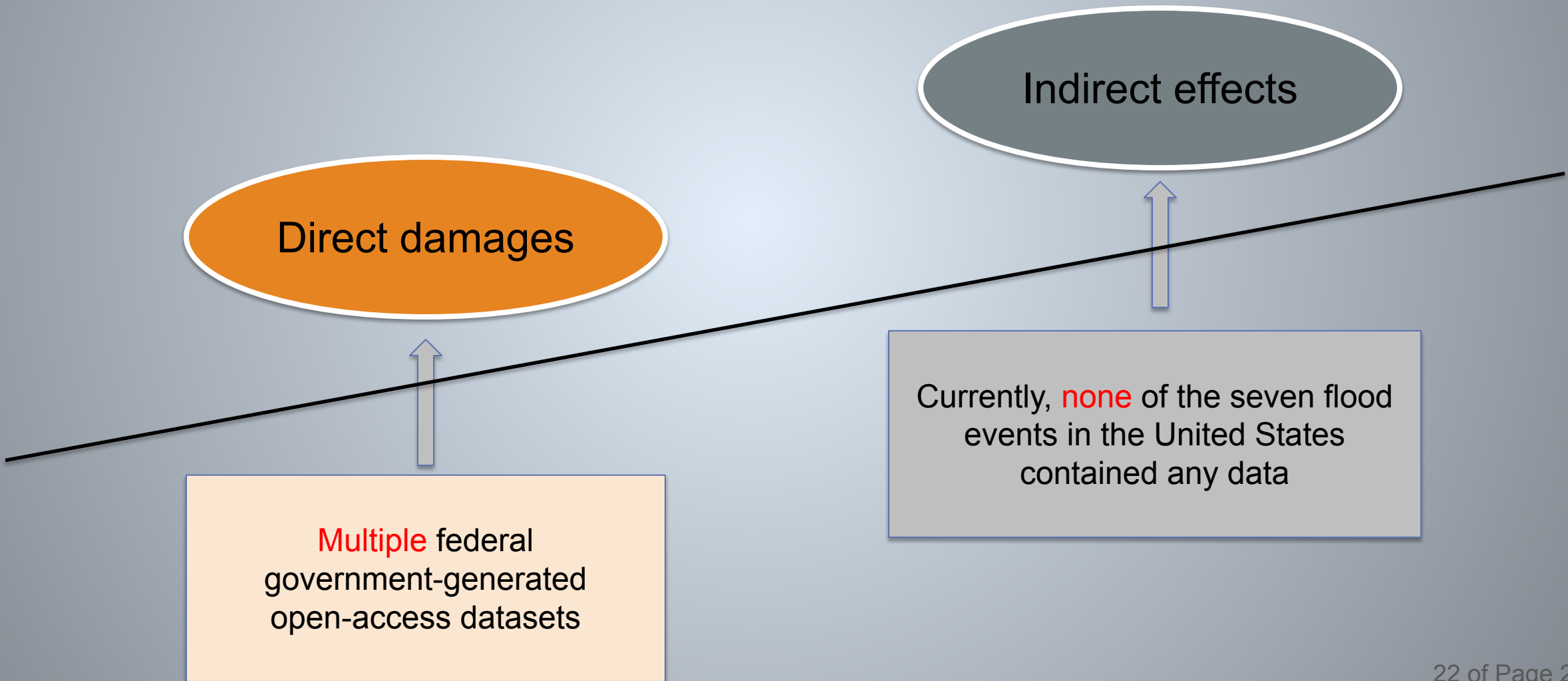o Flood cost estimates in the CEC-U.S. (and Canada) database are conservative due to unrecorded data

Table 7 Comparison between NOAA event estimate and CEC flood-costing project event estimate

U.S. Flood events (2013-2017)	NOAA event estimate (CPI-adjusted price, USD, 2020)	CEC flood-costing project event estimate (CPI-adjusted price, USD 2020)
2013, Colorado flooding, USA	$1.7 billion	$674 million
2014, Michigan and Northeast flooding	$1.1 billion	$188 million
2015, South Carolina and east coast flooding	$2.2 billion	$518 million
2016, Texas and Louisiana flooding	$2.5 billion	$662 million
2016, Houston flooding	$2.9 billion	$667 million
2016, Louisiana flooding	$11 billion	$5.18 billion
2017, California flooding	$1.6 billion	$210 million

Data sources: NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather & Climate Disasters 1980-2020 (2020). Retrieved from https://www.ncdc.noaa.gov/billions/.

Common features in flood costs damages

o Flood economic damage data are unevenly collected by categories/sectors (U.S. and Mexico)

Indirect effects

Direct damages

Multiple federal government-generated open-access datasets

Currently, none of the seven flood events in the United States contained any data

Common features in flood costs damages

Flood damages and costs:

1. Significant economic damages and losses

2. Metropolitan areas: worst-hit region

Flood data availability and accessibility:

1. By country: Mexico > the United States > Canada

2. By category: direct damages > additional losses > indirect effects

3. Data accessibility: : Mexico and the United States > Canada

4. Data at the municipal / county level accessibility: Mexico and the United States > Canada

5. Most comprehensive of data available sector/indicator: house sector and commercial building indicator

Common challenges

Re-cap

- Spatial and temporal scale mismatch

- Incomplete data
  - E.g., missing indicators

- Ensure no double counting

- Lack of attribution to particular flood event

- Difficulty in disentangling flood losses from other disaster losses
  - E.g., Loss from hurricane wind or rain?

Conclusions

1. Flooding causes significant damages and losses across Canada, Mexico, and the United States.

2. Economic cost data for flooding in Mexico are comprehensive, closely matching the CEC flood-costing methodology developed under this project.

3. Top-down: Mexico, a single agency devoted to disasters data collection, centralized and comprehensive data.
    Bottom-up: Canada and U.S., multiple agencies, jurisdictions, and scales, complicated.

4. Flood economic damage data are unevenly collected by sectors/categories.

5. Data from Indigenous communities are missing for many events.

CEC Flood Costing Project

Third Virtual Expert Workshop

Thank you for your attention