Developing a Comprehensive Methodology for Evaluating Economic Impacts of Floods in Canada, Mexico and the United States

Extended abstract

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1 Introduction

Flooding, including in-land and coastal flooding, is one of the most devastating and costly natural hazards in North America (Peterson et al., 2013; Fernández et al., 2018; Bakkensen and Blair, 2020). Because of increased population and more exposed assets in hazard-prone areas, more devastating and costly floods are expected in the future. Changes in climate patterns are likely to exacerbate this trend, bringing heavier rainfall events, sea-level rise, increased flooding from more intense hurricanes, and coastal erosion (IPCC, 2012; Seneviratne et al., 2012; Hodgkins et al., 2017).

Importantly, flood events across the international borders between Canada, Mexico, and the United States have led to significant economic impacts and loss of human life in recent years (Sturdivant et al., 2004). For example, the 1997, 2009 and 2011 Red River floods cumulatively resulted in billions of dollars of damage in Manitoba (Canada) and North Dakota and Minnesota (the United States). Similarly, in the Rio Grande/ Rio Bravo watershed, communities along the United States-Mexico border continue to face serious flood events (Pinson et al., 2014).

Overall, to improve disaster prevention, emergency responses, and recovery strategies, it is necessary to better understand the consequences of floods on local and regional economies, and to develop methodologies to estimate the comprehensive cost of such disasters (Allaire, 2018). At present, the methods by which costs of flood damages are estimated vary significantly among federal and state or provincial jurisdictions across Canada, Mexico and the United States, resulting in widely different quantification of these costs (CENAPRED, 2001; Downton and Pielke, 2005; Smith and Katz, 2013; McGrath, 2015; Davies, 2016; Congressional Budget Office, 2019; Bakkensen and Blair, 2020).

Given the interconnectivity of extreme weather events in Canada, Mexico and the United States, particularly in terms of the flooding history, a harmonized trinational approach for evaluating economic impacts can play an important role in enhancing resilience in at-risk communities and allocation of resources for monitoring. A mutually agreed-upon, comprehensive and comparable methodology, when applied across the three countries, would enable systematic investments by the governmental agencies to enhance resilience to extreme floods, reduce the economic impact of future events, and support real-time monitoring and disaster response. A common cost-assessment methodology would also enable regional collaboration in applied and targeted research on future impacts of extreme events, operations for mitigating impacts of extreme events, analysis of social disparities in flood costs and relief efforts and coordinated policy-making among the three countries. It also would allow tracking of costs, over time and space, for analysis of trends and research on interconnections among events.

The Commission for Environmental Cooperation (CEC) recognized information gaps in estimating economic impacts of floods and initiated in 2019 a collaborative research project. This project, entitled "Costing Floods and Other Extreme Events", has brought together governmental agencies, academic institutions, and stakeholders from the private sector and communities. The work presented in this paper is based on expert dialogue between the project's collaborators; the results of which were published in the International Journal of Disaster Risk Reduction journal in November 2020 (https://www.sciencedirect.com/science/article/pii/S2212420920313637).

2 Cost assessment methods

Assessing the economic impact of floods is a complex process that requires uniform guidelines for collecting, evaluating and reporting pertinent information. The costs of direct impacts are generally easier to quantify than indirect costs. Indirect impacts, termed losses in the context of this paper, may last for months and even years after a flood event (Merz et al., 2010). Overall, considerable variability exists in these assessment methods on at various geographic scales—from household to county/municipality to state/provincial to national—across the three countries. We present here a brief summary of the methods commonly used by each country.

2.1 Methods used in Canada

In Canada, Public Safety Canada administers the Disaster Financial Assistance Arrangements (DFAA), whose regional offices assist with damage assessments, interpretation of guidelines, and surveillance of private damage claims (Public Safety Canada, 2008). There are three key flood-costing methods used in Canada that have been accepted by government, industry, and academics to varying degrees: DFAA-calculated flood-related costs, Hazus, and Computable General Equilibrium (CGE) models. The findings from these flood-costing methodologies are presented through output-generated models, simulations, graphs, and tabular presentation of data. The quality, composition, and accuracy of these outputs are broadly dependent on the input data quality (Davies, 2016).

2.2 Methods used in Mexico

In Mexico, the *Centro Nacional de Prevención de Desastres* (Cenapred) collects information from the public and private sectors and estimates the cost of damages from natural and human-induced hazards, including flood and droughts (Cenapred, 2001). Since 1999, Cenapred has conducted activities aimed at assessing the impact of disasters on the economy and society of the affected regions, as well as their impact on the national economy. The evaluations are presented in an annual book series, called "Socio-economic Impact of Disasters in Mexico," with 20 volumes (Cenapred, 2001). The Cenapred reports encapsulate the reference database for the social and economic impacts of disasters in Mexico, including floods, based on a methodology endorsed by the United Nations Economic Commission for Latin America and the Caribbean (UN ECLAC) (ECLAC, 2004). The practical application of the UN ECLAC methodology has been tested in different Latin American and Caribbean countries, demonstrating its robustness (Bitrán et al., 2005).

2.3 Methods used in the United States

In the United States, government agencies are assigned to collect information on the economic impacts of extreme events at national and subnational levels – —for example, physical damage to residential, commercial, and public buildings; loss of time and productivity; damage to vehicles, offshore energy platforms, and public infrastructure; agricultural assets (crops, livestock, and timber); and disaster restoration and wildfire suppression costs (FEMA, 1997). The majority of recorded damages and/or losses in the United States as a result of flooding are submitted as claims and assessed by individual assessors for insured property, primarily through the National Flood Insurance Program (NFIP), a public program (King, 2011). This method is highly precise but not comprehensive, as a result of low subscription to flood insurance provided by the program and also low coverage limits (e.g., $250,000 in the NFIP). A variety of models are also used in the United States to assess flood damages and losses. Quantitative modeling of flood risk is a core component of an effective flood risk management framework for governments and insurance (Verisk, 2019). Programs and policies at the federal level play an important role in determining the magnitude of flood

losses; these include the Congressional appropriations to FEMA through the Disaster Relief Fund (DRF), FEMA's public assistance (PA) grant program, and Small Business Administration's (SBA) Disaster Loan Program.

3 Discussion

3.1 Common Features in Economic Evaluation Approaches

There are a number of similarities in the flood-costing methodologies between and among the three countries. Common between Canada and the United States is the use of Hazus and its flood model as a method that estimates potential losses from flooding. Parallels can also be drawn between the use of federal budgetary outlays in the United States and the methodology used by the Parliamentary Budget Office (PBO) for Canada. Both approaches function as economic evaluations undertaken by national government agencies to estimate costs of disaster financial assistance. Further, model-based methods that quantify flood risks and impacts are applied similarly in Canada and the United States. The involvement of the insurance industry as holders and users of flood loss data is also a common feature between Canada and the United States.

3.2 Divergence in Economic Evaluation Methods

The methodologies used in Canada and the United States have a limited scope, in terms of the sectors included, but are also negatively affected by the availability and accessibility of the data. This situation differs somewhat in the case of Mexico, where data collection is carried out by government agencies. The centralized use of the UN ECLAC method in Mexico has been effective for disaster assessment. As a unique, holistic, comprehensive, robust and flexible flood-costing approach, the ECLAC method is unlike any of the approaches of the United States and Canada. Another key difference in the economic evaluation approaches of flooding among the three countries is the presence of the private insurance sector. Compared to Mexico, the United States and Canada have significantly higher rates of insurance uptake. As a result, it is postulated that there is greater use and importance of private insurance quantitative risk and probabilistic catastrophe models in the United States and Canada.

3.3 Data Availability, Access and Gaps

A key factor in the success or failure of any methodology is the availability of, quality of, and access to data and metadata (such as location/coordinates, areal extent, and time period of the data) needed to undertake an economic assessment. Here are some insights from our analysis: First, the methodologies used in Canada and the United States contain a limited number of sectors, and a lack of data availability and accessibility limits easy implementation. Second, the overlap with the insurance sector means many Canada and United States data are held in proprietary databases and may not be available to the public. Third, the level of data availability becomes more restrictive for all methodologies, as the application is narrowed to small geographic scales. Research shows that there is no national standard for natural disaster damage data collection in the USA (NWS, 2015; Bakkensen et al., 2017) and that there is no single agency tasked with that effort. In addition, flood loss data are commonly thought to be incomplete and conservative, since flood events that do not result in multiple fatalities, high property loss, or media attention, often go unreported, or are, in some cases, inflated through double counting. Mexico's application of the ECLAC method is accompanied by ease of data access; there is also greater confidence in the methodology, because it has been applied in other Latin American countries.

4 Framework for a Shared and Comprehensive Methodology

Based on expert opinion, from the first workshop convened through Costing Floods and Other Extreme Events, the ECLAC method used in Mexico offered the most comprehensive starting point for developing a common methodology. This method was further enhanced to cover key aspects, such as considering incremental emergency services as part of losses; these modifications are divided into two broad groups: impact delineation and sectoral categories.

First, it was agreed to delineate three types of economic impacts, compared to the two used in the ECLAC method (ECLAC, 2004): Direct Damages, Indirect Effects, and Losses & Additional Costs. This approach would make the usage consistent with that employed in the insurance sector. The new category of Indirect Effects is defined as: second-order effects due to flooding on product, labour and housing markets. These effects only affect societal welfare if a flood results in a change in market imperfections, e.g., when a housing market in a neighbouring region of the inundated area evacuates because of a flood (Jonkhoff, 2009). The value of indirect effects is often derived by applying some pre-determined coefficients to direct damages.

Second, a number of sectoral categories included in the ECLAC method were further modified to provide comprehensive inclusion of flood impacts, particularly the social, infrastructure, and transportation sectors. The changes were also in line with the exclusive focus on economic and monetary impacts adopted by the CEC project.

5 Key Findings

The assessment of existing literature and the expert dialogue in the first workshop points to a number of challenges related to data availability, access, quality, and spatial coverage. It is foreseeable that a range of methods may need to be invoked, at least initially, to fill the data gaps encountered while populating the CEC database. Ensuring comparable quality of data from different sources could be challenging as well. In the long run, it can be envisioned that monitoring and data collection in the three countries can be modified such that those data become readily available and reliance on mathematical models is minimized or eliminated.

6 Recommendations and Future Research

Although there are clear benefits to establishing a shared methodology deployed across the three countries, challenges to its implementation remain. Political leadership, high-level officials from all levels of government, and multiple agencies must agree to gathering data and metadata accurately and then to creating a framework or information warehouse to share those data in a timely fashion.

Vigorous policy debates, based on findings from our proposed methodology, can help draw a contrast between benefits of community-level resilience-building through investments in infrastructure and better preparedness approaches, and the total costs a community accrues due to flooding. Such debates around trade-offs between short-term gains and long-term protection can help set priorities at community- and national-levels.

The notion of what constitutes an "extreme flood" was discussed at the First CEC Expert Workshop, but a clear consensus did not emerge. Developing a definition for extreme flooding, including identification of hydrological, societal and economic thresholds, will require further research and examination of published literature as well as detailed dialogue with government agencies.

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