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Analysis

Climate change and the willingness to pay to reduce ecological and health risks from wastewater flooding in urban centers and the environment

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ABSTRACT

Climate change scenarios predict an increase of extreme rain events, which will increase the risk of wastewater flooding and of missing legal water quality targets. This study elicits the willingness to pay to reduce ecological and health risks from combined sewer overflows (CSOs) in rivers and lakes, and wastewater flooding of residential and commercial zones under the uncertainty of climate change. We implement a discrete choice experiment on a large representative sample of the Swiss population. We find that about 71% of the respondents are willing to pay a higher annual local tax to reduce the risk of CSOs in rivers and lakes. Swiss households strongly value the protection of water bodies, and mostly, the avoidance of high ecological risks and health risks for children related to CSOs in rivers and lakes. Our findings also show that climate change perception has a significant effect on the willingness to pay to reduce these risks. These results are important to support policy makers' decisions on how to deal with emerging risks of climate change in the water sector and where to set priorities.

1. Introduction

Water management faces daunting challenges because of complex changes and large uncertainties, a prime driver being climate change (Milly et al., 2008). Climate change scenarios predict an increase of extreme rain events (May, 2008). Studies in Europe and the U.S. predict an increase of severe storms between 35 and 100% (Butler et al., 2007; Grum et al., 2006). Enhanced weather variability will substantially affect the water sector, and increase flood-related risks (e.g., Kysely et al., 2011). Intense precipitation increases the risk of wastewater flooding of urbanized areas, and combined sewer overflows (CSOs) in rivers and lakes causing an increase in ecological and health risks by missing legal water quality targets.[1] Under climate change, it is highly unlikely that the current level of services supplied by the wastewater systems can be maintained without substantial additional investments into urban drainage infrastructures (Arnbjerg-Nielsen and Fleischer, 2009; MacDonald et al., 2010). This paper estimates the willingness to pay (WTP) to reduce ecological and health risks related to combined sewer overflows in rivers and lakes, and sewer surcharges resulting in flooding of residential and commercial zones under the uncertainty of climate change in Switzerland.

Untreated sewage contains pathogens (e.g., bacteria, parasites, and viruses), chemicals, pharmaceuticals, and nutrients that can pose a risk to human health and the environment (Donovan et al., 2008;

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[1] For example, in Wisconsin it is expected that the frequency of CSOs into Lake Michigan will rise by 50–120% by the end of this century, threatening the usability of recreational beaches (Patz et al., 2008). Likewise, simulations of waste and stormwater flows under climate change in Sweden are predicted to worsen existing drainage problems (Semadeni-Davies et al., 2008). In Norway, the number of CSOs is expected to increase 1.5–3 times as much as the increase in precipitation (Nie et al., 2009).

Ham et al., 2009; Kim et al., 2007; Kummerer, 2009; Musolff et al., 2010; Weyrauch et al., 2010). Children, the elderly, and those with a weakened immune system are particularly vulnerable to negative health effects (e.g., diarrhea, nausea, and infections). For instance, the U.S. EPA estimates that between 1.8 and 3.5 million people fall ill in the U.S. from recreational contact with waters contaminated by sewer overflows alone every year (U.S. EPA, 2001). In addition, wastewater overflowing into rivers and lakes implies an ecological risk for animals and water plants. For example, nutrients such as nitrogen and phosphorus can lead to eutrophication (Jankowski et al., 2006; Thevenon and Pote, 2012). Pharmaceuticals and personal care products contained in the wastewater pose a risk to the aquatic life even at low concentrations (Ankley et al., 2007; Daughton and Ternes, 1999; Kolpin et al., 2002).

A number of studies have simulated the effects of increased heavy precipitation under climate change scenarios on the urban drainage system. They all conclude that the current wastewater system is likely inadequate to deal with the excess water (and sewage in combined systems). Examples of such simulations come from the U.K. (Butler et al., 2007), Sweden (Semadeni-Davies et al., 2008), the U.S. (Patz et al., 2008), and Norway (Nie et al., 2009). Urban drainage systems have to cope with climate change that may seriously affect urban planning, and adaptation strategies must be defined and implemented to reduce ecological and health risks.

Engineers have different technical solutions to counter the effects of climate change on the wastewater sector. For instance, to reduce CSOs, it is possible to build wastewater retention tanks that buffer the wastewater during rain events; to reduce wastewater flooding of streets and cellars it is possible to build larger sewers (Butler et al., 2007). However, these countermeasures to climate change require substantial investments. For countries such as France, Germany, Italy, U.K., and U.S., the replacement values for the public system are typically 2600 US$ per capita and for small countries such as Austria, Denmark, and Switzerland 4800 US$ per capita (Maurer et al., 2005).[2] Therefore, an estimate of the benefits from adapting the sewer system to maintain current service levels under climate change is needed.

This interdisciplinary study estimates the benefits of adapting the wastewater discharge system to climate change to reduce ecological and health risks from three events: (i) combined sewer overflows in rivers and lakes, which are likely to increase the ecological and human health risks, (ii) sewer surcharges in streets resulting in flooding of residential and commercial zones, which induce personal and communal disutility for instance by disrupting the traffic; and iii) sewer surcharges of cellars, which result in personal disutility to the people owning cellars.

This study implements a discrete choice experiment to elicit the willingness to pay to reduce these risks in Switzerland. A representative survey among the Swiss adult online population from a panel of about 110,000 members of the Italian, French and German parts of Switzerland was conducted. The final representative sample of the Swiss population amounts to 1022 interviews. The final dataset contains a rich set of variables. Information has been gathered on the perception of climate change, the level of concern associated with the previous events about human health (children and adults, separately), and the environment. Respondents were asked to pick the most preferred option among a choice set of two alternatives. Each option differs from the others (i) in the type of event (wastewater flooding of cellars, wastewater overflowing in rivers and lakes, wastewater flooding of streets); (ii) in the average number of occurrences of an event; (iii) the health risk related to the event defined in terms of total cases of illness per year; (iv) the population affected (children or adults); (v) the ecological risk; and (vi) the cost (higher local taxes).

An additional attribute describing the scientists' confidence in the prediction for the average number of occurrences of the event has also been included for half of the sample. This treatment allows us to test whether climate change uncertainty influences respondents' WTP. Indeed, the outcomes of policy measures are not known to the researcher with certainty, in particular, in the context of climate change. However, typically in economic valuation it is assumed that the outcomes are certain as if they could be predicted accurately. Only recently, a couple of studies started to include the outcome uncertainty in stated preference surveys (Glenk and Colombo, 2011; Roberts et al., 2008). For example, Roberts et al. (2008) show that including uncertainty in the environmental outcomes affects people's WTP for water quality. Our study also contributes to this literature by presenting realistic scenarios that account for the uncertainty in outcomes because of climate change.

Our results show that Swiss households strongly value the protection of water bodies, and are concerned about the consequences of wastewater surcharges on the environment and on human health. We find that about 71% of the respondents are willing to pay a higher annual local tax to reduce the risk of wastewater overflowing in rivers and lakes. Our findings also suggest that climate change perception has a significant and positive effect on the willingness to pay to reduce these risks: people that perceived long term changes in climate are significantly more willing to pay to reduce these risks than people that did not perceive any change. These results are important to support policy makers' decisions on how to deal with emerging risks of climate change in the water sector and where to set priorities.

2. Literature review

Flood risks have been the main focus of studies addressing climate change, namely in the Netherlands, where severe effects are to be expected (e.g., Botzen, 2013; Botzen and van den Bergh, 2012a, 2012b; Botzen et al., 2009; Brouwer and Schaafsma, 2012), but also in Scotland, the U.K. (e.g., Glenk and Fischer, 2010), or the U.S. (e.g., Daniel et al., 2009). With respect to infrastructures, a number of studies have focused on the provision of (potable) water. Various studies concern developing countries, which face quite different problems than industrialized countries (e.g., Abramson et al., 2011; Brouwer and Akter, 2010; Brouwer et al., 2009; Moreno-Sanchez et al., 2012). In industrialized countries, the willingness to pay for the (uninterrupted) provision of potable water to households or the willingness to accept interruptions was elicited for example in the U.S. (Carson and Mitchell, 1993), in Australia (MacDonald et al., 2005, 2010) and in Spain in the context of the European Water Framework Directive (Martin-Ortega et al., 2011). The latter study, for example, found a high WTP, not only to secure the households' own water provision, but also to maintain a good ecological status of the river.

The willingness to pay for high ecological water quality has been elicited in a number of studies, but often without explicitly mentioning the wastewater infrastructure (Birol et al., 2006) and stormwater management (Braden and Johnston, 2004). An early contingent valuation study elicited WTP for minimum water quality levels for boating, fishing or swimming in the U.S. (Carson and Mitchell, 1993). This was followed by a later large study concerning the value of water quality (Viscusi et al., 2008). An Australian contingent valuation study focused on protest responses, using the example of stormwater pollution abatement (Jorgensen and Syme, 2000). While methodologically very interesting, the suggested policy measures, however, were not related to the wastewater infrastructures. A recent choice experiment from Switzerland investigates the effects on welfare estimates of using risk ladders to communicate risk related to micropollutants in water bodies (Logar and Brouwer, 2013). While this study addresses very advanced water pollution control measures, wastewater is still not treated state-of-the-art in some European countries, in particular in Eastern and

[2] In Switzerland, generations of engineers have developed a highly advanced water supply and wastewater infrastructure system—financed by the population—that provides the highest quality services to all. This infrastructure is expensive; the replacement value has been estimated at $240.3 \cdot 10^9$ US$ ($218 \cdot 10^9$ CHF), with $6.9 \cdot 10^9$ US$ ($6.3 \cdot 10^9$ CHF) annual costs. It is also worth to note that in Switzerland 70% of the sewer system is combined and that pure separate systems are rare (Herlyn and Maurer, 2007).