

1 **Implications of disclosure and non-disclosure of flood hazard maps – a**
2 **synthesis for the Canadian context**

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13 **Implications of disclosure and non-disclosure of flood hazard maps – a** 14 **synthesis for the Canadian context**

15 **Abstract:** Flood is an increasingly costly and impactful hazard in Canada. Risk
16 management approaches need to be applied to stem rising costs and impacts of
17 floods. The foundational tool that supports many risk management strategies is
18 the development of flood mapping products. In Canada, however, there is only a
19 patchwork of flood mapping available, and there is further variability in the
20 accessibility of this information to private and public sectors. This article draws
21 on published studies to synthesize the potential benefits and disbenefits of
22 making flood maps more available and accessible in the Canadian context, with a
23 focus on real-estate transactions, but also with consideration of implications to
24 land use planning, flood insurance uptake, and social equity impacts. The review
25 highlights that accessibility and regulated disclosure of flood maps reduce
26 property values marginally, but not to the full discount that should be applied if
27 flood risks were fully accounted for or realized. There are also substantial
28 benefits of making flood mapping products more accessible, including greater
29 social equity, by removing the challenge of data asymmetry (where some buyers
30 and sellers have better information than others), better emergency preparedness,
31 and increased insurance uptake to manage residual risks.

32 **Résumé:** Les inondations sont un aléa de plus en plus coûteux avec de gros
33 impacts au Canada. Des approches de gestion des risques doivent être appliquées
34 pour contenir la hausse des coûts et les impacts des inondations. L’outil
35 fondamental qui soutient de nombreuses stratégies de gestion des risques est le
36 développement de produits cartographiques des inondations. Au Canada,
37 cependant, il n’y a qu’une mosaïque de ces cartes disponibles. En plus, il existe
38 une grande variabilité dans l’accessibilité de ces informations aux secteurs privé
39 et public. Cet article s’appuie sur des études publiées pour synthétiser les
40 avantages et les inconvénients potentiels d’une plus grande disponibilité et d’un
41 meilleur accès aux cartes des inondations dans le contexte canadien, en analysant
42 les transactions immobilières en particulier, mais également en tenant compte des
43 implications sur l’aménagement du territoire, l’adhésion à l’assurance contre les
44 inondations, et les impacts sur l’équité sociale. Notre étude souligne que
45 l’accessibilité et la divulgation réglementée des cartes d’inondation réduisent
46 légèrement la valeur des propriétés, mais pas dans la totalité de la réduction qui

47 devrait être appliquée si les risques d'inondation étaient pleinement pris en
48 compte ou réalisés. Il y a également des avantages importants lorsque les produits
49 de cartographie des inondations sont plus accessibles, notamment une plus
50 grande équité sociale, la réduction du défi de l'asymétrie des données (où certains
51 acheteurs et vendeurs disposent de meilleures informations que d'autres), une
52 meilleure préparation aux situations d'urgence et une hausse de souscription
53 d'assurances pour gérer les risques résiduels.

54 **Key Policy Highlights:**

- 55 • Making flood maps publicly available and accessible has many benefits..
- 56 • Public awareness campaigns need to accompany flood map disclosure; maps
57 should be easy to understand and up-to-date.
- 58 • While properties within a floodplain may experience a 'flood zone discount',
59 this is less than it should be when considering real risks and associated costs.
60 Actual flood events typically reduce property values more than map disclosure.
- 61 • Flood map disclosure contributes to fairness, and supports land use planning,
62 individual building controls, and flood insurance uptake.
- 63 • Disclosure should be viewed through an equity-lens, and additional research to
64 determine appropriate accompanying policy instruments is needed.

65 **Keywords:** Flood map disclosure, property values, flood insurance, information
66 asymmetry, flood risk mitigation

67 **Introduction**

68 Flood is Canada's most frequent and costly hazard, regularly causing over \$1 billion in
69 direct damage to households, property, and infrastructure, and affecting thousands of
70 Canadians annually (Ziolecki et al. 2020). With climate change, flooding will pose an
71 increasing risk to Canada's economic vitality, infrastructure, environment, and people
72 (Bush and Lemmen 2019). To implement flood mitigation strategies and reduce flood

73 risk, the first step is to identify flood hazard areas.

74 Flood maps provide a common basis for the definition of flood hazard areas, and
75 can inform policy discussions surrounding flood risk mitigation (Bruce 1976; Priest et
76 al. 2016; Elshorbagy et al. 2017). Further, public access to flood mapping is beneficial
77 for public education, increases flood risk awareness and encourages public demand for
78 flood insurance (Sandink et al. 2010), as well as provides transparency and legitimacy
79 of policy discussions surrounding flood risk (Priest et al. 2016). Flood maps are also
80 good companion resources for risk reduction and resiliency activities such as flood
81 forecasting, flood warning, and flood response activities (Ebbwater Consulting Inc. and
82 Pinna Sustainability 2021). There is also recognition that flood-related information is a
83 “public good”, that would accrue benefits to individuals and to society (National
84 Research Council 2009).

85 However, flood modelling and mapping results that place residents and
86 properties within a flood zone are often received negatively or even with open hostility
87 (e.g., Chen 2018), even though the process of flood modelling, mapping, and disclosure
88 does not change an area’s flood hazard or risk. But it does bring up real concerns related
89 to property value, insurance accessibility, and affordability. In particular the concern of
90 flood map disclosure on property values has been raised by many jurisdictions, and is
91 investigated in various studies, particularly for the United States (US) but also for other
92 countries (e.g., Shr and Zipp 2019; Rajapaksa et al. 2016; Meldrum 2016; Filippova et
93 al. 2019; Beltrán, Maddison, and Elliott 2019, 2018; Belanger and Bourdeau-Brien
94 2018; Zhang 2016; Bélanger, Bourdeau-Brien, and Dumestre 2018; Troy and Romm
95 2004), showing that typically, location within a flood zone reduces property values
96 marginally. Studies have also discussed a range of other challenges and benefits
97 associated with flood map disclosure, such as encouraging homeowners to make their

98 homes more flood-resilient (e.g., Kreibich et al. 2005), increasing flood emergency
99 preparedness (e.g., Atreya et al. 2017), increasing uptake of residential flood insurance
100 (IBC, 2019), and have highlighted the social impacts of non-disclosure of flood maps
101 and consequential information asymmetry (e.g., Troy and Romm 2004).

102 While there are many studies that investigate different implications of flood map
103 disclosure and non-disclosure as separate issues, there are limited studies that provide a
104 synthesized overview of these multiple benefits and challenges to guide and inform
105 decision-makers with respect to making flood maps publicly available. Further, most
106 available studies are focused on the US, the United Kingdom (UK) or Europe, while
107 there is limited reference to the Canadian context.

108 The accessibility of flood maps in Canada has undergone several phases
109 throughout the last 50 years. Between 1975 and 1995, Canada had a federally-led
110 program to manage flood hazard mapping (the Flood Damage Reduction Program,
111 FDRP), which intended to coordinate federal and provincial strategies by “defining
112 flood-risk areas, by discouraging continuing investments in those areas, and by
113 following up with appropriate measures to limit damage to existing development”
114 (Bruce 1976). All Provinces and Territories except Prince Edward Island and Yukon
115 Territory took part in the FDRP, and during this period, many of the flood maps
116 available today were developed, and in most cases, made publicly accessible. Since the
117 sunsetting of the FDRP program, flood mapping was devolved to provincial
118 governments, and in some jurisdictions, it was further delegated to regional and
119 municipal governments, who are often strained for resources (Lyle and McLean 2008).
120 Flood maps in Canada can be generated at different levels of detail (tiers), ranging from
121 detailed hydraulically and hydrographically modelled maps for local-scale studies and

122 planning purposes, to regional or national-scale studies targeted at prioritization,
123 insurance, or emergency response (Province of BC 2022).

124 Currently, there is no coherent national approach for flood mapping in Canada,
125 as Provinces and Territories lead the creation of their own mapping programs, resulting
126 in a patchwork of flood mapping, with uneven mapping coverage, differing technical
127 methods, and various approaches to communicating and sharing the hazard information
128 (Ebbwater Consulting Inc. and Minerva Intelligence Inc. 2020). Therefore, accessibility
129 of flood maps to the public and private sectors is inconsistent across the country and is
130 dependent on the approach of the local authority. This ranges from full public access in
131 Alberta and Quebec (both to legacy (FDRP) and modern flood maps), to public access
132 to legacy maps and limited (but increasing) public access to modern maps in British
133 Columbia, to effectively no public access in Nova Scotia and the Northwest Territories
134 (Ebbwater Consulting Inc. and Minerva Intelligence Inc. 2020; British Columbia
135 Emergency Management and Climate Readiness 2023). Even in jurisdictions where
136 flood mapping is publicly available, it is not part of legislated or regulated policy to
137 require disclosure of flood information (Ebbwater Consulting Inc. and Minerva
138 Intelligence Inc. 2020). An advisory report by IBC (2019) re-iterated that many
139 Canadian communities and residents do not have access to the needed information in
140 the form of up-to-date flood data and flood maps to assess and mitigate their risk.

141 Given concerns around climate change, growing development pressures in
142 floodplains, as well as many recent catastrophic flood events (such as the major
143 November 2021 regional flood event in British Columbia; Gillett et al. 2022), provincial
144 and federal governments are increasingly investing in flood hazard mapping programs
145 (Public Safety Canada 2021; Natural Resources Canada 2022). Along with this, however,
146 comes the questions and concerns of many jurisdictions on potential consequences of

147 flood map disclosure to the public. For example, in 2016, the City of Edmonton initially
148 withheld new flood maps citing the potential impact of their disclosure to property
149 values (Stolte 2016). Further, the insurance landscape is changing (e.g., Public Safety
150 Canada, 2022), along with other governance shifts, these will be also affected by the
151 disclosure or non-disclosure of flood maps. For these reasons, there is interest from
152 local, regional, and federal stakeholders to learn from the international experience of
153 flood map disclosure, and on how this can be translated to the Canadian context.

154 Therefore, the overall objective of this study was to synthesize the implications
155 of (non-)disclosure of riverine, lake, and coastal flood maps discussed in the literature,
156 with focus on land use decisions, real estate values, consumer behaviour (e.g., purchase
157 of flood insurance, consideration of personal investment in property-level flood
158 protection measures), and societal impacts, and set these within the Canadian context.
159 Specifically, we asked the following research questions:

- 160 (1) What are the benefits and challenges of flood map disclosure?
- 161 (2) And in contrast, what are the potential consequences of non-disclosure of flood
162 maps?
- 163 (3) Lastly, what does this mean for flood map disclosure in Canada?

164 **Methods**

165 The following sections detail our methodological approach towards the literature search
166 and review, discuss limitations, and lastly, list terminology used throughout the
167 manuscript.

168 *Literature Search and Review*

169 We conducted a review of both peer-review academic literature as well as grey

170 literature reports (e.g., governmental reports), with the goal to draw out key themes to
 171 address our research questions. Specifically, we followed the method described in
 172 Table 1. We conducted a Google scholar search first in August 2021, and conducted a
 173 follow-up search in March/April 2023 to include any recent articles for the key word
 174 combinations provided in Table 2 (note that number of results refers to the 2023
 175 search). Where applicable, only the first 30 pages (about first ~300 entries) were
 176 searched, as afterwards, non-relevant studies became dominant. We manually scanned
 177 titles, considering our inclusion/exclusion criteria (Table 1).

178

179 **Table 1: Overview of the literature search process, with inclusion and exclusion criteria.**

Step	Process	Inclusion Criteria	Exclusion Criteria
1	Search Google scholar for key word combinations (see Table 2)	Key words included. All time periods. Within the first 30 pages (~300 entries).	
2	Manual Scan 1 - Title	Peer-reviewed articles; Seems to include discussion of consequences of making flood maps available.	University theses; website links and other reports; focus on flood hazard modelling/mapping methods only.
3	Manual Scan 2 – Abstract	Includes discussion of making flood maps available; Study area focus primarily on Canadian context and countries with similar social, economic, and political environments to Canada (specifically, the US, Australia, the UK, and western Europe); however, other studies are also included where they provide additional information.	No discussion of making flood maps publicly available; focus on insurance program solely.
4	Download to database	Study relevant to research questions, or provides other, supporting information.	Study does not address making flood maps available (disclosure).
5	Manual Read 3 – Full text	Study relevant to research questions, or provides other, supporting information.	Study does not address making flood maps available (disclosure).
6	Include in article	Study relevant to research questions, or provides other, supporting information.	Study does not address making flood maps available (disclosure).
7	Further targeted search and download for relevant cited references	Study relevant to research questions; Additional aspects that have not yet been captured by previously included studies. Grey literature (governmental, institutional, and consultant reporting) included, where relevant.	

180

181 **Table 2: Numbers of Google scholar search returns for listed key word combinations. Note that the same study**
 182 **may appear under different key word combinations, and thus be double-counted in the total sums.**

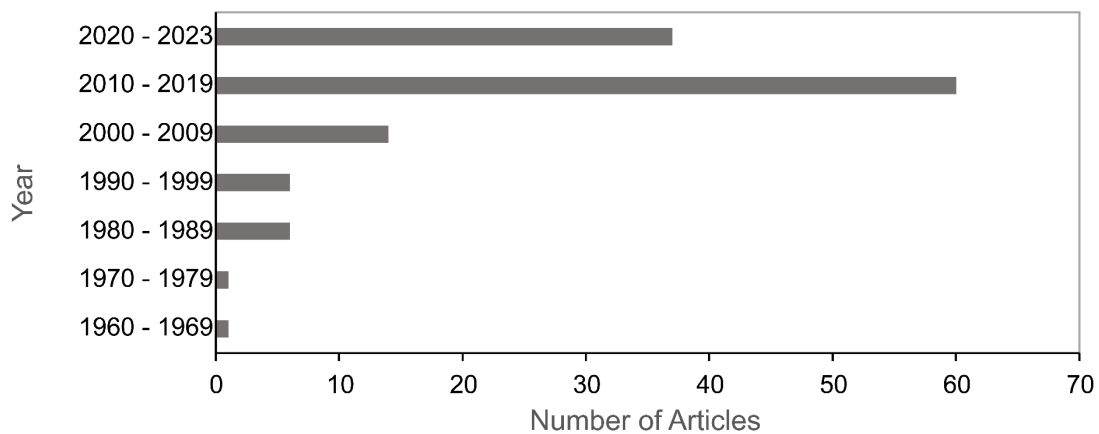
Key word combinations	Google scholar search returns (March/April 2023)	Literature search step 2 (Table 1) completed for the following numbers of search returns
"flood map" AND "real estate"	968	~300
"flood map" AND "property value"	408	~300
"flood map" AND "risk reduction"	1,970	~300
"flood map" AND "insurance"	3,240	~300
"flood map" AND "land use"	4,910	~300
"flood map" AND "social impact"	169	169
"flood map" AND "social equity"	121	121
"flood map" AND "social inequality"	59	59
"flood map" AND "information asymmetry"	39	39
Total	11,884	~1,888

183

184 During this process, we assessed approximately 1,890 search returns (Table 2). For
 185 studies with a relevant title, we read the abstract, and subsequently downloaded all
 186 studies according to our inclusion / exclusion criteria (see Table 1) into the database.
 187 Next, we read the full study to assess for relevance to our research questions, and if
 188 relevant, the study was included in this article. Note that many relevant studies appeared
 189 in several of the search categories, adding robustness to our methods (i.e., most relevant
 190 studies should have been captured). Many of the search results were not directly
 191 applicable to our specific research questions on the consequences of making flood maps
 192 available and flood map disclosure. For instance, many search returns focused on the
 193 technical methods of flood hazard modelling and mapping, flood risk assessments, or
 194 insurance program implementations. These studies were not included in the database.
 195 This literature search was followed by a targeted search of relevant studies and grey
 196 literature (governmental, institutional, and consulting reporting), that was referenced in
 197 database articles, and provided additional, critical information not yet captured in the
 198 previously included studies. Overall, the literature search was focused on the Canadian
 199 context, as well as countries with similar social, economic, and political environments
 200 to Canada (specifically, the US, Australia, the UK, and western Europe). Two case

201 studies from Mexico and Japan were also included for illustrative purposes, as they
202 provided case study experience on the importance of flood maps to increasing flood
203 emergency preparedness of local residents.

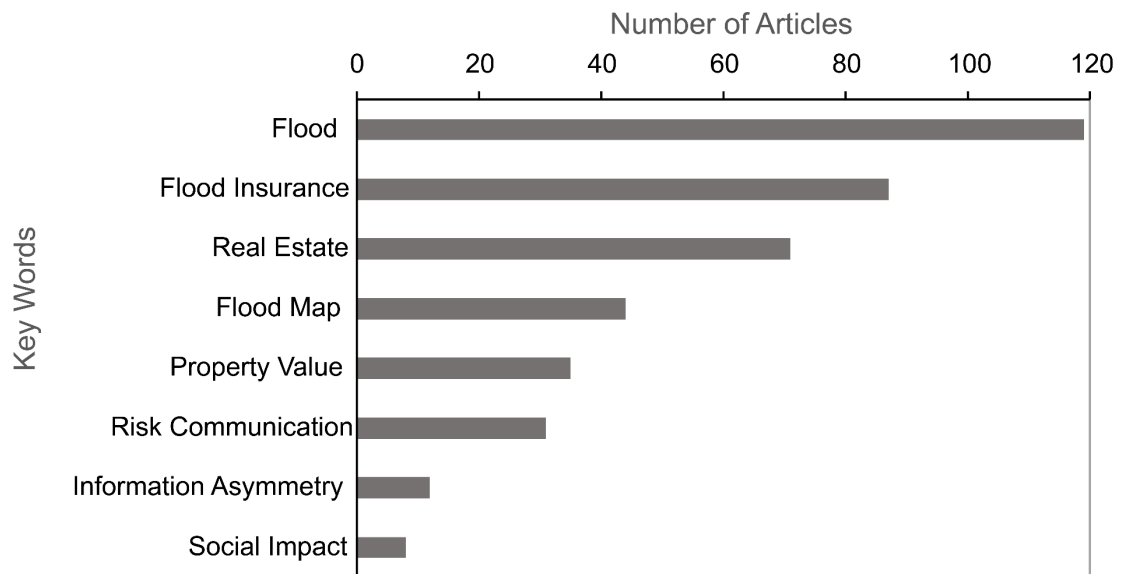
204 Overall, a total of $N = 125$ studies were downloaded into the database (in steps 4 and 7)
205 and assessed in more detail, of which the most relevant studies were included into this
206 article. Publication range of the studies started as early as the 1960s, however with a
207 clear upward trend after 2010 (Figure 1). Figure 2 provides an overview of the assessed
208 studies ($N = 125$), with respect to numbers of studies per key word. Key words
209 primarily related to flood, flood insurance, and real estate, but also to societal aspects
210 such as information asymmetry and social impact.



211

212 **Figure 1: Number of articles (from downloaded and assessed database) published per decade.**

213



214

215 **Figure 2: Key words for studies from downloaded and assessed database.**

216

217 ***Limitations***

218 It is important to note that, while an extensive literature search was conducted, the
 219 search might not have captured all relevant studies, and is not to be considered an
 220 exhaustive search and overview of all existing studies on the topic. Rather, the goal was
 221 to draw out key themes, and discuss them within the context of the research questions
 222 and their relevance for Canada. Further, the search concentrated on specific countries,
 223 as noted above, and did not include studies from across the world. We also note that we
 224 did not conduct any legal research or review for cases related to non-disclosure of flood
 225 or hazard information.

226 Further, the focus in this article is on flood maps generally, recognizing that accuracy in
 227 depicting flood hazard areas for specific likelihood varies widely between flood hazard
 228 maps, depending on their methodology, scale, and the availability of underlying data.
 229 Each flood map comes with many uncertainties, especially with climate change adding
 230 a further layer of uncertainty. Discussing the uncertainties associated with flood

231 mapping in more detail, along with potential trust issues that these mapping
 232 uncertainties can create, was however not the focus of this article.

233 Lastly, this manuscript is focusing specifically on riverine clearwater flooding, lake
 234 flooding, and coastal flooding, and does not explicitly address all other types of
 235 flooding.

236 ***Terminology***

237 For clarity, we list the terminology used to describe and distinguish flood modelling and
 238 mapping products, methods of disclosure, and risk in Table 3.

239 **Table 3: Terminology descriptions.**

240

Term	Description
<i>Flood Mapping & Modelling</i>	
Flooding	The “temporary inundation by water of normally dry land” (NRCan 2018; page 4). This manuscript focuses on riverine clearwater flooding, lake flooding, and coastal flooding.
Coastal flooding	“Occurs when water levels in coastal areas are higher than normal because of high tides and/or storm residuals (storm surge, wind, and waves)” (Province of BC, 2022; page 12).
Lake flooding	“Occurs when water levels in lakes are higher than normal as a result of higher-than-normal inflows and/or downstream blockages or controls. Lake flooding can be compounded by wind and waves” (Province of BC, 2022; page 12).
Creek and river clearwater flooding (riverine flooding)	“Clearwater flooding occurs when high volumes of water coming from precipitation or snowmelt exceed the capacity of rivers or creeks and flows onto adjacent lands” (Province of BC, 2022; page 12).
Flood modelling products	Include hydraulic models and modelling results where hydraulic models are numerical/computational representations of the physical processes of water and are used to predict the characteristic of flood hazard. Flood models and results are not typically used by the general public as they are a technical, intermediate product that requires further processing for its intended use case. The flood model results are typically further processed in Geospatial Information System (GIS) software to create various geospatial products (e.g., line of flood extent, contour lines of flood depth) to be used in creating flood maps.
Flood mapping	The “delineation of flood extents and elevations on a base map. This typically takes the form of flood lines on a map that show the area that will be covered by water, or the elevation that water would reach during a specified flood event. The data shown on the maps, for more complex scenarios, may also include flow velocities, depth, other risk parameters, and vulnerabilities” (NRCan, 2018, page 4).
Flood maps	There are different kinds of flood maps (a general term for flood related products), which can be more precisely defined by type such as inundation, hazard, risk, or awareness maps (NRCan, 2018).

Term	Description
<i>Methods of Disclosure</i>	
Available	Refers to flood modelling and mapping products where the information already exists. It may however be siloed within a public or private organization and not accessible to other parties, whether that is the general public, private industry, or other levels or branches of the same organization.
Publicly available	Means that the information is in theory available to the public but cannot be located or accessed by a lay person in a straight-forward manner (see below for description), nor is the information available in digital format.
Publicly accessible	Means that the information is available free of charge and can be located by the lay person following a reasonable search (e.g., searching the internet for flood map and their location/city/province/etc. or browsing through their local government or community website) similar to the search performed by Minano, Henstra, & Thistlethwaite (2019) to identify flood maps for Canadian communities. The information must be available in digital format through the internet, as other traditional methods (e.g., paper maps at a central library) are not comparable in terms of accessibility.
Disclosure	In the context of this report means that there is a regulated or legislated requirement to share information related to a known or potential flood hazard.
<i>Hazard, Vulnerability, and Risk</i>	
Hazard	A “process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation” (UNDRR, 2017; page 28). It is characterized by its magnitude and likelihood of occurrence.
Equity	Equity refers to fairness and justice in “policies, processes and outcomes for historically and/or currently underrepresented and/or marginalized people” and groups. “It considers power, access, opportunities, treatment, impacts and outcomes” (University of British Columbia Equity and Inclusion Office, 2023; page 1).
Exposure	The “situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas. Measures of exposure can include the number of people or types of assets in an area”(UNDRR, 2017; page 28).
Vulnerability	The “conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards”(UNDRR, 2017; page 28). .
Consequence	The “physical/environmental, social, economic, and political impact or adverse effects that may occur as the result of a hazardous event” (EMBC, 2020, page 84). It is typically determined as a combination of exposure and vulnerability of assets within the hazard extent.
Risk	The “potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity.” (UNDRR, 2017; page 27).
Residual risk	The “disaster risk that remains even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained. The presence of residual risk implies a continuing need to develop and support effective capacities for emergency services, preparedness, response and recovery, together with socioeconomic policies such as safety nets and risk transfer mechanisms, as part of a holistic approach.” (UNDRR, 2016, page 14)
Resilience	The “ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.” (UNDRR, 2016, page 22)

241

242

243

244 **Results and Discussion**

245 Canadians will face increasing risk and losses due to flooding, not only as a result of
246 climate change related impacts, but also from continued development in flood-prone
247 areas (Minano, Henstra, and Thistlethwaite 2019). Indeed, Bouwer (2013) and
248 Kundzewicz (2013) showed that increased exposure due to socioeconomic growth (i.e.,
249 an increase in number of exposed assets and value of assets) will result in flood-related
250 losses that are the same or larger than losses due to climate change. Since the start of
251 recorded flood risk management in Canada, it has been recognized that “the cornerstone
252 of a coordinated program will be flood [...] maps, as a basis for joint agreement on the
253 definition of flood-prone lands” (Bruce 1976).

254 Below we draw on the reviewed literature to discuss first, the benefits and
255 challenges of flood map disclosure, followed by the potential consequences of non-
256 disclosure of flood maps. Lastly, we summarize key findings and what they mean for
257 Canada.

258 ***Benefits and challenges of flood map disclosure***

259 To address our first research question on the benefits and challenges of flood map
260 disclosure, we discuss below a range of themes drawing on examples from the reviewed
261 literature, while recognizing that these themes and examples are not an exhaustive list.
262 We have organized these themes using the language of risk and resiliency.

263 First, we discuss benefits of flood map disclosure, such as using of flood maps to inform
264 land use changes to reduce exposure and to encourage structural building changes to
265 reduce vulnerability (i.e., risk reduction). Then we consider themes related to response
266 and recovery (i.e., resilience), specifically, the benefits of flood maps to increase flood
267 emergency preparedness, and to support management of residual risk via insurance.

268 Further, we also discuss challenges of flood map disclosure, such as the importance of
269 making flood maps understandable, the need of awareness campaigns to accompany
270 flood map disclosure, and lastly, the impact of disclosure on property values.
271 Throughout, we provide some discussion of the potential for unintended consequences
272 when maps are disclosed.

273 *Informing land use changes to reduce exposure*

274 A review of flood risk best practices in Europe highlighted the different uses of flood
275 maps, with flood hazard maps being essential for all types of applications within flood
276 risk management (e.g. land-use planning, disaster response and management, etc.) (Van
277 Alphen et al. 2009). Any land-use policy, from a “bare-bones policy of providing flood
278 risk information to the public” to “more interventionist policies such as land use and
279 building code regulations, relocation programs, and infrastructure improvements” all
280 rely on flood maps - and incorporating the disclosure of these maps into policy (Pralle
281 2019). However, in most cases, development pressures have tended to be at odds with
282 implementation of risk reduction policies for land-use (Lazarus et al. 2018; Kundzewicz
283 et al. 2014). Flood maps can be used to support land-use and planning decisions and
284 regulations to reduce flood risk exposure. However, typically, there is a “lack of strong
285 linkage between the flood map and development, [which] is perhaps at the heart of the
286 difficulties flood risk managers face today” (Sayers et al. 2013).

287 *Encouraging structural building changes to reduce vulnerability*

288 Structural mitigation measures can reduce flood vulnerability in flood prone areas that
289 already have existing development. A household survey following the River Elbe
290 extreme flood in Germany in 2002 found that while typically, structural building
291 changes are mostly effective for small, frequent floods, they also reduced damage

292 significantly in extreme flood events (Kreibich et al. 2005). The study also explored
293 how the experience of previous floods and the knowledge of being in a flood prone area
294 related to homeowners taking building precautionary measures (Kreibich et al. 2005),
295 and found that flood experience was a significant factor for taking building
296 precautionary measures, along with being aware of living in a flood prone area and
297 believing that building measures can help to reduce the risk. However, despite the
298 previous flood and knowledge of living in a flood prone area, 34% of surveyed
299 households still did not consider taking building precautionary measures, pointing to the
300 need for information campaigns and financial incentives to improve preparedness.
301 Similarly, Thistlethwaite et al. (2018) found in a survey of Canadian households that the
302 experience of flooding leads to much more adoption of property-level flood protection
303 measures than only awareness of being in a flood zone (for instance, via accessible
304 flood maps).

305 Despite the lack of findings in the literature of a direct causal link between
306 actions to reduce flood vulnerability through government intervention or individual
307 action and the accessibility of flood maps, there is a strong heuristic argument that risk
308 (and therefore hazard) knowledge is a necessary precursor to action to reduce risk. This
309 is, in fact, the basis of Priority 1 of the Sendai Framework, the international blueprint
310 for disaster risk reduction (UNDRR 2015).

311 *Increasing flood emergency preparedness*

312 Flood maps can improve emergency preparedness by providing information on potential
313 flood depths and extents. It was observed in Japan that residents, who were informed
314 about flood depth maps, evacuated earlier, indicating that public awareness of relevant
315 flood risk information such as flood depth can lead to risk reducing behaviour (Van
316 Alphen et al. 2009). A case study in Tabasco, Mexico reported that local residents'

317 flood preparedness decisions were driven by “communities having accessible flood [...] 318 maps, sharing flood experiences with family, having early warning systems, and having 319 shelters, amongst other factors” (Atreya et al. 2017). The study found however that only 320 8% of the residents were aware of flood maps, even though access to such information 321 was one of the strongest factors in improving individual flood preparedness. During the 322 1997 Red River flood in Winnipeg, the lack of publicly accessible and consistent flood 323 risk information also caused considerable stress to local residents as they tried to 324 prepare for the flood (Morris-Oswald and Simonovic 1997; Shrubsole et al. 2003).

325 *Supporting management of residual risk via insurance*

326 Flood risk can never be eliminated, despite risk reduction measures, a residual risk 327 always remains. One way to manage this residual risk and improve recovery (i.e., 328 resilience) is via flood insurance (Kousky and Light 2019; Kousky et al. 2021; 329 Yiannakoulis et al. 2018). For flood insurance to be effective however, a long-term 330 financial commitment from the government to improving flood mapping and public 331 awareness is key, and there is a need to “align public-facing risk maps that allow 332 insurers as well as property owners and governments to collaborate on identifying, 333 updating and managing risk” (IBC, 2019). Further, there are two main motivations for 334 governments to publicize flood maps with respect to flood insurance:

- 335 (1) As part of an overall policy to strategically reduce flood risk and signal to 336 private industry of government commitment towards an efficient market of risk- 337 based premiums thus incentivizing development of affordable flood insurance 338 policies (IBC 2019).

339 (2) As a public information tool to increase flood awareness and drive demand for
340 insurance, therefore expanding the risk pool and lowering overall cost (IBC
341 2019; Kousky et al. 2020).

342 These motivations, and the response from private industry and home-owners,
343 can be seen in flood insurance implementation in the US, Australia, and the UK. As
344 described by Thistlethwaite and Henstra (2018), “Australia’s maps support public risk
345 awareness, while the UK and the US use maps as a transparent means to determine
346 premium adjustments”. As part of the insurance schemes, flood hazard maps are made
347 available publicly. In the US, insurance is administered federally, and quasi-mandatory,
348 if the property is located within the official, and publicly accessible, flood maps. In
349 Australia, authoritative data on flood risk is available via a federally-administered
350 portal, and the increased awareness of flood risk triggered property-owner demand for
351 insurance (Thistlethwaite and Henstra 2018). In the UK, the government supports flood
352 mapping through development of flood models; the model results are not completely
353 open but are shared with the insurers through a licensing agreement (Flood Re 2016,
354 2018). One of the concerns with opening up flood data is that it could potentially reduce
355 incentives for the private industry to develop more accurate flood risk models needed
356 for risk-reflective pricing (Flood Re 2016, 2018).

357 In contrast, one of the main issues limiting insurance uptake of private residents
358 within flood hazard areas in the US, is that they are not aware of their flood risk (along
359 with cognitive biases, and pricing where the people who would need flood insurance the
360 most, often can afford it the least) (Kousky et al. 2020).

361 In the Canadian context, where flood mapping is currently led by Provinces and
362 Territories in a patchwork manner, and where map quality and availability vary
363 substantially between jurisdictions (Ebbwater Consulting Inc. and Minerva Intelligence

364 Inc. 2020), Henstra, Minano, and Thistlethwaite (2019) question the fairness of such a
365 framework for floodplain residents when flood risk management policies are
366 increasingly advocating individual responsibility (e.g., private flood insurance). While
367 private insurance companies often develop their own, Canada-wide flood products,
368 these high-level flood maps often have a coarse spatial resolution or do not reflect the
369 large diversity of the Canadian landscape well (Ebbwater Consulting Inc. 2021).
370 Accessibility to high-quality flood maps across Canada would remediate this issue.

371 However, high quality publicly accessible maps can also lead to financial
372 challenges for insurers and individuals. Insurance companies rely on “shouldering”,
373 where people at lower risk buy flood insurance. These premiums are pooled with high
374 risk properties to spread the overall financial burden. For instance in the UK, while the
375 refinement of flood hazard mapping has led to improved property-level risk
376 assessments, it resulted in higher premiums for those most at risk (Flood Re 2016). This
377 occurs because a coarser flood map effectively pools the risk within an area, whereas a
378 more granular map reveals variable risk, some higher and some lower, within the same
379 area. This refinement in modelling and mapping can result in certain property owners
380 being assigned such a high flood risk that they can no longer access affordable flood
381 insurance. This unexpected financial burden needs to be considered in policy, even if it
382 does reflect the true financial risks of living in high flood hazard areas and provides a
383 financial signal to property owners to manage and reduce their risk (e.g., by moving, by
384 investing in property-level flood mitigation, etc.).

385

386 *The need to make flood maps easy to find, understandable, and up-to-date*

387 Even when flood maps are publicly available, there are still challenges in increasing
388 public awareness of floods. Some of these are due to accessibility and comprehension of

389 flood maps. A review of publicly available flood map products in Canada reported that
390 maps were difficult to find from online searches and those that could be found were
391 often not the best suited for communication of flood risk to the general public (Henstra,
392 Minano, and Thistlethwaite 2019). A further barrier to public access to quality flood
393 maps is that such maps require frequent review and updates, and many maps available
394 in Canada are outdated, and when studied in 2014 had a median age of 18 years (MMM
395 Group, JFSA, and Matrix Solutions Inc. 2014). There have been many maps developed
396 since this time, but the public accessibility of these is limited (Ebbwater Consulting Inc.
397 and Minerva Intelligence Inc. 2020).

398 *The need of awareness campaigns to accompany flood map disclosure*

399 There is strong evidence that public memory of flood risk is short-lived and that
400 providing access to flood maps online is one way to sustain public awareness of flood
401 risk (Minano and Peddle 2018). However, maps by themselves, outside of a larger
402 media campaign promoting flood awareness, have questionable effectiveness (Handmer
403 1980; Shrubsole et al. 2003). In a study of using maps for public communication of
404 flood hazards for the Canadian Flood Damage Reduction Program (FDRP), Handmer
405 (1980) found that “there was substantial increase in flood awareness following release
406 of the maps”, but noted that the associated media publicity was likely the primary
407 reason for the increase in flood awareness.

408 The European Union’s approach to flood risk management, as defined in their
409 Floods Directive (FD), explicitly requires that flood risk maps and plans be publicly
410 accessible. Following implementation of the FD, an evaluation of citizen awareness in
411 six EU countries reported that citizen awareness and participation rates are closely
412 related to how much countries were already engaging their citizens in the flood risk
413 management process (Priest et al. 2016). This highlights one of the criticisms of the FD,

414 in that it is procedural (e.g., developing and publishing flood maps) rather than
415 stipulating fixed requirements. This results in member nations setting substantially
416 different objectives in terms of, for example, public engagement (Priest et al. 2016).

417 Several studies have also shown that “passive information distribution”
418 (Handmer 1980) or an “information only” approach (Bruce 1976), where maps are
419 provided in isolation from other resources or awareness campaigns, are ineffective to
420 increase public awareness of flood risk.

421 Alexander et al. (2016) discusses the use of flood maps as a “technological
422 bridging mechanism” in which maps are not an end in and of themselves, but a tool to
423 support “a host of activities, such as spatial planning, emergency management and
424 awareness raising amongst at-risk communities”. These can be addressed by both flood
425 risk professionals and public stakeholders and facilitated via online information sharing
426 and networking portals to support the distribution of the information and the exchange
427 of best practice knowledge.

428 A comparative study of ten Canadian communities, for which both FDRP-era
429 mapping from the 1980s/1990s and more modern flood maps are available, found that
430 even though these historical flood maps existed, subsequent development occurred in
431 the flood hazard area for most of the locations (Ebbwater Consulting 2017). Overall, the
432 number of exposed buildings from the FDRP-era to today increased due to a
433 combination of increased flood extents of newer flood maps, and increased number of
434 assets within the flood extents. Development in the floodplain occurred despite the
435 availability of FDRP maps for land use planning. This finding supports the need for a
436 stronger link between flood mapping and actual policy implementation to change
437 development practices.

438 Similarly, Lazarus (2018) observed a pattern of systemic growth in residential
439 footprint size for renovated and new structures in hurricane zones on the US Atlantic
440 and Gulf Coasts. This tendency to “build back bigger” exists despite decades of
441 regulatory efforts and availability of Federal Emergency Management Agency (FEMA)
442 maps that delineate flood risk areas and highlights the need for educational campaigns
443 to accompany flood map disclosure, especially as FEMA’s flood maps are flood
444 insurance rate maps intended to define special hazard areas and risk premium zones, to
445 identify areas requiring mandatory insurance purchase and to calculate policy costs, and
446 not targeted at informing the public. In contrast to the FEMA maps, a new free online
447 tool delineating property level flood risk information across the US¹, published by First
448 Street Foundation in 2020, states that one of its main intended uses is to inform
449 individuals of their property-level flood risks. Following the release of this new flood
450 risk tool, a FEMA spokesperson has reportedly clarified that “FEMA’s maps are
451 notably different in their intended use and design” compared to First Street’s maps in
452 that FEMA maps are not intended to “inform someone’s decision to acquire flood
453 insurance or take an action to reduce their individual risk” (Kaufman et al. 2020). In
454 contrast, the First Street Foundation states specifically as their main purpose to “address
455 asymmetry in access to high-quality climate change data by quantifying and
456 communicating America’s environmental risks so that everyone can make informed
457 decisions for the future. By making flood [...] risk data accessible and easy to
458 understand, individuals and communities can prepare for and mitigate risks before they
459 become a reality.” (First Street Foundation 2022). First Street Foundation’s data
460 releases are accompanied by an easy-to-navigate website addressed at the general

¹ <https://firststreet.org/flood-lab/published-research/2020-national-flood-risk-assessment-highlights/>.

461 public, much press coverage, and cooperation with many research institutions. It is
462 however too early to evaluate the impact of the First Street Foundation maps on
463 individual real-estate decisions and insurance uptake.

464 Lastly, it also matters how flood hazard and risk is visualized. For instance,
465 Dobson, et al. (2018) found that visualization of cartoon-house images with water level
466 led participants in a simulation experience to select lower-risk properties, than when
467 participants were presented with the information in map format.

468 *The impacts of flood map disclosure on property values*

469 The impacts of flood zone designation on property values is one of the main concerns
470 around disclosing flood maps, and multiple studies (e.g., Shr and Zipp 2019; Rajapaksa
471 et al. 2016; Meldrum 2016; Filippova et al. 2019; Beltrán, Maddison, and Elliott 2019,
472 2018; Belanger and Bourdeau-Brien 2018; Zhang 2016; Bélanger, Bourdeau-Brien, and
473 Dumestre 2018; Troy and Romm 2004) have explored it, assessing impacts for a range
474 of countries, including the US, England, Australia, New Zealand, Canada, and others.

475 While the results are varied, there is typical agreement that location within a
476 flood zone reduces property values somewhat, as, under ideal conditions, a property
477 located within a floodplain SHOULD experience a “flood zone discount”, proportional
478 to the risk and social cost of buying within a floodplain (Gourevitch et al. 2023; Chivers
479 and Flores 2001) For instance, results from a large dataset in England found that after
480 publication of detailed flood maps from the UK Environmental Agency, and in
481 combination with a more risk-based pricing of flood insurance, the value of residential
482 houses in the flood zone decreased, with an average difference in values from in flood
483 zone to outside flood zone of 1.5% (Bélanger and Bourdeau-Brien 2018). Property
484 values in Pennsylvania decreased by more than 11% when the property was designated
485 into a flood zone, but even where the flood zone designation was removed again later,

486 the property value did not rebound (Shr and Zipp 2019). It should be noted that
487 Pennsylvania has a disclosure act that requires buyers be informed of a property's
488 designation within a flood zone and that the price decrease of being mapped into a flood
489 zone is equivalent to the flood insurance premium (Shr and Zipp 2019). Typically, in
490 the US, the negative impacts to property value from publication or update of flood map
491 information is mainly due to the associated increase in flood premium for the property
492 (Indaco, Ortega, and Tapinar 2018).

493 Using flood maps to develop floodplain management regulations, such as
494 requiring increased building elevation or flood construction levels (FCLs), can also
495 “reduce [undeveloped] land values because they increase development costs”, and thus,
496 can reduce development pressures for undeveloped land within a floodplain (Holway
497 and Burby 1990).Hino and Burke (2021) assessed the effect of regulatory floodplain
498 maps on properties values nationwide across the United States (US),and found that
499 “being zoned into the floodplain reduces property values by 2.1%”. However, this same
500 study presented two types of benchmarks to provide context for the estimated 2.1%
501 discount. The benchmarks are designed to capture the full financial cost of flood
502 insurance and found theoretical flood zone discounts in the range of 4.7 to 10.6%, and 4
503 to 20% in an ideal and efficient market. The larger theoretical discounts compared to the
504 estimated 2.1% from actual property data indicate that “floodplain presence is not fully
505 reflected in property values”, therefore, while property values are reduced when the
506 property is zoned in a floodplain, the reduction does not adequately reflect the higher
507 risk of being in that location and associated insurance costs.

508 Furthermore, the flood zone discount is largely informed by flood risk
509 awareness through a combination of community exposure, personal experience with
510 flooding, and flood disclosure regulations (Hino and Burke 2021). For example, Hino

511 and Burke (2021) showed that US counties, where >10% of properties are within a
512 floodplain, had flood risk discounts “approximately 4 percentage points more negative
513 than in counties with a smaller share of properties in the floodplain”, thus highlighting
514 the effect of increased risk awareness due to community exposure and personal
515 experience with flooding. Surveys of property owners in the U.S. have shown that
516 buyers are not fully informed, or are informed late in the purchasing processes, about
517 flood risk and associated costs of insurance when purchasing their property. This a
518 classic form of market failure in information where the buyer is unable to properly
519 value their purchase to account for the cost of risk (Chivers and Flores 2001). Chivers
520 and Flores (2001) found that most buyers learn about the potential for flooding on the
521 property late in the home-ownership process: 8% learn about it prior to offer; 6% prior
522 to closing; 60% during closing; 4% after moving; 6% after being flooded; and 16% at
523 some other time. The survey further found that maps are not the primary source that
524 buyers learn about a property’s flood zone designation: 58% learn about it from flood
525 certification; 30% from Multiple Listing Service (MSL) data; 2% from Flood Insurance
526 Rate Maps (FIRM); and 7% from the mortgage lender. Simply, despite the public
527 availability of flood zone maps in the US, the typical buyer does not seek out this
528 information. Therefore, there exists information asymmetry within floodplain real-estate
529 transactions, an aspect discussed later on in this manuscript.

530 There is also substantial evidence that buyers go through a cycle of “learning”
531 and “forgetting” when it comes to flood risk (Hino and Burke 2021), and that the effect
532 of actual floods “fades away” over time (Bélanger and Bourdeau-Brien 2018). This is
533 likely due to investor’s “myopia” and “amnesia”, leading to a situation where
534 “perceived flood risk (and observed home prices) likely diverge considerably from
535 actual risk (and risk-adjusted prices), particularly if a long period has passed since the

536 last flood.”, which is particular concerning given the increasing risks with climate
537 change (Pryce, Chen, and Galster 2011).

538 A recent study that looked at real-estate indicators (prices, time to sell, etc.) in
539 Canada post-flood showed that homes typically sell for 8.2% less after a catastrophic
540 flood and take longer to sell (Bakos et al. 2022). Notably, this study only followed real-
541 estate values for 6 months post-event, and so only showcases the learning stage of flood
542 risk. Despite this finding, another study surveyed residents of two towns in Nova Scotia
543 and found that most respondents (>75%) favoured the disclosure of flood maps during
544 property sales (Howard and Sherren 2023).

545 Similarly, a study in Calgary found that property values decreased over the
546 short-term after the catastrophic 2013 floods by a median dwelling value of \$37,000 in
547 flooded areas (where evacuation occurred). However, over the long-term (from 1991 to
548 2016), property value increased more in mapped high flood hazard areas, in contrast to
549 lower flood hazard areas (Darlington, Yiannakoulis, and Elshorbagy 2022). This may
550 be, according to the authors, due to the high appreciation of water-front property in the
551 downtown area, where the highest property values and family incomes are found.

552 Actual flood events can have much stronger negative impact on property values
553 than the disclosure of flood maps (Rajapaksa et al. 2016; Zhang 2016). A study from
554 Australia compared the real estate value impacts of the release of flood map information
555 to the public (in 2009) with impacts from the extreme flood event of 2011 for Brisbane
556 (Rajapaksa et al. 2016). They found that flood map disclosure decreased property values
557 by 1-4%, whereas the 2011 floods reduced property values by 18-19%. Similarly,
558 Zhang (2016) found for North Dakota/Minnesota in the Red River floodplain that while
559 the floodplain designation had a negative impact on house prices (strongest for lower-
560 priced homes), the major flood of 2009 reduced property prices much more than the

561 floodplain designation had. However, that effect was not long-lived and diminished
562 after 2010. Chivers and Flores (2001) found evidence of a flood risk discount for
563 Boulder, Colorado homes, but only in the years immediately after the flood event.

564 To close this section on the impact of flood disclosure on property values it is
565 important to highlight that a reduction in property value, however small, will have very
566 real consequences to those whose homes or properties are devalued. The marginal
567 impact of the devaluation will depend on individual circumstances such as expected
568 tenure in the home, household income, and risk perception among other factors. Further,
569 a recent U.S. study has shown that low-income households are more likely to lose
570 equity if an appropriate flood zone discount were to be applied across hazard areas and
571 that this has “the potential to exacerbate wealth gaps” (Gourevitch et al. 2023).
572 Although not directly related to property valuation, Canadian research has shown that
573 there are large socially vulnerable populations living in areas of high flood hazards
574 (Public Safety Canada 2022) and some portion of these populations may be property
575 owners and will be subject to the same challenges as their U.S. counterparts. The
576 exploration of potential policy solutions to limit exacerbating inequities is outside the
577 focus of this work, but most certainly an area for future study.

578 ***Potential consequences of non-disclosure of flood maps***

579 Here, we address our second research question on the potential consequences of non-
580 disclosure of flood maps. Specifically, here, we refer to non-disclosure in the following
581 two situations:

- 582 (1) Flood maps exist, but they are not publicly available.
- 583 (2) Flood maps exist and are publicly available, but the public is insufficiently
584 aware, willing, or able to access the information.

585 The second situation is included here, as one of the commonly cited motivations
586 for publicizing flood maps is to promote public awareness and incentivize risk reducing
587 behaviour. Many studies have however noted that “simply placing environmental
588 information in the public domain does not guarantee [it] will be used” (Pope 2008), in
589 contrast to using complementary tools (e.g., mandatory disclosure regulation) or
590 awareness campaigns, which allow flood information to be recognized and utilized.

591 Below, we discuss potential consequences of non-disclosure of flood maps,
592 including information asymmetry with respect to property values caused by non-
593 disclosure and the impact on the uptake of flood insurance.

594 *Non-disclosure causing information asymmetry with respect to property values.*

595 In the absence of publicly accessible transparent flood maps from an authoritative
596 source, there exists information asymmetry, i.e., differing groups have different
597 information access to guide their decisions (Broxterman and Zhou 2023). This
598 information asymmetry can have wide-ranging impacts on flood risk management by
599 acting as a barrier to policy dialogue, perpetuating an inefficient real-estate market that
600 does not capture the cost of building and residing on floodplains, and preventing
601 accurate cost-benefit analysis of structural and non-structural mitigation investments.

602 Below we discuss information asymmetry for (1) real estate sellers relative to buyers,
603 (2) buyers of different socio-economic backgrounds, (3) commercial real-estate buyers
604 relative to the typical home-buyer, and (4) governments and insurers relative to property
605 owners.

606 *(1) Information asymmetry of buyers and sellers.* Information asymmetry exists
607 between buyers and sellers in floodplain real-estate transactions: the buyer is likely
608 unaware of flood risk within the already complex undertaking of property purchase, and

609 the seller is likely better informed simply as a result of living or owning the property
610 and being exposed to local experience and information (Pope 2008). Even if some
611 buyers are informed, as long as there exists some non-trivial fraction of uninformed
612 buyers, the property price will not reflect that of a “full information” environment as the
613 sellers can wait for offers from the uninformed buyers (Pope 2008; Hino and Burke
614 2021). Mandatory disclosure can be a regulatory tool to reduce information asymmetry
615 to ensure that buyers are informed sufficiently in advance of the purchase to take flood
616 risk into consideration. An evaluation of housing prices in North Carolina found that
617 following implementation of disclosure regulations, the mandatory floodplain disclosure
618 by sellers caused buyers to become aware of the floodplain property’s flood risks (Pope
619 2008). This led to a flood discount of 3.8-4.5%, while there was no difference in
620 property prices for inside/outside flood zone properties before the mandatory disclosure
621 (Pope 2008). Chivers and Flores (2001) also attributed the lack of flood discount in
622 standalone home purchases for Boulder, Colorado, to information asymmetry, and
623 specifically to the fact that buyers learn about flood risk and flood insurance
624 requirements very late in the purchasing process. In contrast, for the same area,
625 Meldrum (2016) found that condominium prices had an observable flood discount.
626 They concluded that condo buyers were likely better informed about their flood risk
627 related financial obligations through the condo’s Home Owners Association
628 documentation.

629 *(2) Information asymmetry for buyers with different socio-economic backgrounds.* Troy
630 and Romm (2004) observed a negative price effect due to the California flood hazard
631 disclosure regulations, specifically, this negative price effect was mainly due to price
632 changes in the state’s predominantly Hispanic neighbourhoods. The floodplain homes in
633 largely Hispanic neighbourhoods reduced in price, but there was relatively little effect

634 in non-Hispanic neighbourhoods. Similarly, a more recent U.S. wide study showed the
635 overevaluation (i.e., the inverse of a flood zone discount) of homes in predominantly
636 white neighbourhoods was significantly higher than in predominantly racialized
637 neighbourhoods (Gourevitch et al. 2023). The Troy and Room (2004) study
638 hypothesized two explanations. First, there is a disproportionately larger representation of
639 Hispanics residing in floodplain properties in California compared to any other group,
640 thus the price impact of disclosure regulations would disproportionately affect Hispanics.
641 Second, there are pre-existing biases which are corrected by the disclosure regulation.
642 Prior to California's disclosure regulation, the disclosure mechanism was regulated
643 through the mortgage process, for instance through mortgage applications to regulated
644 lenders such as banks. However, when property buyers obtained mortgages through
645 less-regulated informal sources, including subprime lenders, it may not have triggered
646 disclosure (Troy and Romm 2004). If these hypotheses are true, then mandatory
647 disclosure regulations can be a "step forward towards more equitable and unbiased
648 dissemination" in flood risk (Troy and Romm 2004). However, we note that these are
649 hypotheses and the causality has not yet been proven, thus, further research into socio-
650 economic information asymmetries is needed.

651 *(3) Information asymmetry of commercial and non-commercial buyers.* Hino and
652 Burke's (2021) review of the US housing market prices indicated that "more
653 sophisticated commercial buyers and more risk-aware buyers respond more to
654 floodplain information". This is attributed to commercial buyers' familiarity and
655 experience with accessing flood risk information, compared to a typical non-
656 commercial buyer who is less experienced. Their findings indicate that these
657 uninformed and optimistic buyers lead to overvaluation of floodplain properties. The

658 result is that “development in the floodplain likely exceeds what would be observed if
659 prices fully reflected information about flood risk” (Hino and Burke 2021).

660 Where information asymmetry exists, it allows for the cost of flood risk to be
661 transferred from more informed buyers to less informed buyers. Communication of
662 flood hazards and flood risks through flood maps, combined with real-estate disclosure
663 regulations, could be one way to “ensure such risk is appropriately reflected in market
664 outcomes” (Hino and Burke 2021).

665 *(4) Information asymmetry with respect to real-estate investment trusts (REITs).* Flood
666 risks have financial impacts even for those who do not directly own property. Investors
667 can indirectly own property through Real Estate Investment Trusts (REITs). These
668 REITs hold billions of dollars in Canadian real estate and can be directly purchased on
669 the Toronto Stock Exchange, or as part of a diversified portfolio in, for example, a
670 pension fund. An analysis of REIT holdings revealed that 17% of the investment
671 properties were within a 0.5% annual exceedance probability (1:200-year floodplain),
672 compared to the national average 11%² (Clark 2021). There is a concentration of risk
673 that is higher than if you randomly selected buildings for investment. Increased public
674 access to flood risk information would allow investors to “more accurately appraise the
675 value of trades and reduce the potential of markets becoming disconnected from reality”
676 (Clark 2021).

677 *Non-disclosure impacting the uptake of flood insurance*

678 There will always be some residual risk to flooding, even with flood reduction measures

² <https://climatechoices.ca/flood-threats-to-canadas-real-estate/>

679 in place. Flood insurance, whether privately or publicly funded, can be an instrument in
680 flood risk reduction by (1) providing the necessarily financial recovery resources post-
681 flood, and (2) acting as a “rationing device” or “price signal” for use of floodplains in
682 places where the compulsory insurance exists and the cost of insurance premium
683 reflects the flood risk (Krutilla 1966; Chivers and Flores 2001). One of the main
684 challenges to implementation includes awareness and willingness of floodplain
685 residents to take up flood insurance.

686 Thistlethwaite et al. (2020) recognized that there are barriers to uptake of flood
687 insurance in Canada due to policy gaps, including specifically lack of access to flood
688 maps and the outdated nature of existing flood maps. Their public opinion survey found
689 that of the “50% of respondents who reported that they would not buy flood insurance,
690 89% gave the reason that their home was not at risk of flooding” (Thistlethwaite et al.
691 2020). Further, 72% of the respondents believed that there would be no increase in
692 flood risk in the next 25 years. Overall, the study found that residents’ low perception of
693 current and future flood risk was a substantial barrier to their willingness to purchase
694 flood insurance. One approach to address the perception challenge and promote the
695 level of flood risk awareness needed to reduce the barrier for flood insurance purchase
696 is to have updated and publicly accessible maps (Thistlethwaite et al. 2020).

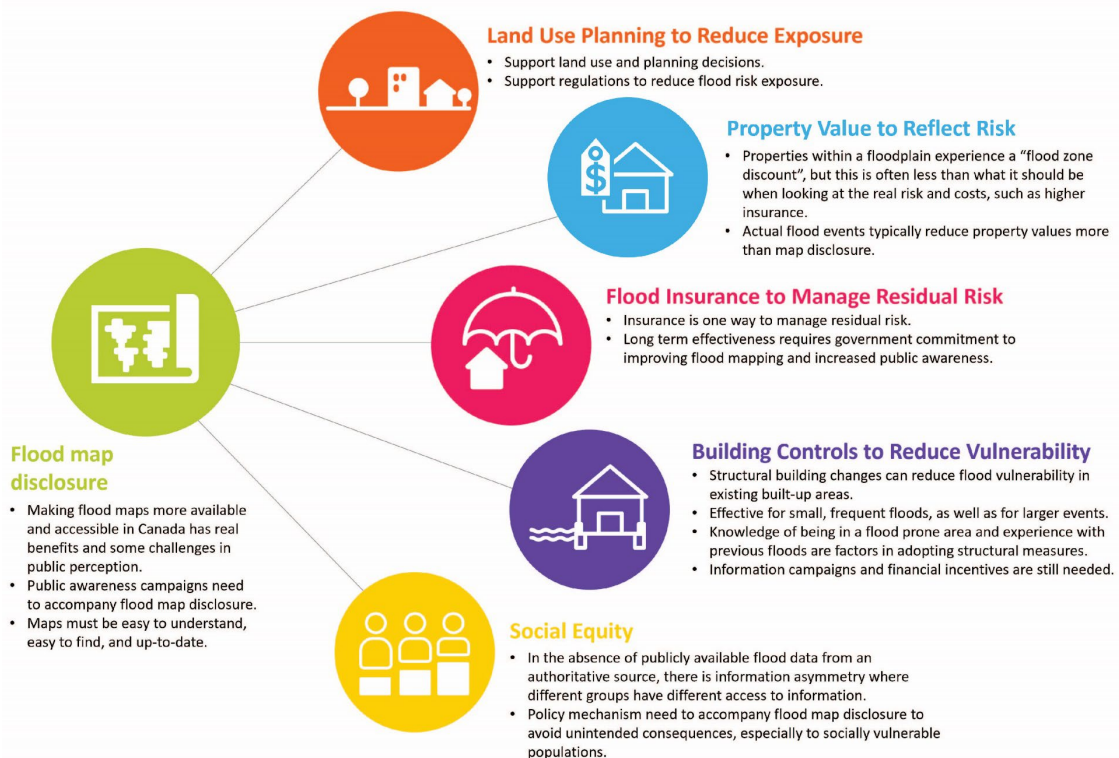
697 The insurance industry has long undertaken its own flood risk assessments,
698 including creation of flood hazard maps to “determine insurability, differentiate
699 premiums, or to assess long-term financial solvency” (De Moel, Van Alphen, and Aerts
700 2009). These flood assessments are generally considered by the industry as confidential
701 commercial information, even though the results could have beneficial uses in other
702 sectors, including for emergency planning.

703 Floodplain residents who are not well informed about their flood risk are
 704 exposed to potentially devastating post-disaster financial impacts such as mortgage
 705 default and personal bankruptcy (Minano, Henstra, and Thistlethwaite 2019).

706 ***Key findings – and what they mean for Canada***

707 In Canada, the public accessibility of up-to-date flood maps continues to pose a
 708 challenge, and in many Provinces and Territories, high quality, recent flood maps do not
 709 exist for all communities exposed to flood hazards, or if they do exist, they are not
 710 accessible in a straight-forward manner to the public (Ebbwater Consulting Inc. and
 711 Minerva Intelligence Inc. 2020). Yet, as discussed in the sections above, there are many
 712 benefits to making flood maps available and accessible to the public (Figure 3).

713



714

715 **Figure 3: Benefits and consequences of making flood maps available.**

716 Benefits include the necessity of flood maps to incorporate them into land use policy to

717 encourage exposure reduction and to inform property owners of their flood risk to
718 encourage building-level measures for risk reduction. Further, publicly accessible flood
719 maps can improve emergency preparedness by informing residents prior to a flood
720 event and increase flood insurance uptake to manage residual risks.

721 One of the concerns often mentioned is the potential impact of flood map
722 disclosure on real estate property. However, as discussed above, this flood zone
723 discount should be expected, given the higher risk associated with the property, and in
724 fact, is typically not high enough to cover the actual risk, or the higher flood insurance
725 premiums. Furthermore, the impacts of actual floods on property values are much
726 higher than impacts due to the release of flood maps – and flood map disclosure does
727 not change the risk for the properties, but instead, provides opportunity to implement
728 risk mitigation strategies (e.g., structural building changes, or land use planning).

729 Yet, simply releasing flood maps is not enough, and it should be ensured that
730 flood maps released to the public are easy to find, understandable, and appropriate for
731 public communication. Further, awareness campaigns should accompany any flood map
732 disclosure, as otherwise many flood zone property owners and residents might not be
733 aware of their risk. Importantly, the non-disclosure of a flood hazard has important and
734 wide-ranging implications, including the potential to create and/or exacerbate inequities
735 through information asymmetry, and a reduction in insurance uptake to manage residual
736 risks. We further believe that public access to standardized maps would be the best way
737 to ensure quality, transparency, and consistency in the flood insurance market. The need
738 for transparency will continue to be relevant as flood mapping and modelling will be
739 refined based on updated technology and information, and these changes will impact the
740 availability and affordability of flood insurance. This does not however mean that flood
741 maps should be released without first considering the potential for unintended

742 consequences, especially to socially vulnerable populations. Additional research into
743 policy mechanisms that balance the individual and societal costs associated with both
744 floods damages and with the policy tools (e.g., disclosure) to reduce risk should be
745 undertaken.

746 Arguably given the above, the costs of improved accessibility and/or disclosure
747 are greatly outweighed by the benefits. Canada would benefit from better accessibility
748 to flood modelling and mapping products, and there should be additional consideration
749 to pursue regulatory changes to require disclosure of flood hazards along with
750 appropriate public awareness campaigns; this would have to be pursued through the
751 authority of Provincial and Territorial governments.

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