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ORIGINAL ARTICLE

Singing in the rain: Valuing the economic benefits of avoiding insecurity from urban flooding

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Avoiding households' fear of urban flooding damages during heavy rain is a benefit component often overlooked in cost–benefit analysis (CBA) of measures preventing these damages. A contingent valuation (CV) survey shows that the monetary value of the welfare gain to Norwegian households from avoiding this insecurity, can be substantial. Households who feel exposed and live close to areas with previous urban flooding, have higher willingness-to-pay in terms of increased municipal charges, to avoid insecurity than those that live further away. We discuss how such measures of "closeness to flooding" can be used in future CBAs of measures preventing urban flooding. Adding the benefits of reduced insecurity in CBAs could justify higher investment in urban flood prevention.

KEYWORDS
benefit-cost appraisal, flood damages, urban drainage

1 | INTRODUCTION

Urban flooding occurs mainly during brief and intensive rainfall in densely populated areas, often with insufficient drainage and sewer systems. This is known as *pluvial flooding*, as opposed to fluvial floods, which are strongly related to overflowed rivers. Although pluvial floods cause lesser damage per event than fluvial, the pluvial ones occur more frequently and can thus still cause high aggregate costs to the society. These social costs might increase over time as climate change likely increases the frequency of extreme rainfall events, and the urban population and wealth grow (Cettner, Ashley, Hedström, & Viklander, 2012; Semadeni-Davies, Hernebring, Svensson, & Gustafsson, 2008; Tait, Ashley, Cashman, Blanksby, & Saul, 2008; Willems, 2012). Pluvial as well as fluvial floods across Europe in recent years, clearly show the large impact flooding can have in many cities. The total losses of flooding in UK during the summer of 2007, was estimated to be about £4 billion (€6.9 billion 2015) (Chatterton, Viavattene, Morris, Penning-Rowsell, & Tapsell, 2010). In Copenhagen, flooding from a cloudburst, 2 July 2011, caused damages of 6 billion Danish kroner (equivalent to 0.85 billion €-2015) (Rasmussen, 2014).

There are two main categories of preventive measures against pluvial flooding: (a) structural measures and (b) nonstructural measures. Structural measures aim to reduce flood risk by managing the flow from outside or within urban settlements. These range from hard-engineered measures like new pipes to "softer" measures like natural ponds. Nonstructural measures intend to keep people safe from flooding through emergency preparedness, warning systems, and sustainably developed or well-planned urban areas. Measures from both groups are complementary, and can be implemented simultaneously (Jha, Bloch, & Lamond, 2012). Often, the local authorities have to prioritise among a number of pluvial flood prevention measures and projects. Cost–benefit analysis (CBA), which aims to quantify and value (in monetary terms) the social benefits and costs to affected interest groups over the life time of a project (Boardman, 2011), can be a useful tool for ranking such projects.

CBAs are routinely used in Norway for project evaluation in general (see the national guidelines for CBA NGAF,

2014) and for infrastructure projects in particular. Stated preference (SP) methods (like contingent valuation [CV]) have been used to elicit unit values for people's willingness-to-pay (WTP) to avoid environmental and health impacts (see e.g., NPRA, 2014 for the CBA handbook for road projects). However, for urban flooding prevention projects, CBAs have so far rarely been used.

Flooding in cities results in a number of social costs, such as traffic disturbance, damage to infrastructure and buildings (both residential and commercial), insecurity among people fearing new floods, sick leave due to polluted water, lost lives, lost sales for businesses, and pollution of drinking water and local lakes and rivers (Lindholm *et al*., 2008). Chatterton *et al*. (2010) found, based on a CV study (DEFRA, 2004), that insecurity and psychological stress (in terms of a list of health symptoms[1]), was the second most costly subitem for society in the 2007 fluvial flood in England. Only the damage costs to residential houses and businesses were higher. This shows the importance of including these intangible costs in CBAs of flood preventions measures.

According to Elvik (2006), insecurity can be regarded as sense of lack of or insufficient level of safety. For individuals, insecurity in itself will be a burden, in terms of worrying about the impacts of flooding such as real estate value loss, additional clean-up work, vermin in the basement, etc., even if the flooding does not occur. Security against flooding can be considered as a public good like clean air and water and access to urban parks, which obviously has a value to humans although they do not have a market price. While private goods can be valued using market prices, SP and revealed preference (RP) methods are needed to value changes in the quality or quantity of such public goods as environmental quality and flood insecurity (Messner *et al*., 2007; Navrud & Magnussen, 2013). As SP methods are intended to value future changes in both the use and nonuse value of public goods, they are frequently used to support decision-making, e.g., when developing public areas. The SP methods, choice modelling (CM) and CV (Bateman *et al*., 2002), can value the welfare loss from flooding; (see e.g., Brouwer, Akter, Brander, & Haque, 2007 for applications of the CM and CV method, respectively, Navrud, Huu Tuan, & Duc Tinh, 2012). In this study, the aim is to estimate the WTP for avoiding the insecurity of having urban floods overall for use in CBAs of preventive measures, and not for the individual characteristics of a flood which CM aims for. Thus, CV was chosen as the most appropriate method in this decision context. (Bateman *et al*., 2002). While there have been CV surveys assessing insecurity from fluvial floods (Botzen, Aerts, & van den Bergh, 2009; DEFRA, 2004; Grann, 2011), there are, to our knowledge, no applications of the CV method to value insecurity from pluvial floods.

The main aim of this study is therefore to apply the CV method to estimate households' WTP to avoid the insecurity from pluvial floods in urban areas, as a measure of the social benefits of avoiding this loss in their wellbeing. Their WTP to avoid insecurity were calculated as the difference between their WTP for two scenarios: (A) "Preventive measures," i.e., measures undertaken by the municipality that would fully prevent future urban flooding, and (B) "Insurance," i.e., the municipality establishing an insurance fund to cover households' deductibles and other private costs not covered by their insurance in the event of pluvial floods. Thus, we estimate the WTP for avoiding insecurity as what people would be willing to pay on top of getting their damage costs fully covered in order to avoid urban floods altogether. We further aim to test the validity of the CV survey by exploring how households' WTP varies with income, demographic variables, level of pluvial flood exposure, previous experience with floods, and level of anxiety for floods. Finally, we aim to show how our results can be used in future CBAs of measures preventing pluvial floods in urban areas. For the rest of this paper, pluvial floods in urban areas will be referred to as "urban floods."

The next section describes the sample, design process and final outline of our CV survey. The third section reports and discusses the main survey results, and explores what factors determine households' WTP to avoid insecurity from urban floods. The fourth section presents the welfare measure of insecurity in terms of mean WTP/household/year. In conclusion, we discuss the limitations and future research agenda for applying CV to value insecurity for flooding, as well as the transferability of our results for use in CBA of flood prevention measures.

1.1 | CV survey and CV scenario design

CV surveys can be carried out by telephone, mail, face-to-face interviews, internet surveys (from lists of e-mail addresses), or internet panel surveys (where professional survey companies have recruited a panel of people to answer internet surveys). According to Lindhjem and Navrud (2011), internet panel surveys perform just as well as the previous "golden standard" of face-to-face interviews. If there is any difference between these two survey modes, WTP-estimates seem to be lower in internet surveys. Thus, in Norway, with more than 95% of the population having access to internet, an internet panel survey was found to be the most cost and time effective survey mode for our survey.

A professional survey firm (Norstat) conducted the survey among their panellists during March and April 2016. As we looked at urban floods, we did not aim for a random sample of the Norwegian population, but rather a random sample of households in cities within postal code areas where urban flood events had been recorded in recent years. The response rate was 25.1%, which is considered satisfactory in internet surveys. We aimed for a random sample of urban households being exposed to urban floods at different levels; from "no exposure" to "very much exposed." This enables the estimation of welfare estimates for each level of exposure, which can provide unit values for use in future CBAs of flood prevention measures. Midway through the survey we discovered, that in spite of our sampling strategy based on postal codes where urban floods had occurred, only about 5% of the respondents stated that they were "quite," "much," and "very much" exposed to urban floods. In order to get a sufficiently high number of respondents that felt exposed, and thus more reliable WTP estimates for the "quite," "much," and "very much" exposed categories, we introduced an initial screening question. This allowed only respondents stating they were prone to flooding to respond. Thus, in the final net sample, 19.8% of the respondents were "quite," "much," or "very much" exposed to urban flooding. Note, however, that in Norway overall, probably much less than 5% are exposed to urban flooding, and that our number is a result of our sampling and screening procedures.

The survey instrument was developed and pretested; starting with one-to-one interviews (Bateman *et al.*, 2002). Six people randomly drawn from the internet panel (representing both genders, different age groups and educational levels) attended this session at a central facility. Three out of six were preselected to have experienced floods in order to test the survey instrument also on those with flood experience (a random sample of six would likely have resulted in none having experienced flood). These respondents completed a first version of the internet survey, talking aloud about their responses, while we sat beside them, taking notes and asking clarifying follow-up questions (these sessions were recorded on video, and evaluated afterwards). This first pretest led to rewriting of some questions to make them clearer. We also changed the payment vehicle from increased sewage bill to an increase in the overall municipal charges (of which the sewage bill is a part), which the respondents seem to be more familiar with. The second pretest involved distributing the revised survey to 30 internet panel respondents living in postal code areas in cities where urban floods had occurred. In the pilot, we had randomised the order of the two CV scenarios households were asked to state their WTP for. This seemed to confuse people. Thus, in the final survey the scenarios were presented in the same order for everyone; asking WTP for preventive measures first (scenario A), and then WTP for the alternative in terms of a municipal insurance fund (scenario B) that would cover all private costs of households (in excess of what their insurance covered) if they got flooded. The difference in WTP between these two CV scenarios is what people are willing to pay in excess of getting their damage costs fully covered, and thus their WTP to avoid the insecurity from flooding.

In order to get a high-response rate (and thus a more representative sample) and valid responses, survey questions should be asked in logical order, be concise, clear, and be single questions (i.e., not asking for more than one thing in the same questions). According to Alberini and Kahn (2006) and McMahon, Moran, Sutherland, and Simmonds (2000), terms and valuation scenarios should be well-defined without scientific jargon. Our final questionnaire consisted of the following five parts:

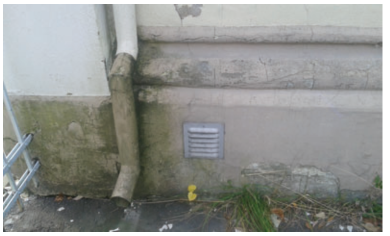
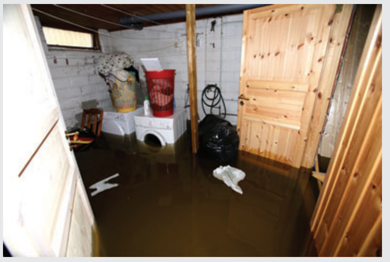
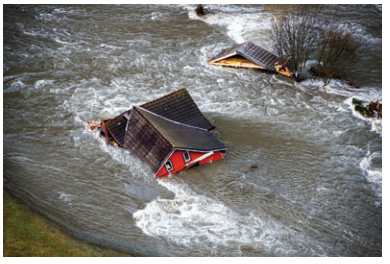
1. Introductory part that put urban floods in a broader context, and helps respondents to distinguish between different levels of flooding from precipitation, and identify the level we are looking at (defined as level 2 in Table 1; and termed "urban floods" here)
2. Attitudinal and behavioural questions
3. Two CV scenarios (A: "Preventive measures" and B: "Insurance") with accompanying WTP questions (wtpA and wtpB, respectively), where the difference (wtpA-wtpB) was used to elicit respondents' WTP for avoiding insecurity from urban floods (se detailed description below)
4. Follow-up questions about the reasons for being willing to pay or not
5. Questions about demographic variables (age, education, gender, etc.) and personal and household income[2]

Regarding part (3) and following (Grann, 2011), households' WTP for avoiding insecurity from urban floods was estimated as the difference in their WTP for two CV scenarios; A and B. Firstly, in scenario A, respondents were asked the most they were willing to pay in increased annual municipal charges for the local authorities to implement measures that would fully prevent all urban floods (wtpA). Secondly, in scenario B, they were asked the most they were willing to pay in annual municipal charges so the authorities could establish a collective and additional home insurance fund that would cover all households' future damage costs from urban flooding, in excess of what their private insurance would cover, e.g., their deductibles (wtpB). Thus, in both scenarios, they would pay to have no private costs if flooding occurs; i.e., in scenario A there would not be floods, and in scenario B they would get all their physical damage costs covered. However, in scenario B they would still have the insecurity from knowing that urban flooding could occur. Thus, the difference between wtpA and wtpB reflects households' WTP to avoid insecurity for urban flooding; defined as wtpAB = wtpA—wtpB.

Parts (2) and (5) provided data on households' attitudes, behaviour, experiences with flooding, demographics, and income that were used to test the validity of their WTP responses. We were particularly interested in testing whether their responses were in accordance with expectations from economic theory (Bateman *et al.*, 2002). Thus, in this study we wanted to test whether:

- Household WTP increases with household income
- Household WTP increases with more experience or exposure to flooding, i.e., what we have termed "Closeness to flooding"

TABLE 1 Precipitation damage to residential housing. Three levels defined and shown to the respondents in the internet survey. Level 2 is the subject of the contingent valuation scenarios, which in this paper is termed "urban floods" (Photos: level 1: Geir Torgersen; level 2: Tore Øyvind Moen, Varden; and level 3 Helge Mikalsen, VG)

Level	Characteristics	Possible causes	Possible damage	
1.	Moisture/small damage to property	Poor drainage around house, leaky roofs, etc	Small	
2.	Small floods/inundation	Pluvial flood due to insufficient sewer and drainage capacity	Substantial	
3.	Extensive floods	Fluvial flooding due to overflowed river	Disastrous	

- Household WTP is higher for the more inclusive good, i.e., scenario A: "Preventive measures" (which avoids all damage costs *and* insecurity) than B: "Insurance" (which avoids all damage costs, but not the insecurity). This is also termed an (internal) "scope test," which households pass if their wtpA > wtpB. However, wtpA = wtpB could occur if people have zero WTP to avoid insecurity, while wtpA < wtpB would not be rational, and will not pass the test. Stating, wtpA < wtpB could be rational if people do not trust the municipality to undertake preventive measure and/or it would take a long time for them to be implemented and/or they would not be effective in preventing all future urban floods. However, CV surveys in Norway have shown that people trust the government to undertake measures and for them to immediate and effective; also with regards to flooding (see e.g., Grann, 2011; Navrud, Lindhjem, & Magnussen, 2017). Thus, we believe that in this survey the respondents stating wtpA < wtpB are not rational and/or made a mistake, and will be excluded from further analysis

Regarding part (1), Table 1 was shown to the respondents in order for them to distinguish between the different levels of flooding from precipitation, where urban floods is level 2 and thus the subject of the CV scenarios.

The pretesting showed that many households were unfamiliar with the term "urban floods" or interpreted it in different ways. Therefore, the expression "Level 2-floods" was used throughout the internet survey to help respondents distinguish it from the less and more severe levels of flooding (levels 1 and 3, respectively), and to make sure that they all understood urban floods in the same way. Each time the term "Level 2-floods" occurred in the survey, respondents could just click on it to get the text in Table 1 repeated to them in a pop-up box. During the pretest, we also noticed that some respondents confused level 2 with water pipe leaks, which can also lead to harmful flooding, but this was not the subject of this survey. Therefore, we added a question about whether they had experienced water pipe leaks or not, and afterwards made clear that this survey was about flooding from precipitation only.

A realistic and fair payment vehicle for the provision of the public good in question is essential in order to get valid WTP estimates. As insufficient sewer mains and limited drainage of water in public areas are the most common causes for urban floods, charges connected to sewage disposal seemed to be an appropriate payment vehicle. Almost all household in urban areas have service pipes connected to the municipal water and sewer mains. Thus, almost all households in Norway pay, usually quarterly, for disposal and treatment of sewage as part of their municipal charges bill. This bill also includes payment for the provision of drinking water, waste collection, and chimney cleaning. Thus, an increase in municipal charges was found to be the most appropriate payment vehicle for this study. It is important to note that the payment vehicle in both scenarios (A and B) was identical; i.e., an increase in households' annual bill for municipal services.

In scenario A, the payments would cover investment costs in flood prevention measures. In scenario B, payments would cover an additional insurance the municipalities would buy in order to compensate households affected by floods for any expenditure the households would have in excess of what their insurance covers. This could be private deductibles, and reduction in compensation due to old age of affected household items. Thus, in scenario A, household payments would avoid the flood, while in scenario B, their payments would not, but their private damage costs from floods would be fully covered.

A payment card (Bateman *et al*., 2002; Navrud, Ready, Magnussen, & Bergland, 2008) was used to elicit households' WTP for CV scenarios A and B. The payment card consisted of a horizontal line with different amounts ranging from 0 to 12 000 NOK,[3] but avoiding round numbers like 500 and 1000 NOK. The respondents were asked to move the cursor on the line from a starting point to the very left of 0 NOK to the highest amount their household certainly would be willing to pay. They could also select the options; "don't know" and "other amount, please specify the amount." They had to move the cursor or select one of these two options, to be allowed to continue the survey. This procedure secures high item response rates in internet surveys. The respondents were then asked the following WTP-question: *"How much is the most, if anything, your household certainly is willing to pay in increased municipal charges pr. year to …?"*

A payment card is especially suitable for internet surveys. Depending on their answer, the respondents were then routed to debriefing/follow-up questions; either *"What is the main reason you are willing to pay something for..?" or "What is the main reason you are not willing to pay anything for..?"*. These questions were important during the pretesting to check whether the CV scenarios and WTP questions worked well, but were also used in the main survey to identify possible invalid reasons for paying and to identify zero protests bid (i.e., respondents protesting the CV scenarios by stating zero WTP for other reasons than having zero welfare loss). As we had two CV scenarios, A and B, they had to go through this procedure twice. After having stated their WTP for A and then B, their two WTP amounts were displayed side by side in the same screen, and they were asked whether they would keep the amounts or revise them. The respondents were also told in an advance disclosure procedure that they would be asked to value two scenarios. These two procedures were put in place to make respondents aware of the difference between the two scenarios.

2 | RESULTS AND DISCUSSION

The results showed that 863 out of 1060 respondents stated their WTP for *both* wtpA and wtpB. However, 5% of them protested by answering zero WTP and stating *"I pay more than enough in municipal charges" as the main reason for not being willing to pay anything.* Thus, it seemed like 95% of the respondents accepted increased municipal charges as a realistic and fair payment vehicle.

We apply the Interval Midpoint WTP-model (Cameron & Huppert, 1989; Tian, Yu, & Holst, 2011) to estimate respondents' WTP from their response to the payment card. The method assumes that respondents' "true" WTP lies at the midpoint between the selected amount and the next WTP amount (to the right) on the sliding scale. For respondents stating the lowest value ("0 NOK") and the highest value ("12 000 NOK" or "more than 12 000 NOK, please state the amount") these exact amounts were used as their "true" WTP.

This section is structured as follows: First, we describe the exclusion criteria and categories of respondents excluded from the gross sample in order to define the *net* sample used for the econometric (regression) analysis. Second, we present descriptive statistics of the net sample for the explanatory variables used in the econometric analyses. Third, we present the results from the econometric analysis of wtpAB in terms of Probit and ordinary least square (OLS) models. These models are also tests of criterion validity; i.e., whether WTP varies with determinants as expected from economic theory and results from previous CV surveys. The statistical software R® (Bell Laboratories, New Jersey, US), version 3.2.0 and R-studio® (RStudio, Inc, Boston, US), version 0.98.1103 were used for the analysis. Fourth, we present mean WTP estimates for the value of avoiding insecurity from urban floods (mean wtpAB), for use in CBAs of preventive measures.

2.1 | Exclusion criteria

We excluded respondents with missing or unreliable responses to the WTP-questions. According to Bateman *et al*. (2002), these should include the following three categories:

1. "Don't know"—responses to the WTP-questions.
2. "Protest zeros," i.e., respondents stating WTP = 0, and selecting one alternative which reveal that they have not stated their "true" WTP. Thus, they have a positive WTP, but state zero WTP because they protest some part of the CV scenario. Response options regarded as protest zeros were: "The authorities should pay for/do more for preventive measures," "I already pay enough in municipal charges," and "I think alternative A (or B) seems unrealistic." These responses confirmed that they protested against the CV scenario, and that they very well could have a "true" positive (non-zero) WTP. Thus, counting these responses as zero WTP could underestimate mean WTP, and the respondents should therefore be excluded from the sample (Navrud *et al.*, 2008). Respondents stated wtpA and wtpB separately, and had to provide the main reason for zero WTP for each of them. "Real" zero bids were respondents that stated: "I cannot afford to pay," and those that were not concerned about urban flooding. Among those that stated zero WTP, there were 51 (out of 165) and 118 (out of 276) zero protest bidders for scenarios A and B, respectively. This level of protest bidders, 30–40% of the zero answers, is about the same or somewhat higher than found in other CV surveys (Bateman *et al.*, 2002). In order to determine what characterised the zero protest bidders, probit models of protest zeros bids versus real zero bids were regressed against socio-economic variables (*Age, Male, LogHouseInc, HighEducation*, *Worker,* and *Basement*). The only significant explanatory variable (at the 10% level) of the variables listed in Table 3 was *Male* for scenario B. Thus, men provide more protest zeros than women when asked their WTP in terms of increased municipal charges in the "Insurance" scenario.
3. Unrealistically high WTP bids; i.e., respondents who refuse to take the survey seriously and/or provide unrealistically high bids. Only one respondent was identified in this category.

Table 2 shows the number of respondents for each of these three exclusion categories. Furthermore, the table reports the number of inconsistent non-zero WTP bids, defined as wtpAB being negative, meaning wtpA < wtpB. As scenario A should make households better off, or at least as well off as B, wtpAB<0 is not rational, and these respondents were removed from further analysis. According to Bateman *et al*. (2002), a comparison of characteristics between the excluded and the net sample should be made. A comparison of the socio-economic characteristics shows that the respondents in the excluded sample have on average only slightly lower age, income, education level and workforce participation (i.e., variables Age, Income, HighEducation, and Worker, respectively) than those in the net sample.

TABLE 2 Number of respondents (*N*) in gross sample, excluded for different reasons and net sample

Category	*N*
Net sample	
wtpAB > 0	311
wtpAB = 0	332
Sum net sample	643
Excluded	
Don't knows for wtpA or/and wtpB	197
Protest bid for wtpA or/and wtpB	131
Unrealistically HIGH value of bidsfor wtpA or/and wtpB, WTP > 15 000 NOK	1
wtpAB < 0	88
Sum gross sample	1060

Furthermore, the gender composition, percentage of households having basement, and level of felt exposure to urban floods is also quite similar. Thus, as our net sample is not significantly different from the excluded sample, we can assume the net sample to be representative of the randomly sampled target population. Table 2 shows that the net sample consists of 643 respondents. Out of these, 311 had positive WTP and 332 had a real zero WTP, to avoid insecurity from urban flooding.

Table 3 provides summary statistics and descriptions of the explanatory (independent) variables, including variable names, of the net sample used in this analysis. As seen from the first column in Table 3, dummy variables were often constructed from merging several reply options from the questionnaire. Four of the variables in the table characterise physical and mental "closeness" to urban floods. These were considered important, and are presented and discussed in Tables 4–6. These variables tell if the respondents are exposed to or annoyed by urban floods, and if they have experienced an urban flood in their own house or know about any flooded houses in the region.

2.2 | Econometric analysis

To test the validity of the WTP responses WTP was regressed on socio-economic and other variables (defined in Table 3) expected to affect household WTP. As dependent variables, we used wtpA, wtpB, and wtpAB, respectively, in separate models. These WTP-variables, as well as the income variable were log-transformed, which means the regression coefficient for the income variable is the income elasticity of WTP.[4] However, for wtpAB, income was not significant (at the 10% level), neither with income as the only variable nor when we added the socioeconomic variables of Age, Male, HighEducation, Worker, and Basement. Running the same OLS models of wtpAB, but only for those exposed to urban flooding (i.e., *Exposed* = 1; see Table 3), we got the same result. In the OLS models of wtpA and wtpB (with only positive values, as for wtpAB), we found a significant and positive income elasticity for

TABLE 3 Summary statistics for explanatory variables for the net sample*

Variables	Variable name	*N*	Mean	SD
Age (in years)	Age	643	46.82	15.40
IncomePerpers 2015 (NOK)	PersInc	561	558 289	326 245
IncomeHousehold 2015 (NOK)	HouseInc	557	814 542	440 185
Male (1 = male/0 = female)	Male	643	0.49	0.50
Higher education (1 = College, University/0 = other)	HighEducation	639	0.72	0.45
Worker (1 = worker/0 = retired/social security recipient/student/unemployed/homeworker)	Worker	643	0.68	0.47
Basement in own resident (1 = yes/0 = no)	Basement	643	0.71	0.45
Exposed to flooding? (1 = highly, very, pretty much/0 = little, not at all)	Exposed	627	0.20	0.40
Annoyed by insecurity to flooding? (1 = highly, very, pretty much/0 = little, not at all)	Annoyed	643	0.07	0.26
I know others in my region affected by flooding (yes = 1/others = 0)	DistantFlood	643	0.33	0.47
Experience of flooding at home at own house (1 = yes/0 = no)	OwnExperience	643	0.10	0.30
I want to pay for others to get a reduction in their risk of urban flooding (1 = I agree, somewhat agree, neutral/0 = I disagree, somewhat disagree)	PayOther	630	0.69	0.46

*1NOK = €0.11 (2015).

wtpB of 0.49 when regressing on personal income only, and 0.47 when adding socioeconomic variables. This is in accordance with economic theory, and previous CV studies which typically find the income elasticity of WTP for public goods to be less than 1 (Bateman *et al*., 2002; Kristrom & Riera, 1996). For the other models, the income elasticity of WTP was not significantly different from zero. This indicates that people think preventive measures (wtpA) are important to pay for, independent of their income. It seems easier for them to state their WTP in terms of insurance, and wtpB seems to be more dependent on their income. This is in agreement with the findings for pluvial floods by Grann (2011).

Tables 4–6 present 13 regression models of WTP to avoid insecurity of urban floods (wtpAB). Due to the skewed distribution of wtpAB, we were not running a joint model for the entire net sample, but rather two types of separate models: (a) explaining *why* respondents were willing to pay something or not to avoid the insecurity (probit models); and (b) models only for those that were willing to pay something in order to find which factors determined *how much* they were willing to pay (OLS models). Thus, Table 4 (models 1–5) shows probit models with the dependent variable being whether they had positive wtpAB or not (i.e., taking the value 1 when wtpAB>0 and zero if wtpAB = 0). Table 5 (models 6–10) are OLS-models only for households that stated positive WTP (i.e., wtpAB>0). Finally, Table 6 (models 11–13) is a more detailed version of Table 5, where some significant variables are further separated into categorical value based on the response options.

All models include all independent variables from Table 3, except *PersInc*. One general requirement for

TABLE 4 Regression models 1–5 (Probit) with the probability of having positive willingness-to-pay for avoiding the insecurity from urban floods as the dependent variable (wtpAB>0 defined 1 and wtpAB=0 is defined as 0)

Probit 1 = wtpAB>0/0 = wtpAB = 0	Model 1 (probit)		Model 2 (probit)		Model 3 (probit)		Model 4 (probit)		Model 5 (probit)	
N	536		544		556		556		556	
Variables	*z* value	Pr (>|z|)	*z* value	Pr (>|z|)	*z* value	Pr (>|z|)	*z* value	Pr (>|z|)	*z* value	Pr (>|z|)
Age	−2.64	0.01***	−2.26	0.02**	−2.37	0.02**	−2.59	0.01***	−2.47	0.01**
Male	−1.63	0.10	−1.85	0.06*	−1.72	0.09*	−1.72	0.08*	−1.79	0.07*
LogHouseInc	−0.88	0.38	−0.79	0.43	−0.80	0.42	−0.90	0.37	−0.80	0.42
HighEducation	1.18	0.24	1.53	0.13	1.35	0.18	1.38	0.17	1.36	0.18
Worker	−1.14	0.25	−1.23	0.22	−1.27	0.20	−1.29	0.20	−1.26	0.21
Basement	0.82	0.41	0.47	0.64	0.49	0.62	0.60	0.55	0.77	0.44
Exposed	0.87	0.38	2.66	0.01***						
Annoyed	1.95	0.05			2.84	0.00***				
DistantFlood	1.38	0.17					2.17	0.03**		
OwnExperience	−0.74	0.46							1.15	0.25
PayOther	4.44	0.00***								
(Intercept)	1.00	0.32	1.15	0.25	1.20	0.23	1.30	0.19	1.21	0.23

***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level.

TABLE 5 Regression models 6–10 [ordinary least square (OLS)] with willingness-to-pay to avoid insecurity from urban floods as the dependent variable (only for those with wtpAB>0)

OLS wtpAB>0 *N* Adjusted R^2	Model 6 (OLS) 270 0.09		Model 7 (OLS) 273 0.04		Model 8 (OLS) 279 0.05		Model 9 (OLS) 279 0.03		Model 10 (OLS) 279 0.05	
Variables	*t* value	Pr(>|*t*|)	*t* value	Pr(>|*t*|)	*t* value	Pr(>|*t*|)	*t* value	Pr(>|*t*|)	*t* value	Pr(>|*t*|)
Age	1.59	0.11	1.80	0.07*	1.71	0.09*	1.52	0.13	1.64	0.10
Male	−0.57	0.57	−0.65	0.51	−0.57	0.57	−0.57	0.57	−0.76	0.45
LogHouseInc	0.05	0.96	0.19	0.85	0.36	0.72	0.19	0.85	0.45	0.66
HighEducation	0.40	0.69	0.71	0.48	0.56	0.58	0.58	0.56	0.28	0.78
Worker	−0.95	0.34	−1.07	0.28	−1.17	0.24	−1.09	0.28	−1.09	0.28
Basement	1.32	0.19	1.05	0.30	1.27	0.21	1.51	0.13	1.46	0.14
Exposed	0.69	0.49	2.53	0.01**						
Annoyed	1.02	0.31			2.91	0.00***				
DistantFlood	1.39	0.16					2.28	0.02**		
OwnExperience	1.44	0.15							3.36	0.00***
PayOther	3.18	0.00***								
(Intercept)	3.93	0.00***	3.98	0.00***	3.93	0.00***	4.05	0.00***	3.87	0.00***

***Significant at the 1% level; **5% level; *10% level.

reliable models are uncorrelated parameters. Due to the high collinearity between all *PersInc* and *HouseInc* ($R = 0.74$), one of them had to be excluded. *HouseInc* was preferred, as respondents were asked for household WTP (in terms of increased annual municipal charges), which is of course determined not only by personal income, but the overall household income. Observed collinearity between the three "flood variables" *Exposed*, *Annoyed* and *OwnExperience* (R varies between 0.37 and 0.56) could have biased the results in Model 1. Furthermore, there was weak correlation between these three variables and the variable *DistantFlood* (R varies between 0.22 and 0.24).

As these four variables characterise some aspect of what we have previously referred to as "closeness to flooding," they seem to be important determinants for WTP. For models 2–5 and 6–10, we only included one of them at a time, to see which of them best explained the variation in WTP. Socio-economic variables showed very little correlation, and were thus included in all models.

In model 1, *PayOther* is significant and positive (at the 1% level), showing that people who answered "yes" to the statement "*I want to pay for others in the community to have their risk of flooding reduced*" have higher probability of stating positive WTP for avoiding insecurity than those

TABLE 6 Regression models 11–13 (ordinary least square [OLS]) with willingness-to-pay to avoid insecurity from urban floods (only for those with wtpAB>0) as the dependent variable. The independent variables Exposed, Annoyed, and DistantFlood are here categorical variables

N Adjusted R^2	Model 11 (OLS) 273 0.05		Model 12 (OLS) 279 0.06		Model 13 (OLS) 279 0.04	
Variables	*t* value	Pr(>|*t*|)	*t* value	Pr(>|*t*|)	*t* value	Pr(>|*t*|)
Age	1.75	0.08*	1.71	0.09*	1.43	0.15
Male	−0.68	0.50	−0.74	0.46	−0.68	0.50
LogHouseInc	0.08	0.93	0.16	0.88	0.32	0.75
HighEducation	0.84	0.40	0.34	0.73	0.49	0.62
Worker	−0.99	0.32	−1.01	0.32	−1.25	0.21
Basement	1.16	0.25	1.44	0.15	1.28	0.20
Exposed1 (little)	−1.81	0.07*				
Exposed2 (quite)	0.48	0.63				
Exposed3 (much and very)	2.22	0.03**				
Annoyed1 (little)			−1.85	0.07*		
Annoyed2 (quite)			0.88	0.38		
Annoyed3 (much and very)			3.04	0.00***		
DistantFlood1 (within own region, >1 km away)					0.83	0.41
DistantFlood2 (between 100 m and 1 km away)					1.52	0.13
DistantFlood3 (<100 m away)					2.85	0.00***
(Intercept)	4.21	0.00***	4.23	0.00***	3.97	0.00***

***Significant at the 1% level; **5% level; *10% level.

that say "no" to this statement. Model 6 goes on to show that WTP for the latter group is lower than for the former; for those with positive WTP. This type of altruism does not represent double-counting when aggregating over all households, as people gain utility from knowing others get more secure (and know that these other people have to pay increased municipal charges to avoid insecurity).

In Table 4, Age is significant and negative, showing that there is a lower probability of being willing to pay something with higher age. But among those that are willing to pay something, and according to models 7 and 8 in Table 5, the WTP seems to increase with higher age.

Models 2–5 imply that men are more likely than women to state wtpAB = 0. Comparing models 5 and 10, we see that while *OwnExperience is* highly significant with a positive sign in model 10, this variable is not significant in model 5. This indicates that having experienced floods does not influence the decision on whether you are willing to pay something or not, but if you have positive WTP, it is higher if you have had this experience.

Models 6–10 show that all four "closeness variables" are significant (at the 5% level) and positive, confirming our theoretical expectation that people feeling "close to flooding" have higher WTP to avoid insecurity from flooding than those that don't (given that they have wtpAB>0). Each of these "closeness variables," except *OwnExperience*, have several reply options. In order to see whether each reply option is significant, we reran models 7–9, but now with each category as a dummy (with the exception of the "hidden options" of *"Not exposed at all," "Not annoyed at all,"* and "*No—I don't know any others within my region affected by floods* for the *Exposed*, *Annoyed* and *DistantFlood* variables"; respectively).

The results presented in Table 6 show that the most exposed, annoyed and knowledgeable about flood damages within 100 m of their home, have a significantly higher WTP than those that are not exposed, not annoyed or do not know about flood damages in their region, respectively.

Even if *Age* is significant at 10% level in models 11 and 12, none of the demographic variables seemed to affect WTP as much as *Exposed, Annoyed,* and *DistantFlood* do.

According to Carson and Flores (2000), it is reasonable to assume that respondents who are "closer" to flooding, both literally and figuratively, should also have a higher probability of paying for an increment in the public good "security against flooding," than people with little experiences in this regards. Results in Tables 4–6 confirm this hypothesis.

2.3 | Calculating mean WTP

Based on the net sample of 643 respondents (see Table 2), we can calculate *mean* WTP for avoiding insecurity from urban flooding (i.e., for all respondents with wtpAB ≥ 0). Mean WTP is the correct welfare measure in CBA of the preventive measures, and would be aggregated over the number of affected households for each project in order to estimate the aggregate social benefits from avoiding insecurity. However, as we have seen above, WTP varies with "closeness to flooding." This means that if we used our mean WTP estimate in CBAs, we would implicitly assume that the distribution across different levels of closeness to flooding would be the same at the site of the specific flood prevention project (of which we were conducted a CBA) as the distribution in our sample. This is probably not the case as our sample was not representative of the overall population. Here, close to 20% of the respondents stated that they were prone to flooding, while for the overall population the number is probably less than 5%. Thus, conducting a CBA of preventive measures nationwide, using the mean WTP estimate from our survey, multiplied by the total number of Norwegian households, would produce a biased aggregate benefit estimate. To correct for this, we will present estimates of mean WTP for each category of the "closeness to flooding" variables, and multiply these estimates with the corresponding number of affected households in each of these categories.

The same would apply to the demographic variables, if the sample is not representative of the affected households at the project site where we will perform a CBA, whether this is a local or a national flood prevention project/plan. Our sample was not representative of the Norwegian population with regards to income and education, as both were higher in our sample than in the Norwegian population (SSB, 2016a, 2016b). However, as opposed to the "Closeness of flooding" variables, none of these variables had a significant impact on WTP. Thus, there was no reason to make adjustments for these demographic variables.

Table 7 shows the WTP for each category of the "Closeness to flooding" variables: Exposed, DistantFlood, and OwnExperience. The fourth closeness variable, "Annoyed" (even though also significantly affecting WTP) was found to be difficult to use in CBAs of preventive measures as it would be hard to find the distribution of the affected population on the different categories of this variable. However, for the other three variables this should be possible, and enable the calculation of aggregate benefits of a national flood prevention plan.

As expected, households' WTP increased with higher levels of each of the three "closeness to flooding" variables. If we compare the highest level/category of "Closeness to flooding" across the three variables (*Exposed3*, *DistantFlood3,* and *OwnExperience1*) we see that the lowest WTP estimate belongs to respondents with personal experience with flooding (*OwnExperience1*). This indicates more insecurity among those who believe they can be affected (reflected in the *Exposed* and *DistantFlood* variables) than among those who actually have been affected (*OwnExperience*). This could be explained by people having experienced flood damage thinking it was not so bad as they had expected, and/or that these people later on have

TABLE 7 Willingness-to-pay (WTP) per household per year (in terms of increased municipal charges) to avoid insecurity from urban floods, for different categories of three variables/measures of "closeness to flooding"; Self- assessed exposure to urban floods at own home (Exposed), distance to others that had experienced floods (DistantFlood), and experience with flooding at own home (OwnExperience)

WTP-values in Norwegian Kroner (NOK) (1 NOK = 0.11€ (2015)) Variables	Median WTP	Mean WTP	SE mean	N
Exposed0 (no)	0	399	63	227
Exposed1 (little)	150	416	56	273
Exposed2 (quite)	250	665	115	99
Exposed3 (much and very)	425	1200	465	28
Exposed (NA)	0	350	161	16
DistantFlood0 (do not know any floods within region)	0	367	32	434
DistantFlood1 (within own region, >1 km away)	150	584	126	115
DistantFlood2 (between 100m and 1km away)	300	693	192	63
DistantFlood3 (<100m away)	400	1255	425	31
OwnExperience0 (no)	0	432	39	581
OwnExperience1 (yes)	275	938	243	62

put in place preventive measures (e.g., moving all valuable in the basement to a higher floor) that have made them worry less about the possible damages from future urban floods.

For those not exposed or affected (i.e., the lowest category of "closeness to flooding" in all these three variables), mean WTP /Household/year is quite stable around 400 NOK.[5]

For practical purposes, we believe that the WTP estimates from the variable based on Distance to other areas with floods (*DistantFlood*) is most appropriate to use in CBAs of smaller projects. If the authorities should initiate a preventive flood project, it is usually because more than one household is exposed. This is because it is easy to map different zones based on distances from former flood affected areas. Moreover, the small number of observations (respondents) for the most affected categories makes the mean WTP estimate for these categories more uncertain than for the others. As a conservative, lower estimate, we suggest insecurity cost within the 1 km zone from the previously affected areas to be 800–900 NOK per household per year. Outside this zone, we suggest using a WTP of 400 NOK per household per year.

As there, to our knowledge, are no previous studies specifically valuing insecurity of the impact of pluvial floods, we compare our results to WTP estimates from two previous studies of impacts from fluvial (river) floods. DEFRA (2004) conducted a survey in the UK to calculate the health benefits from reduced flood risk. They recommended a value of £200 (2004) per household per year for affected households. Using a Purchase Power Parity-corrected exchange rate between UK £ and NOK in 2004, and adjusting with the Norwegian consumer price index (CPI); from 2004 until 2015 (the year of our study) this corresponds to about 3000 NOK (2015). Grann (2011) conducted a CV study near the urban center of Drammen, Norway in 2011, and found a mean WTP/household/year for avoiding the insecurity from river flooding to be about 100 NOK (adjusted with the CPI from 2011- to 2015-NOK). Note that this is the mean WTP over *all* categories of exposure to floods; including those not exposed. Furthermore, even if Drammen is considered to be exposed to floods, there had been no disastrous river floods just before the survey was conducted; which there had been prior to the UK CV survey. This might be one explanation for the difference in WTP between the two studies.

3 | CONCLUSION

If the benefit of reduced insecurity for urban flooding is valued, social benefits of avoiding these floods will increase. This can affect the outcome of CBAs of measures preventing urban floods, justify implementing a higher number of preventive measures and/or change the ranking of projects involving such measures (Navrud *et al*., 2012; Navrud & Magnussen, 2013). The outcome of this CV study should thus be of special interest to local politicians and urban planners using CBAs as a decision support tool, but also to insurers in their assessment of the overall risk to households and their WTP insurance premiums for urban floods.

This study shows that it is possible to measure the WTP to avoid insecurity for urban flooding in a CV survey. In the CV-studies, respondents were asked about their preferences for hypothetical scenarios. In general, the hypothetical context is the main argument against CV, while those in favour of CV argue that the respondents are able to place this in a real context if the scenario is carefully designed and the payment vehicle is realistic. Currently, CV is seen as relatively uncontroversial, but the results should be considered as an order of magnitude estimate (Boardman, 2011; Messner *et al*., 2007; Navrud, 2005). There are some limitations to the study: From the gross sample of 1060 respondents, 39% were excluded mainly due to what we considered as inconsistent answers. Finally, 643 observations were left for the analysis. Even if only 16% of the respondents stated this to be a difficult survey to answer, future studies should pay even greater attention to the phrasing and design of the CV scenarios in order to reduce the number of inconsistent answers. We have no indication that the exclusion of inconsistent answers reduced the representativeness of the net sample, but this is certainly an area for future research. Furthermore, for households most exposed to urban floods there are relatively few observations, making WTP estimates for this group more uncertain than for the lower levels of flood exposure. Thus, future studies should, if possible, apply sampling procedures achieving more respondents highly exposed to urban floods; and combine measures of subjective exposure with objective measures of exposure. Also, more studies are needed in order to validate our approach of comparing WTP for two scenarios to value insecurity, together with other ways of applying CV and CM to this still little researched topic.

While demographic variables have no significant impact on WTP for avoiding insecurity (with the possible exceptions of age and gender), measures of physical and psychological closeness to flooding seem to be significant. The survey indicates that people who do not regard flooding as a big concern, have a mean WTP /household/year of about 400 NOK while those who are concerned are on average willing to pay two to three times this amount annually to avoid the insecurity.

The valuation method applied here, and the results of this study, can serve at least three purposes:

1. Social benefits of avoiding insecurity can be included in CBAs of measures/projects/plans to prevent urban flooding, and similar benefits should be added for other types of floods (e.g river floods). DEFRA, 2004 states that more "tangible" losses from flooding (property damages etc) are the largest components of flood damage costs, but that inclusion of health impact can change the ranking of prevention projects. This is due to the fact that unlike the "one-time costs" of physcial property damage associated with individual flood events, the insecurity from the risk of flooding is a "continuous cost" for the affected households. Although, households' annual "cost" of insecurity is limited, and will fluctate with changing weather and over seasons, these costs could easily add up to a significant amount when aggregated over time for all affected households.
2. CV studies like ours can shed light on a hidden everyday psycological challenge for some people, which others do not care much about. Publicity in the local media where households are exposed, can be a way to address this issue. For example, neighbours living in higher elevation can be informed that they should carefully consider where to drain their rainwater to reduce the insecurity of flooding to people downhill. Simple information and awareness raising measures like this can be implemented in affected small urban areas by local authorities without initiating expensive technical projects. As information measures alone are rarely effective, the welfare loss from insecurity could be used as an argument to introduce clearer restrictions on how residents can drain rainwater from their own property; and/or uphill households can be made liable also for the insecurity costs of flooding to people downhill.
3. This method of measuring the social benefits of avoiding insecurity of flooding caused by rainwater can be relevant for river flooding and other natural hazards like landslides. Note, however, that our study does not look at events with disastrous and fatal consequences; and thus the method applies to other natural hazards causing the same type and level of physical damage. The insecurity cost estimates per household/year are not directly transferable to flooding in rural areas, as there are usually better opportunities for infiltration there and fluvial floods are more likely the cause of flooding, but it could serve as a preliminary, order of magnitude estimate of insecurity costs also in the rural context.

If the inclusion of the additional benefits from avoided insecurity results in more flood prevention projects passing the benefit–cost test and being implemented, the title of our paper will be realised—more people will be singing in the rain.

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NOTES

[1]The description of the health symptoms people were asked their WTP to avoid in the CV study by DEFRA (2004) was: "You always feel nervous, have palpitations or feel tense when reminded of the flood. You always feel emotionally estranged, separated, or cut off from others. You are always being reminded of the flood by triggers (such as TV programs). You always have difficulty concentrating on tasks or completing tasks. You often experience difficulty sleeping. These symptoms will distress you very much'.

[2]Income questions were placed in the last part of the survey, as they could invoke negative feelings among some respondents and make them exit the survey early on if placed in the beginning.

[3]1NOK = €0.11 (2015).

[4]The log transformation also contributed positively to making the skewed distribution of WTP (as in most CV studies) closer to the normal distribution (Pevalin & Robson, 2009).

[5]1NOK = €0.11 (2015).

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