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# Land use trade-offs for flood protection: A choice experiment with visualizations

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ABSTRACT

Hydrological processes respond to changes in land use. Thus, hydrological ecosystem services can be affected by land use trade-offs and need to be considered in both land use management and water management. In this paper we present a choice experiment study from a medium-sized mountainous catchment area in Switzerland investigating individual preferences for long-term land use changes. The study focuses on trade-offs concerning reforestation, settlement development, and river management and on resulting effects on flow regulation and flood protection ecosystem services. Furthermore, the study investigates the influence of political choice recommendations on individual choice behavior.

We report three major results: (1) Respondents showed clear but heterogeneous preferences for long-term land use changes. (2) Respondents were willing to trade off extensive agricultural land for flood protection ecosystem services, namely through reforestation and widening of the riverine zone. (3) Choice recommendations by political parties and interest groups did influence individual choice behavior in Discrete Choice Experiments but did not, as expected, decrease implicit benefit estimates.


## 1. Introduction

In Alpine areas, where land is a scarce resource, land use competition and trade-off decisions between land use alternatives are in the focus of land management. High land use competition results in land use changes, such as urbanization, reforestation, or changes in agricultural management. These land use changes substantially affect and alter hydrological processes in freshwater ecosystems (Bronstert et al., 2002; Eshleman, 2004) including effects on stream flows, flood potential, and sedimentation (DeFries et al., 2004). The impact of land cover and land use change on stream flow, water discharge, and flood potential has received substantial attention in the last decades (e.g. Gerten and Lucht, 2012; Gerten et al., 2008; Jones and Grant, 1996; Molnar et al., 2006; O'Connell et al., 2007; Schnorbus and Alila, 2004; Schoonover et al., 2006; Tong, 1990; Zhang and Schilling, 2006). Awareness has risen that, in order to provide flood protection on a sustainable basis, it is necessary to apply a holistic approach, considering not only technical flood protection measures but also land use management (Calder and Aylward, 2006; Wheater and Evans, 2009).

In the mountainous areas of the Swiss Alps, flood prevention plays an important role on the agenda of river and riverine zone management (FOWG, 2001). To avoid unwanted and possibly irreversible effects of land use trade-offs on hydrological ecosystem service provision (as defined by Brauman et al., 2007), land use management needs to take into account ecological, economic, and social values as well as the political acceptance (de Groot et al., 2010). Stated preference methods, such as discrete choice experiments (DCE), are suitable methods for testing the political acceptance of environmental scenarios and for valuing nonmarketable goods and services provided by these scenarios (Freeman, 2003).

In this paper, we investigate the acceptance of long-term land use changes (2010 to 2100) and their impact on flow regulation and flood protection ecosystem services on the catchment scale with a case study in the Swiss mountains. The study focuses on land use trade-offs (concerning forest, agricultural, settlement, and riverbed area) which must be considered in strategies for increasing the capacity of a catchment to provide natural flood protection. In order to address the key challenges in assessing land use trade-offs, we developed a DCE to

*Abbreviations:* DRZ, downstream riverine zone

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(1) determine individual preferences for settlement development, reforestation, and technical vs. ecological measures for water regulation, (2) to investigate whether people are willing to trade off land for flood protection ecosystem services, and (3) to investigate whether political recommendations influence individuals' decisions on these trade-offs.

The remainder of the article is organized as follows: In Section 2, we describe the study area with a focus on land use trade-offs and their impact on flood protection. Section 3 contains a methodological introduction to Discrete Choice Experiments. Experiment setup and study design are described in Section 4. The study results are presented in Section 5 and discussed in Section 6.

## 2. Study area

Over centuries, flood protection in Switzerland has moved from local control structures, retaining dams, and barriers in the early modern period to large river corrections and canalizations in the 18th and 19th centuries (Vischer, 2003). In the 20th century the concept of mere flood protection has further evolved to the principles of integrated water management, an intersectoral approach encompassing management of water resources, water bodies and water infrastructures on the catchment scale. The approach encompasses human interventions with all water bodies that need to be coordinated, specifically use of, protection of and protection from water (WA21, 2011). With the introduction of the new concept, the focus of water management has changed from small-scale sectoral to catchment-scale integrated management strategies (FOWG, 2001), targeting ecosystems, their functions, and their positive and negative impacts on human wellbeing across administrative boundaries.

The Kleine Emme catchment underlies a nivo-pluvial-prealpine runoff regime (LHG, 1992) and does not contain any barrier lakes. Precipitation mainly consists of rainwater, which is directly transformed into discharge due to the geological and pedological conditions of the catchment, which may lead to flooding during all times of the year, although mainly in summer (Stadelmann and Lovas, 2000). Management measures, such as an increase of the riverine zone, protection forests, and accurate settlement planning, may add to the catchment's natural flow regulation capacity and thus support technical flood protection.

### 2.1. Catchment characteristics

The Kleine Emme catchment (Fig. 1) with an area of 478 km$^2$ is situated in central Switzerland, in the Canton of Lucerne, and includes the UNESCO Biosphere Entlebuch. The upland of the river encompasses 320 km$^2$ of mountainous area. The rural to periurban lowland covers 158 km$^2$. Approximately 35% of the study area are covered with deciduous, coniferous and mixed forests. Currently, development pressure is high in the periurban area adjacent to the city of Lucerne (north-east of the catchment) and decreases with increasing distance to Lucerne. In the upland, the population remains constant with around 16,000 inhabitants.

Overuse of forest resources between the 7th and 19th centuries led to devastating floods, causing the need for technical protection measures and reforestation. Documentation of technical flood protection measures in the study area goes back to at least 1800 (Fellmann, 1917). Since 1880, afforestation in the catchment raised the area covered by forest from 22% to 35% (Stadelmann and Lovas, 2000). Additionally, extensive technical protection measures were taken at the beginning of the 20th century (Fellmann, 1917). Nevertheless, minor flood events that cause noticeable damages happen every 10 years on average. The last major flood event

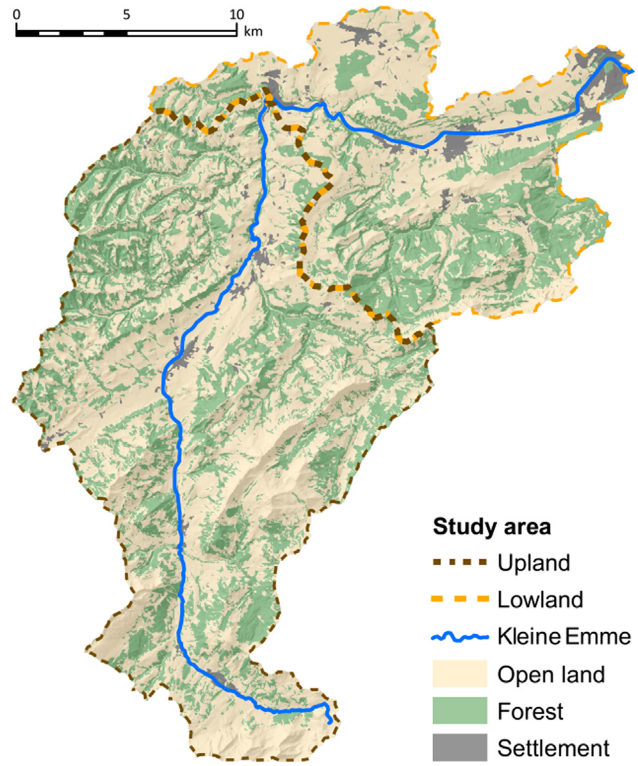


**Fig. 1.** The Kleine Emme catchment, divided into upland (upstream area) and lowland (downstream area), with forest, open land, and settlement area. Settlement pressure is highest in the north-eastern corner of the catchment and lowest in the southern mountainous area.

happened in 2005, causing damages of more than 100 million CHF[1] and initiating a large flood protection and renaturation project in the downstream area.

Based on an extensive analysis of global and regional climate models in the European climate research projects PRUDENCE (Christensen et al., 2007) and STARDEX (Goodess, 2003) and their specific evaluation for the Alps (Frei, 2006; Frei et al., 2006; Schmidli et al., 2007), Schädler et al. (2007) conclude that by 2050, as compared to 1990, an increase in the mean annual temperature and seasonal precipitation combined with snowmelt will result in higher flood peaks and flood volumes particularly in the winter half year. Furthermore, soil has a limited natural potential for water retention, therefore, due to a change of snowfall to rainfall and increased rainfall intensity, increasing sediment transport is expected (Schädler et al., 2007). Flood protection is thus of particular importance in the Kleine Emme catchment and will become even more important in the future as large volume flood events are expected to happen more frequently.

### 2.2. Land use trade-offs with effects on flood protection

In the Kleine Emme catchment, productive ground (i.e., settlement area and agricultural land) is a scarce resource. Research question (2) investigates whether and to what extent residents in the Kleine Emme catchment are willing to trade off land (forest, agricultural land, settlement area) for flood protection ecosystem services.

In the upstream area, respondents are expected to make a trade-off between forest and agricultural land use (meadows and

[1] 1 USD = 0.937 CHF (website of the Swiss National Bank, accessed on 10/06/2013).

pastures): increasing the area of agricultural land means less forest and vice versa. Although it is very challenging to identify, quantify, and predict the hydrological consequences of land use changes (Eckhardt et al., 2003), it is widely discussed that on a local scale deforestation generally results in a significant increase in annual water yield and changes runoff characteristics (Bosch and Hewlett, 1982). Reforestation on the other hand can to some extent reverse the hydrological responses to deforestation (Kim et al., 2014). Thorough reviews on the subject are given by, e.g., Ellison et al. (2012) and Eshleman (2004). While reforestation may positively impact the water storage capacity of the ground and the flow regulation capacity of the catchment (Eshleman, 2004), an increase of forest area changes the landscape aesthetics and may negatively influence the scenic beauty (Hunziker and Kienast, 1999) of the Entlebuch catchment. Research question (2.1) therefore addresses the willingness to pay of respondents for reforestation in order to increase natural flow regulation, until the point where the aesthetic effect equals or overweighs the flood protection benefit.

In the downstream area, the respondents traded off having a larger riverine zone against the revenues of agricultural land use. Today, the river is mostly channeled with a small riverine zone, which leaves more space for agricultural land use but also requires more sophisticated technical means of flood protection as compared to having natural flood protection from larger riverine zones. The land use in the downstream area also competes with settlement development. Housing areas in the flat plain close to the river offer amenities, such as a nice view of the water surface (Baranzini and Schaerer, 2011) and easy access to the river for recreation purposes. On the other hand, settlements near the river face greater flood risks and require expensive technical means of flood protection structures (e.g., flood dams) and specific asset protection, such as watertight doors and windows, protection walls, and backflow traps (FOWG, 2001). In fact, flood risk concerns lead people to not develop housing estates in areas close to the river. Research question (2.2) therefore refers to eliciting preferences for settlement development considering the subsequent loss of agricultural area and the increasing exposure to flood hazards.

The various kinds of land use competition put pressure on the river ecosystem, especially on the space available for the river to naturally flow (and overflow). While numerous river training and construction projects in Switzerland considerably improved flood safety and contributed extensively to the economic development of large areas in floodplains, minor as well as major flood events regularly demonstrate that structural measures have a limited protection effect (FOWG, 2001). The FOWG (2001) guidelines, in agreement with the Federal Law on Flood Control (WBG, 1991), therefore demand holistic flood protection planning, including land use planning measures to preserve open space along rivers and prevention of uncontrollable increase of damage potential on floodplains. However, natural streams need significantly more space at the expense of agricultural and residential land than channeled rivers. Therefore, research question (2.3) asks, to what extent residents are willing to trade off agricultural land and accompanying technical flood protection measures for a bigger riverine zone and increased natural flow regulation capacity.

## 3. Methodology

Stated preference methods, such as the Discrete Choice Experiment, can be used to determine the economic value of ecosystem goods and services by asking individuals directly to state their preferences for non-marketed goods. For an introduction to stated preference methods see, e.g., Champ et al. (2003) or Louviere et al., (2000); a review on environmental valuation with DCE is given by Hoyos (2010). DCE offer several advantages relative to other valuation methods (Holmes and Adamowicz, 2003) and are suited to deal with situations where changes are multidimensional and trade-offs are of particular interest (Hanley et al., 2001). DCE have been used in numerous studies to determine stakeholders' approval of intended land use changes (e.g., Brouwer and Schaafsma, 2013; Hanley et al., 2006; Newell and Swallow, 2012; Olschewski et al., 2012; Vecchiato and Tempesta, 2013).

Using visualizations in stated preference studies has become a widespread practice. The use of visualization techniques ranges from pictograms and illustrative drawings (e.g., Brouwer and Schaafsma, 2013; Johnston et al., 2002; Morse-Jones et al., 2012; Newell and Swallow, 2012; Nguyen et al., 2013) to photorealistic pictures (e.g., Arnold et al., 2009; Grêt-Regamey et al., 2007; Rehr et al., 2014), 3D visualizations (e.g., Dijkstra et al., 2003; Laing et al., 2005, 2009; Rid and Profeta, 2011) and virtual reality representations (e.g., Bateman et al., 2009; Bishop et al., 2009). Visualizations help to convey realistic change scenarios, reduce reliance upon response heuristics, and thereby allow underlying preferences to be more effectively measured (Bateman et al., 2009). They also reduce the fatigue of respondents and thus help prevent tiring effects (Dijkstra et al., 2003). Another advantage is that visualizations improve the comprehension of complex DCE content and by doing so have been found to significantly reduce gain-loss asymmetries (Bateman et al., 2009).

### 3.1. Statistical modeling

Discrete Choice Experiments are based on random utility theory (RUT). As introduced by McFadden (1973), the utility $U_{ij}$ of alternative $j$ for individual $i$ can be modeled as a function of an observable deterministic utility component $V_{ij}$ and an unobservable random component $\varepsilon_{ij}$ providing the remaining variability of the model:

$$U_{ij} = V_{ij}(x_j, \beta) + \varepsilon_{ij}, \quad (1)$$

where $x$ is the observed vector of attributes and $\beta$ is a vector of marginal utility parameters. In RUT the error terms $\varepsilon_{ij}$ are assumed to be independently and identically distributed (IID) following a standard type I extreme-value-distribution. The multinomial logit model (MNL), which is the most basic discrete-choice model, imposes the restrictions that the $\beta$s are constant across individuals and that choices are independent from irrelevant alternatives (IIA). The probability $P_{ij}$ that individual $i$ chooses alternative $j$ out of K alternatives can be formally denoted as:

$$P_{ij} = \frac{\exp(V_{ij})}{\sum_{k=1}^{K} \exp(V_{ik})}. \quad (2)$$

If the marginal utility of the attributes is believed to vary with individual characteristics such as age, gender, personal habits etc., interaction terms can be included in the utility function. The more complex mixed logit model (ML, McFadden and Train, 2000) relaxes the IIA assumption and allows for variations of the individual utility parameters across the sampled observations. The $\beta$s are assumed to be random parameters following a specific distribution (such as normal, lognormal, uniform or triangular) specified by the researcher as to capture unobserved heterogeneity across individuals. Essentially, the standard deviations of the random parameters form an additional error component (Hensher and Greene, 2003).

To calculate marginal prices, $MP_l$ of attribute $l$ is computed as the negative ratio of the respective attribute coefficient ($\beta_1$) and the coefficient of the cost variable ($\beta_2$) (further explained in Alberini et al., 2006):

$$MP_l = -\frac{\beta_1}{\beta_2}. \quad (3)$$

If it is assumed that the relationship between changes in the attribute level and changes in utility do not have a linear relationship, the single attribute parameter can be replaced by multiple unique parameters using dummy or effects coding (Louviere et al., 2000). If attribute $l$ has $n$ levels, it is represented with $n-1$ parameters ($\beta_{11}-\beta_{1(n-1)}$). The $n$th parameter represents the current situation and is set to zero. The marginal values of the levels of attribute $l$ are then computed for each level individually by replacing $\beta_1$ with the parameters estimated for each level, e.g., for attribute level $l_1$:

$$MP_{l_1} = -\frac{\beta_{11}}{\beta_2}. \quad (4)$$

## 4. Experiment setup and design

### 4.1. Choice Experiment attributes

Based on the land use trade-offs described in Section 2.2, we used three land use attributes (settlement development, forest re-growth, and size of the riverine zone combined with flood protection measures) and a cost attribute. Four levels were set for each attribute showing different scenarios of the year 2100 (Table 1). The long-term time frame of 90 years was chosen to make forest re-growth scenarios biologically feasible. In each attribute, one level was set to cover the status quo level representing the current situation in the study area. The other levels were defined to cover extreme scenarios addressing the various large uncertainties inherent in a long-term perspective. Rather large changes between attribute levels were required to cover the complete range of scenario situations without increasing the number of attribute levels and to facilitate the perception of land use changes in the visualizations.

The Swiss Federal Act on Forest (ForA, 2013) generally prohibits forest clearing, which makes a deforestation scenario highly unlikely. Yet, natural reforestation is likely to happen on abandoned alpine pastures on steep slopes (Gellrich et al., 2007). The natural reforestation scenario can be further extended by reforestation measures specifically aimed at flood protection forests to reduce the flood risk. The forest attribute describes the rate of forest-regrowth in the upstream area and the current land use (e.g., pasture, bog) of the area turned into forest. Given that deforestation in the study area is an unrealistic scenario, a status quo and three re-growth levels were specified with the “plus 60%”-level as the extreme scenario of reforestation. Additionally, biotic and abiotic characteristics of the newly reforested area (e.g., “small, remote clearings on steep slopes”) were given for each level.

According to the most recent population scenarios of the Swiss Federal Statistical Office (FSO), the population in the canton of Lucerne (377,000 in the year 2010) is predicted to grow between 4% and 27% until 2035 (FSO, 2014). Based on the federal scenarios, the canton of Lucerne assumes a growth of 12% between 2013 and 2035 (LUSTAT, 2014). National population development scenarios assume the population development rate to range between −14%

**Table 1**
Attributes and levels used in the choice experiment.

| Attribute | Attribute levels | | | |
|---|---|---|---|---|
| **Forest**<br>Forest management in the upstream area (% of forest cover) | **No change**<br>(35% forest)<br>• Active maintenance of remote open areas and bogs | **Plus 20% forest**<br>(42% forest)<br>• Natural reforestation of remotest areas | **Plus 40% forest**<br>(49% forest)<br>• Natural reforestation of rather remote areas | **Plus 60% forest**<br>(56% forest)<br>• Active and natural reforestation<br>• Nat. reforestation of protected bogs |
| **Settlement**<br>Settlement area and population development in the downstream area | **Slight decrease**<br>• No conversion of buildings outside residential area<br>• Deconstruction of buildings outside residential area after end of use<br>• Population and settlement area decrease slightly | **No change**<br>• Population and settlement area remain stable | **Slight increase**<br>• The villages Malters and Schachen grow togethe<br>• Population and settlement area increase slightly | **Strong increase**<br>• Littau, Malters and Schachen grow together<br>• New residential areas on hillsides between Malters and Wolhusen<br>• Population and settlement area increase strongly |
| **Flood**<br>Flood protection measures and size of the downstream riverine zone (DRZ) | **No change**<br>• No measures<br>• Riverbed capacity = 550 $m^3/s$<br>• 110 ha DRZ | **Flood project**<br>• Technical measures<br>• Riverbed capacity = 700 $m^3/s$<br>• 180 ha DRZ | **Widening**<br>• Upstream flood detention basins<br>• Riverbed capacity = 550 $m^3/s$<br>• Assumed peak reduction of 20%<br>• 200 ha DRZ | **Project + widening**<br>• Technical measures<br>• Riverbed capacity = 700 $m^3/s$<br>• 200 ha DRZ |
| **Cost**<br>Scenario costs (% changes of individual yearly income taxes) | **−2% income taxes**<br>• Range from −40 to −360 CHF | **0% tax change**<br>• 0 CHF | **+2% income taxes**<br>• Range from 40 to 360 CHF | **+ 4% income taxes**<br>• Range from 80 to 720 CHF |

and +44% until 2060 based on a population of 7.87 Mio in 2010 (FSO, 2010). Based on the population scenarios, we assume that the population development in the catchment will range between slight population decrease and strong population increase. A population and settlement area decrease, a status quo, and two population and settlement area increase scenarios were selected as levels for the downstream settlement attribute. Settlement area reduction was explained to the respondents as reduction of the local population with subsequent mandatory building removal (instead of a conversion) of abandoned buildings outside the residential zone. The levels were not given in numeric terms of population change, e.g., percentage of increase or decrease, but by explicitly naming the locations of the new residential areas (e.g., “the residential areas of the Malters and Schachen parish communities will join and will together form a new suburban community”) and displaying the residential areas in the visualizations.

The flood attribute describes the on-site flood protection and stream widening measures at the river banks. Considering technical and ecological aspects, a status quo level and three other levels were created, implying that the varying combination of measures leads to similar increase in flood protection in all attribute levels (except the current state). The first level describes an actual project, which is currently being implemented in the study area, with technical flood protection measures for increasing the riverbed capacity and some increase (plus 70 ha from currently 110 ha to 180 ha) in the downstream riverine zone (DRZ). The second level follows a mostly natural flood protection strategy and consists of a large increase of the DRZ (plus 90 ha) and the creation of upstream flood detention basins to reduce the peak flow of the river in heavy rain events (assuming a peak flow reduction of 20%). The third level combines a large increase in the DRZ (plus 90 ha) with technical flood protection measures, that are intended to increase the riverbed capacity. Respondents received information about the size of the DRZ, the volume of the riverbed, and the assumed peak flow reduction generated by detention basins.

DCE methodology is often applied to construct hypothetical markets using a survey and determine the willingness to pay (WTP) for an increase in an environmental quality or good or to determine the willingness to accept (WTA) for a reduction in an environmental quality or good in exchange for (monetary) compensation (Freeman, 2003). Generally it is assumed that respondents prefer higher over lower qualities of the environmental good in question, e.g., higher drinking water quality is preferred over lower quality. Thus, WTP is expected to increase with higher perceived quality of the environmental good. In some cases, however, the evaluation of a specific attribute in hypothetical scenarios might not be a priori known, e.g., forestation might be positively perceived as improving water retention but might also be negatively perceived influencing visual landscape aesthetics. In these cases and in case, where thorough pre-testing on the perception of specific attributes in the DCE are not possible, literature suggests to extend the scale of the payment vehicle in the DCE and allow for positive and negative levels of the cost attributes (e.g., done by Adamowicz et al., 1998; Rid and Profeta, 2011; Rose and Masiero, 2010). Furthermore, some of the choice set scenarios (e.g., river widening without technical protection) may actually be less costly than maintaining the existing structures over the next 90 years. Thus, respondents were offered a negative cost level implying a decrease in annual tax payments, a zero-level and two positive cost levels implying an increase in annual payments. Based on Schläpfer’s (2008) findings that hypothetical costs presented in dichotomous choice-questions should be as close as possible to actual costs of individual households, the cost attribute was specified as a change in individual taxes that are used by the local government to cover yearly contributions to flood protection. The contribution was expressed as a percentage of income taxes paid in 2011 (aggregated to 6 different tax classes).

### 4.2. Visualizations

GIS-based 3D visualizations were created for the landscape-scale attributes forest and settlement using ArcGIS 10 (ESRI, 2010) and Visual Nature Studio (3D Nature, 2012) software. The forest scenarios were designed with a spatially explicit multi criteria evaluation (Malczewski, 1999) based on literature and expert knowledge. Climatic, topographic, ecologic, and socio-economic factors were incorporated to estimate the re-growth potential of the local forest. Locations with the highest potential were selected for the plus 20% forest level, followed by locations with lower potential for the remaining forest levels. We used maps of current and planned settlement areas and topographic factors and then created population and settlement development storylines to spatially fix the development areas in the pictures for the settlement attribute. The visualizations of both attributes show typical sections of the landscape with characteristic changes in forest and settlement cover. The flood attribute was visualized as a close-up using a picture editing software. This allowed for a closer, more detailed view of specific on-site measures. Fig. 2 shows examples of the attribute visualizations.

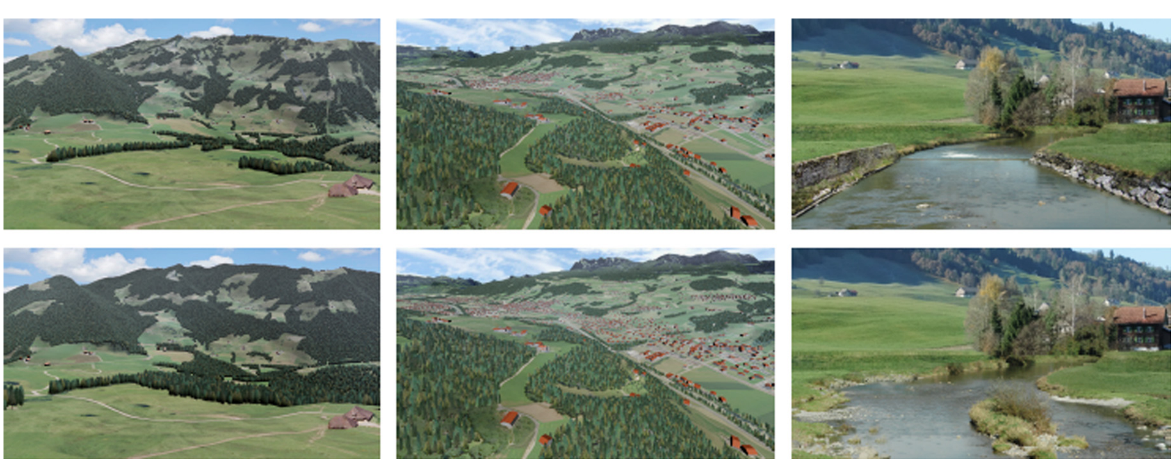

**Fig. 2.** Visualizations of the status quo levels (upper row) of the attributes forest, settlement, and flood; and of an alternative level (lower row, from left to right: plus 60% forest; strong settlement increase; widening)

### 4.3. Survey design

Respondents were asked to choose between two alternative future scenarios and an opt-out statement (“neither scenario”). The comparison of two choice scenarios with four attributes and four levels each results in a full factorial design of 4\widehat8=65,536 combinations. Following Louviere et al., (2000), we used the smallest possible orthogonal main effects design with 32 choice sets in the pretest. These sets were blocked into four groups to reduce the number of decisions per respondent to eight. The same number of choice sets and blocks was used in the main survey.

The survey consisting of an introduction letter, an information document and, a questionnaire booklet was sent to the respondents by postal service. A separate information sheet with choice recommendations from several political parties and interest groups (further explained in Section 4.4) was included in 50% of the envelopes.

The information document was designed as a DIN A2 poster. The front side contained a section with introductory information about the geographic situation of the study area including volume of the riverbed, flood frequencies, and peak flow. A second section informed about the influence of forest area and settlement area on the catchments natural water storage and flow regulation capacity and about possible flood protection/ river management measures and their effects on discharge capacity. The third section informed about the mechanisms of public and individual financial contributions to flood protection. The back side showed an overview of the DCE attributes with text descriptions, visualizations, and symbols of all attribute levels (except for the cost attribute, which was not visualized). Participants were instructed to check back with the poster while answering the choice questions.

The questionnaire started with general warm-up questions regarding recreational habits, attitudes towards landscape, nature and flood hazards, and personal experience of flood damages. Next, participants were asked to classify themselves into one of six predefined tax classes, which were used later on to derive an individual WTP for the choice scenarios. The ensuing choice tasks were described with symbols and attribute titles referring to the information poster (Fig. 3). The booklet concluded with questions regarding scenario feedback, protest answers, and usual statistical information.

### 4.4. Choice recommendations and protest answers

Schläpfer and Schmitt (2008) have shown that offering information about the opinions of political parties and interest groups to respondents in a referendum DCE leads to (1) a reduction of the frequency of non-usable responses, (2) a decrease of the implicit benefit estimates for the proposed policies, and (3) a transformation from general attitudes towards public spending for nature and landscape conservation to preferences for specific policies. We adopted the choice recommendation approach to test for replicability of Schläpfer’s findings (1) and (2).

Several political parties, interest groups, and environmental organizations were contacted by phone and email and were asked whether they would provide choice recommendations for the 32 choice sets presented in the survey. Five cantonal political parties, one cantonal environmental organization, and one national interest group were recruited. All organizations are regional sections (Canton of Lucerne) of national organizations, except the Swiss Farmers Union, which is a national organization. The persons in charge agreed to give recommendations twice, first within the pretest and again within the survey. Half of the survey participants were assigned to the “recommendation group” and received a list with the choice recommendations from all organizations for each choice task they had to answer (Fig. 4). The party positions that were sent with the final survey are summed up in Table 2. The “People’s Party” (Schweizer Volkspartei, SVP) recommended the opt-out statement in all choice-sets, thus encouraging strategic

| | CDP | LDP | GP | PN | SFU | SDP | PP |
|---|---|---|---|---|---|---|---|
| Scenario 1 | neither | B | A | A | neither | B | neither |
| Scenario 2 | neither | neither | neither | neither | B | A | neither |
| Scenario 3 | A | neither | B | B | neither | A | neither |
| Scenario 4 | B | neither | neither | B | B | B | neither |

**Fig. 4.** Excerpt of the choice recommendation list sent to respondents

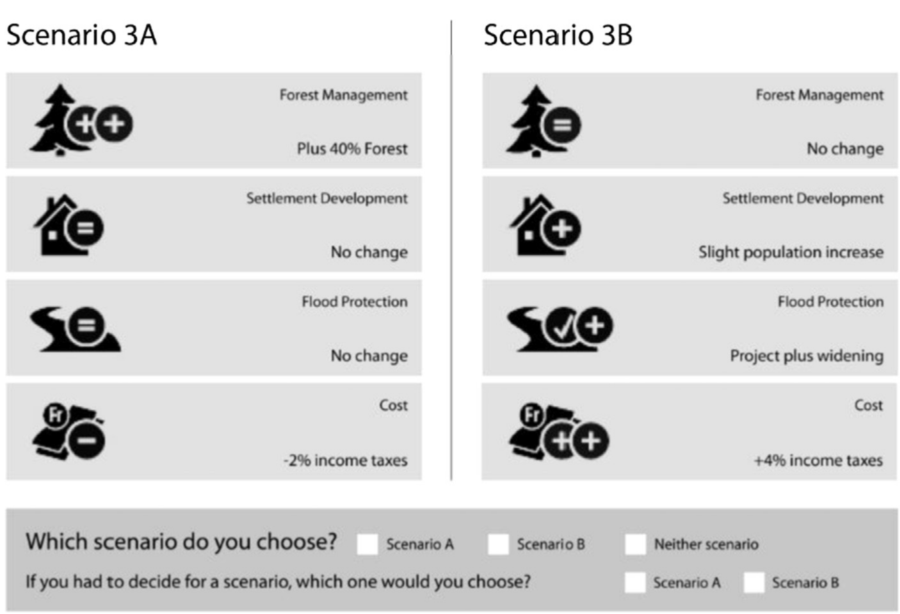


**Fig. 3.** Example of a choice task with short description and symbolization of the attribute levels

protest behavior. Although these recommendations were counted as protest behavior, they were included to test their influence on respondents' choice behavior.

Literature shows that the opt-out statement in DCE studies is usually selected in a significant proportion of the choice tasks. Meeting Huber and Zwerina's (1996) request for attribute utility balance, the proportion of opt-out responses may sum up to around 33%. Hanley et al. (2006) treat opt-outs analogously to zero bids in contingent valuation studies, indicating no utility if selected. Yet there exist different reasons for opting-out. Boyle (2003) distinguishes between genuine zeros and protest responses. In the present study, genuine zeros and negative values were covered by two cost attribute levels (0% and −2%). Boyle (2003) further divides protest zeros into disagreement with some component of the study, lack of understanding of the task, and strategic behavior in an attempt to influence the survey results. The choice recommendations of the "People's Party" were assigned to the latter category.

### 4.5. Sampling method and data stratification

The initial version of the questionnaire was repeatedly discussed with local experts in forest management, spatial planning, and flood protection and pretested with a focus group. The pretest with an orthogonal design was sent out to gain prior parameter information. The study area was segmented in upstream and downstream area. In each segment, 180 printed questionnaires were mailed to randomly selected adult inhabitants for pre-testing purposes, resulting in a sample size of 90 answers. Based on the answers, a prior utility function was derived, which was then used to create a Bayesian C-efficient design (Bliemer and Rose, 2005; Kanninen, 1993) for the main survey. Following respondents' feedback, the levels of the flood attribute were refined and the respective visualizations were updated. The survey was printed and mailed to 3200 spatially segmented, but otherwise randomly selected adult inhabitants. 48 questionnaires could not be delivered. A reminder was sent three weeks after the first mail. 592 questionnaires, i.e., 18.8%, were returned. 13 questionnaires were excluded from the preference analysis because respondents had not filled out the choice tasks or had given random answers in the introductory and feedback questions. 32 respondents chose the opt-out statement (or empty value) in all eight choice tasks. As zero and negative values were covered by the cost attribute, these questionnaires were treated as protest answers and were also excluded from further analysis. Thus, the survey resulted in 547 usable questionnaires. The sample characteristics of the survey (including protest respondents) are presented in Table 3. Distributions are similar in both segments and $\chi^2$-test for independence is significant only for the "educational level"-variable, which is higher in the downstream area, and for the distance of respondents' residence to the Kleine Emme River, which is larger in the downstream area. 101 of the 592 respondents reported that they suffered damages on private infrastructure in the last large flood event in 2005.

The information on political parties' recommendations given to the respondents influenced the choice of alternatives (Table 4). While in both segments of downstream or upstream respondents alternative

**Table 2**
Frequency of alternatives recommended by the political parties and interest groups.

| Party or interest group | Alternative A or B | Neither |
|---|---|---|
| Christian Democrats Party (CDP) | 18 | 14 |
| Liberal Democrats Party (LDP) | 19 | 13 |
| Green Party (GP) | 17 | 15 |
| Social Democrats Party (SDP) | 30 | 2 |
| People's Party (PP) | 0 | 32 |
| Swiss Farmers Union (SFU) | 18 | 14 |
| Pro Natura (PN) | 25 | 7 |

**Table 3**
Segmented socio-demographic and economic characteristics of the sample.

| | | Downstream | Upstream | Pearson's $\chi^2$ |
|---|---|---|---|---|
| Choice recommendation | Yes | 147 | 134 | 0.852 |
| | No | 141 | 150 | |
| Gender | Female | 119 | 122 | 0.22 |
| | Male | 169 | 160 | 8.001 |
| Age | 18–29 | 52 | 58 | |
| | 30–39 | 30 | 33 | 8.001 |
| | 40–49 | 69 | 65 | |
| | 50–59 | 61 | 41 | |
| | 60–69 | 47 | 40 | |
| | 70–79 | 19 | 28 | |
| | 80+ | 7 | 12 | |
| Tax class (CHF) | <2000 | 40 | 49 | 8.506 |
| | 2000–6000 | 93 | 108 | |
| | 6001–10,000 | 103 | 84 | |
| | 10,001–14,000 | 27 | 23 | |
| | 14,001–18,000 | 9 | 6 | |
| | >18,000 | 10 | 3 | |
| Education | Primary school | 24 | 36 | 7.934* |
| | Apprenticeship | 124 | 139 | |
| | High school | 28 | 24 | |
| | Diploma/certificate | 71 | 57 | |
| | University | 41 | 27 | |
| Housing distance to Kleine Emme river | <50 m | 8 | 28 | 24.669*** |
| | 50–99 m | 26 | 35 | |
| | 100–199 m | 29 | 38 | |
| | 200–500 m | 78 | 83 | |
| | >500 m | 144 | 93 | |
| Damage suffered in 2005 flood | Yes | 50 | 51 | 0.028 |
| | No | 234 | 230 | |

* $p < 0.1$.
*** $p < 0.01$.

**Table 4**
Frequency analysis of alternatives chosen (all respondents included).

| Information treatment | Alternative A | Alternative B | Neither | No answer | Pearson's $\chi^2$ | Pearson's $\chi^2$ (A+B vs. other) |
|---|---|---|---|---|---|---|
| Recommendation | 773 (28%) | 699 (25%) | 891 (32%) | 426 (15%) | 37.776*** | 3.499* |
| Control | 787 (33%) | 773 (32%) | 709 (30%) | 115 (5%) | | |

Significance levels:
* $=p<0.1$.
*** $=p<0.01$.

**Table 5**
Frequency of income tax classes.

| Tax class (CHF) | Frequency* |
|---|---|
| < 2,000 | 84 |
| 2,000–6,000 | 198 |
| 6,001–10,000 | 184 |
| 10,001–14,000 | 45 |
| 14,001–18,000 | 14 |
| > 18,000 | 11 |
| Total | 536 |

* Nr. of respondents; protest answers excluded.

A was chosen slightly more often than alternative B, respondents who received political recommendations more frequently chose the "neither" option or did not answer the choice task at all as compared to respondents who did not receive information on the recommendations of political parties (Table 4, last column).

With protest answers excluded, 536 of the 547 respondents assigned their income to one of six predefined income tax classes (Table 5). The class mean values were multiplied with the number of respondents per class and averaged over all respondents to derive the average price representing the cost attribute levels. The value in the lowest class was set to 1000 CHF and in the highest class to 18,000 CHF. The respondents paid 6175 CHF income taxes on average in 2011. Tax changes at the $-2\%$, 2% and 4% level thus corresponded to $-123.5$ CHF, 123.5 CHF, and 247 CHF, respectively.

## 5. Results

### 5.1. Estimation results

All models presented in this paper were estimated with BIOGIEME 2.0, an open source program developed by Bierlaire (2003). A general, additive utility function $U_{ij}$ was set up for options A and B:

$$U(\text{Flood protection}) = \beta_{forest} \times \text{FOREST} + \beta_{settle} \times \text{SETTLEMENT} + \beta_{flood} \times \text{FLOOD} + \beta_{cost} \times \text{COST} + \varepsilon_{ij} \quad (5)$$

where the $\beta$s refer to the marginal utility related to the DCE attributes and $\varepsilon_{ij}$ cannot be observed. An alternative-specific constant (ASC) was specified in the option "neither" to capture opt-out preferences. Technically the ASC captures the average effect on utility of all factors that are not included in the model (Train, 2003). If the ASC is associated with a behavioral assumption (Adamowicz et al., 1998), statistically significant and positive parameter estimates for $ASC_{neither}$ indicate that individuals prefer to choose the "neither" option instead of choosing either one of the scenarios (all else equal), which may occur due to status-quo bias to decision making (Samuelson and Zeckhauser, 1988). Further interpretations of the ASC are discussed by Meyerhoff and Liebe (2009). Using the 4219 choice observations delivered by 547 respondents, different MNLs and MLs were estimated with linear and nonlinear coding and varying inclusion of constants. The parameter estimates of the best fitting MNL and ML model are presented in Table 6.

#### 5.1.1. Multinomial logit model

A basic MNL model with three dummy coded attributes, a linear cost attribute, and an ASC for the "neither" option was found to have the highest absolute log-likelihood value. Adjusted $\rho^2$ reached a value of 0.034. Louviere et al. (2000) consider $\rho^2$-values of 0.2 to 0.4 an extremely good model fit, which is equivalent to 0.7 to 0.9 in linear functions (Domencich and McFadden, 1975). Although $\rho^2$ and adjusted $\rho^2$ (Ben-Akiva and Swait, 1986) are clearly below 0.2, most parameters are significant on the 1% level. The low goodness of fit indicates unobserved preference heterogeneity across respondents, interactions between variables, omitted variables, or a combination of these factors.

The results of the MNL estimation are reported in the first column of Table 6. "No change" (status quo) levels were selected in all attributes as base levels for the dummy coding. The respective parameter values are zero (e.g., Louviere et al., 2000) and thus lack additional statistic information. The dummy-coding of the attributes allowed estimating preferences for each attribute level individually. The resulting utility parameters show that preferences did not linearly correspond to attribute level changes. Whereas respondents showed positive preferences for a 20%- and 40%-increase in forestation, a strongly negative preference was associated with 60% more forest. A similar pattern was observed in the settlement attribute. The level with the highest growth was perceived as negative by the respondents. Regarding the flood attribute, an increase in the total riverine zone area was rated positive. For the two 200 ha levels (widening vs. project plus widening), preferences were stronger for natural measures (widening) than for the combination of technical and natural measures (project plus widening). The sign of the cost attribute's utility parameter was negative, which corresponds to economic theory.

#### 5.1.2. Mixed logit model

ML models offer a way to increase the model fit by using random instead of fixed parameters. The random parameters in the ML model define the degree of unobserved heterogeneity (via standard deviation of the parameter) and preference heterogeneity around the mean of an attribute-specific parameter in the utility function (Hensher and Greene, 2003). To test for unobserved heterogeneity across respondents, three ML models were set up with uniform, normal, and lognormal distributions using a number of 50 to 1000 Halton draws. The highest $\rho^2$ value was achieved assuming a normal distribution for all attributes except the cost attribute, which was specified as a non-random parameter (Table 6). As expected, the value of the adjusted $\rho^2$ in the ML is higher than in the MNL, implying a better model fit for the ML model. While the absolute values of the ML utility parameters are generally higher than in the MNL, all parameter signs are consistent.

**Table 6**
MNL and ML model parameters.

| Variables | MNL | ML mean | ML standard deviation |
|---|---|---|---|
| Forest plus 20% | 0.180** (0.0794) | 0.282** (0.107) | 0.0527 (0.304) |
| Forest plus 40% | 0.333*** (0.0588) | 0.437*** (0.0994) | 1.05*** (0.156) |
| Forest plus 60% | −0.164** (0.0626) | −0.734*** (0.149) | −2.22*** (0.172) |
| Settlement slight decrease | 0.134 (0.0860) | 0.252* (1.83) | −1.48*** (0.134) |
| Settlement slight increase | 0.329*** (0.0616) | 0.499*** (0.109) | −1.21*** (0.139) |
| Settlement strong increase | −0.645*** (0.101) | −1.50*** (0.199) | 2.35*** (0.198) |
| Flood project | 0.171** (0.0691) | 0.215* (0.115) | −1.23*** (0.138) |
| Flood widening | 0.401*** (0.0653) | 0.597*** (0.106) | 1.01 *** (0.149) |
| Flood project plus widening | 0.309*** (0.0751) | 0.336** (0.124) | −1.29*** (0.144) |
| Cost | −0.0781*** (0.0137) | −0.104*** (0.0218) | - |
| $ASC_{neither}$ | 0.120 (0.0778) | 0.199** (0.0970) | - |
| Log-likelihood | −4466.99 | −4088.76 | - |
| $\rho^2$ | 0.036 | 0.118 | - |
| Adjusted $\rho^2$ | 0.034 | 0.114 | - |
| Nr. of Halton draws | - | 1000 | |

(1) Standard error in parentheses; (2) Significance levels:
* $= p < 0.1$.
** $= p < 0.05$.
*** $= p < 0.01$.

**Table 7**
Interaction variables tested in the choice models.

| Variable class | Interaction variable | Explanation |
|---|---|---|
| Socio-demographic | Gender | |
| | Age | |
| | Income | Tax classes according to Table 5 |
| Attitudinal | Professional background | Farmers vs. other professions |
| Spatial | Recreation | Frequency of recreational activity along the Kleine Emme river |
| Event-specific | Upstream | Domicile in upstream or downstream area |
| | Distance | Distance of domicile to the Kleine Emme river |
| | Damage | Damage suffered during the 2005 flood event |
| | Recommendation | Information treatment (political choice recommendations) |

The forest parameter estimates show that respondents have positive preferences for a 20%-increase (0.282) and a 40%-increase (0.437) in forest area. For a 60%-increase, preferences tip and become strongly negative (−0.734). The settlement parameter estimates exhibit a similar pattern. A decrease of settlement area is appreciated by respondents (0.252) and a slight increase of the residential area in the case study region has an even higher marginal utility (0.499). Again, the third attribute level marks a tipping point and preferences turn strongly negative for a strong increase of land used as residential area (−1.5). Levels of the flood attribute include technical as well as ecological aspects. A significant widening of the riverine zone is preferentially chosen (0.597), followed by a combination of technical measures and widening (0.336). The currently planned flood project is also considered positive (0.215). The cost parameter shows a negative sign (−0.104). The significant value of the $ASC_{neither}$ parameter (0.199) indicates that respondents preferred the “neither” option when the alternatives were set to the base level scenario. Significant standard deviations are found in all attribute levels except the 20%-increase forest level, indicating high variability in preferences. The large absolute values of the standard deviations point to high preference heterogeneity across respondents.

### 5.1.3. Models with interactions

While ML models account for unobserved preference heterogeneity across respondents, respondent-specific sources of heterogeneity cannot be discovered by ML model parameters (Boxall and Adamowicz, 2002). The influence of socio-demographic characteristics, attitudes, and levels of information etc. can for example be analyzed by including interactions with choice-specific attributes in the utility function (e.g., Birol et al., 2006; Schläpfer, 2008), changing the utility function as follows:

$$U(\text{Flood protection}) = (\beta_{forest} \times \text{FOREST} + \beta_{settle} \times \text{SETTLEMENT} + \beta_{flood} \times \text{FLOOD} + \beta_{cost} \times \text{COST}) \times (1 + \beta_{interaction} \times \text{INTERACTION}), \quad (6)$$

where the last multiplication term represents respondent-specific socio-demographic, attitudinal, spatial, and event-specific characteristics. Several MNL and ML models with interactions (listed in Table 7) were estimated.

Yet, the only model providing significant interaction parameters was the recommendation (REC) model accounting for the information treatment with political choice recommendations (Table 8). The $MNL_{REC}$ model failed to identify all parameters and increased adjusted $\rho^2$ only by 0.04, as compared to the MNL model. The $ML_{REC}$ model identified all parameters but adjusted $\rho^2$ decreased by 0.017, as compared to the ML model. This result indicates that preferences vary strongly between respondents, which can be assigned to the level of political information given to respondents (REC treatment). Five significant interaction parameters were found in the $ML_{REC}$ model. The most remarkable differences between the REC group (considering political recommendations) and the control group (no recommendations) were found in the plus 60% level of the forest attribute: The control group shows positive preferences for a 60%-increase in forest (0.397), while the REC group respondents show negative preferences for this attribute level (−0.187). Another interesting finding is that the value for the cost parameter was lower in the REC group (−0.090) than in the control group (−0.151).

**Table 8**
MNL and ML model with interaction variable recommendation.

| Variables | $MNL_{REC}$ REC=0 | $MNL_{REC}$ REC=1 | $ML_{REC}$ mean REC=0 | $ML_{REC}$ interactions mean (var*REC) |
|---|---|---|---|---|
| Forest plus 20% | 0.513*** (0.124) | 0.369 (0.299) | 0.862*** (0.200) | 0.771 (0.272) |
| Forest plus 40% | 0.540*** (0.124) | 0.137*** (0.234) | 1.16*** (0.276) | 1.268 (0.291) |
| Forest plus 60% | −0.00226 (0.00872) | −0.287 (489) | 0.397** (0.162) | −0.187*** (0.419) |
| Settlement slight decrease | 0.0159 (0.110) | 0.329 (143) | 0.137 (0.119) | 0.159 (0.211) |
| Settlement slight increase | 0.341*** (0.0811) | 0.268 (0.298) | 0.290** (0.121) | 0.176*** (0.125) |
| Settlement strong increase | −0.688*** (0.128) | −0.707 (0.263) | −1.52*** (0.209) | −1.593 (0.162) |
| Flood project | 0.369*** (0.0900) | 0.242 (0.293) | 0.417*** (0.109) | 0.386 (0.184) |
| Flood widening | 0.574*** (0.0881) | 0.162*** (0.165) | 0.532*** (0.137) | 0.342 ** (0.160) |
| Flood project plus widening | 0.641*** (0.101) | 0.068*** (0.165) | 0.623*** (0.154) | 0.389** (0.134) |
| Cost | −0.115*** (0.0180) | −0.055*** (0.17) | −0.151*** (0.0249) | −0.090** (0.153) |
| ASC for "neither" | 0.223*** (0.0790) | - | 0.387*** (0.0998) | - |
| Log-likelihood | −4439.409 | - | −4155.589 | - |
| $\rho^2$ | 0.042 | - | 0.103 | - |
| Adjusted $\rho^2$ | 0.038 | - | 0.097 | - |
| Nr. of Halton draws | - | - | 1000 | - |

(1) Standard error in parentheses; (2) Significance levels:
* $= p < 0.1$.
** $= p < 0.05$.
*** $= p < 0.01$.

**Table 9**
Marginal WTP values in CHF.

| Attribute | Levels | ML | $ML_{REC}$ | $ML_{REC}$ interactions |
|---|---|---|---|---|
| | | Marginal WTP (CHF) | Marginal WTP (CHF) mean (REC=0) | Marginal WTP (CHF) mean (REC=1) |
| Forest | Plus 20% (42%) | 167.44 (70.53) | 352.51 (96.16) | 526.11 (215.71) |
| | Plus 40% (49%) | 259.47 (84.93) | 474.37 (134.34) | 865.75 (343.28) |
| | Plus 60% (56%) | −435.81 (122.41) | 162.35 (69.93) | −127.39 (116.72) |
| Settlement | Slight settlement decrease | 149.63 (95.74) | 56.02 (51.59) | 108.21 (104.66) |
| | Slight settlement increase | 296.28 (92.80) | 118.59 (54.46) | 120.37 (64.82) |
| | Strong settlement increase | −890.63 (194.50) | −621.59 (119.06) | −1087.42 (331.84) |
| Flood | Flood project | 127.66 (69.18) | 170.53 (48.62) | 263.85 (102.33) |
| | Widening | 354.47 (90.75) | 217.56 (62.58) | 233.54 (94.43) |
| | Project+widening | 199.5 (76.47) | 254.77 (68.02) | 265.83 (98.55) |

(1) Standard error in parentheses.

A possible explanation for the lower cost sensitivity in the REC group is that respondents who were given the choice recommendations (except for the "People's Party") were generally more aware and approving of the generational trade-off that had to be made in the experiment, as compared to uninformed respondents. The political recommendations thus influenced respondents in two ways, i.e., to either deny any payments or to uprate expected benefits.

## 5.2. Willingness to pay for land use changes and trade-offs

The ML model without interactions provided the best model fit (based on a comparison of the $\rho^2$ values). The ML model together with the $ML_{REC}$ model (that provided 5 significant interaction parameters) was therefore selected to analyze WTP values.

From Eqs. (3) and (4) it follows that the change in the marginal price defines the WTP for any change from the present attribute level to the future attribute level. WTP values represent the economic value of trade-offs people are willing to make for increasing the flood protection capacity of the catchment. WTP values were estimated from the ML and $ML_{REC}$ model parameters and the average tax paid for flood protection. The marginal WTP values (implicit prices) are presented in Table 9. The means and standard deviations of the parameters are additionally given in Fig. 5 for easier interpretation. The base levels of the dummy coding correspond to the current situation. Since no additional utility is gained in these levels, they are represented by zero values.

### 5.2.1. WTP: Mixed logit model

In all scenarios except the plus 20% forest attribute level, the parameter values show significant standard deviations, indicating high variability in preferences. A possible reason for the heterogeneity is the long-term time frame of the study[2], hence most of the respondents will only partly benefit from the payments they make. Trading off values between generations may exceed the interest or the comprehension of some respondents.

Marginal WTP for the reforestation attribute shows a clear tipping point between the plus 40% and plus 60% forest level, indicating that respondents are willing to invest up to 260 CHF per year and person in flood protection forests in remote, economically unviable areas but not at the cost of losing the existing landscape pattern of bogs, open grass patches and forest to mostly

[2] The authors explicitly decided against having "time" as an additional attribute in this study. While it is certainly true that different time frames of the specific attributes might influence choices, "time" was left to be captured by the stochastic component of the utility function, as we were more interested to investigate preferences for land use trade-offs in general as opposed to investigate trade-offs in terms of time-of-billing and time-of-effect of measures respondents were billed for. Also, to avoid bias and reduce tiring effects, we decided to reduce the complexity of the choice task and not to include a time attribute.

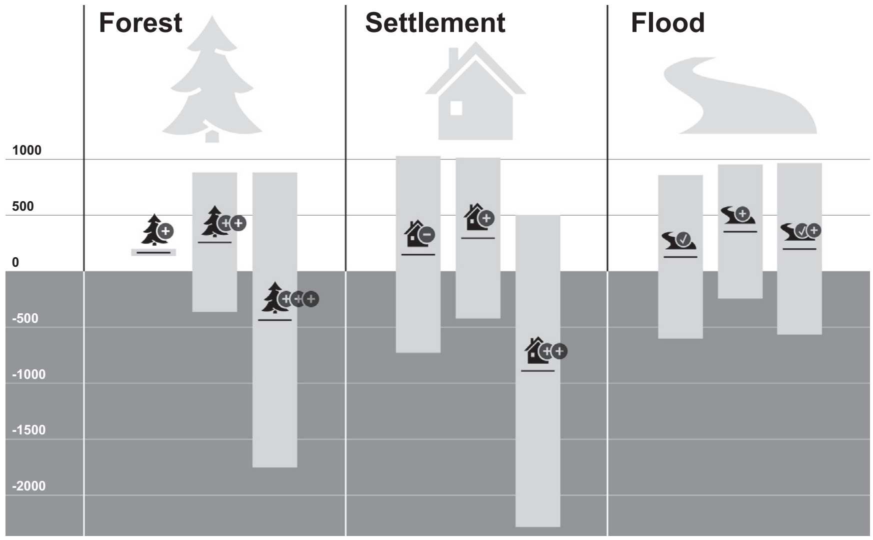


**Fig. 5.** Marginal WTP (mean and region of the confidence interval) in CHF for attributes and levels based on the ML model. The base-levels represent the current situation and are always zero, since no additional utility is gained.

dense forest. In order to compensate a 60% increase of forest, payments at around 436 CHF would be necessary.

Interestingly, WTP is positive for the settlement decrease level (150 CHF), even though it is only significant at the 10% level. Yet, WTP for a slight increase in settlement is almost twice as high (296 CHF) and shows a higher level of statistical significance. Similar to the forest attribute there is a tipping point after the moderate growth level, resulting in compensation payments of 891 CHF to compensate for an extreme increase in growth of settlement area.

Preference estimates for the flood attribute show that all alternative levels are preferred over the status quo. While in the case of the other attributes moderate levels are preferred, the flood attribute which needs the most additional space (increase of DRZ and flood detention basins) reaches the highest WTP (354 CHF). The natural flood protection scenario is preferred over the mainly technical solution (128 CHF) or the combined version (200 CHF) which does not involve flood detention basins. These findings suggest that (1) given the same level of protection, there is a WTP of 72 CHF per person and year for an additional 20 ha of DRZ (trade-off between project and project plus widening) and (2) reducing the peak flow with additional detention basins in the upstream area leads to an additional WTP of 154 CHF (trade-off between project plus widening and widening).

### 5.2.2. *WTP: Mixed logit model with recommendation interactions*

The $ML_{REC}$ model provided significant differences in five parameter estimates, all of them showing lower parameter values in the REC group as compared to the control group (Table 8). However, these differences were not apparent in the WTP estimates (Table 9), as the REC group shows lower cost sensitivity than the control group.

The control group showed a WTP of 162 CHF for the plus 60% forest level as compared to only 127 CHF in the REC group. The first settlement increase level was rated lower in the control group (119 CHF) than in the REC group (120 CHF). While all levels in the flood attribute achieved positive ratings from both groups, WTP was significantly higher among the REC group in the two cases that involve natural protection measures: 234 CHF (REC) vs. 218 CHF (control) for the widening level and 266 CHF (REC) vs. 255 CHF (control) for the level combining project and widening.

The differences in cost sensitivity result in a higher WTP in the REC group, as compared to the control group, for attribute levels without significant differences in parameter estimates. E.g., the flood project did not show significant differences in parameter estimates but resulted in a much higher WTP in the REC group (264 CHF) as compared to the control group (171 CHF). This outcome stands opposite to Schläpfer and Schmitt's (2008) findings that political recommendations reduce respondents' WTP.

## 6. Conclusions

In this paper, we present the design and implementation of a DCE for estimating individual preferences for trade-offs between land use changes with effects on flood protection and for investigating the influence of political recommendations on individual choice behavior.

The parameters of the best fitting ML model reveal that respondents were indeed willing to approve of trade-offs in favor of an increase in natural flood protection capacity. (1) They approved trading off remote, barely productive agricultural land in the upstream area for an increase in forest area in order to increase the natural flood protection capacity of the catchment in the downstream area. (2) Respondents partly agreed to the scenario with reduced population and settlement area, thus saving land for a reduction of exposure to flood hazards. (3) Giving more space to the river for flow regulation and peak flow reduction was widely approved by respondents. Yet, independent of the socio-demographic or economic background, the preferences of the participants show high levels of heterogeneity.

Schläpfer and Schmitt (2008) found that choice recommendations reduced the frequency of non-usable responses. Our study however shows different results. Of the 32 respondents who chose "neither" in all eight choice tasks 22 belonged to the REC group. Further, the rate of not answered choice tasks was 10% higher in the REC group. However, the increased number of non-usable answers is most probably caused by the fact that the "People's Party", which is strongly represented in the study area, recommended to opt out in all choice tasks. The party even published a small note in a local newspaper and recommended declining all scenarios in the questionnaire. Contrary to Schläpfer and Schmitt's (2008) findings that recommendations decreased the implicit benefit estimates for the proposed policies, the control group in our study reacted more sensitive to the scenario costs than the REC group. WTP was higher among respondents in the REC group. Yet, respondents who received political information did not show a more radical preference structure than the control group. In fact, most parameters even decreased in absolute value, which implies that the diversity in the recommendations also diversified respondents' opinions. This supports Schläpfer's (2011) findings that meaningful heterogeneity is increased by political inputs given to respondents. Based on these findings we conclude that people's choices are in fact influenced by political information (as stated by Schläpfer and Schmitt, 2008), but diverging recommendations on complex subjects can lead to even more heterogeneous preferences. Thus, we recommend further research on how political recommendations actually influence decision making in the context of stated preference analysis. The findings of this study point out that framing information in referendum style questionnaires should be very carefully prepared and should follow a clear, consistent line to avoid adding more complexity and confusion to the subject.

In summary, our study results show preferences for land use trade-offs to support flow regulation and flood protection services. Hydrological ecosystem services are complex and strongly respond to land use changes. Information and elaborate choice recommendations can help in eliciting preferences. This paper may serve as an input for watershed managers to develop strategies for increasing the natural capacity of catchments to provide flood protection in addition to technical solutions, such as river dams and barrier lakes, that are often not able to completely prevent flooding.

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## References

3D Nature LLC, 2012. 3D Landscape Design & Visualization Software, ⟨http://www.3dnature.com/⟩.
Adamowicz, W., Boxall, P., Williams, M., Louviere, J., 1998. Stated preference approaches for measuring passive use values: choice experiments and contingent valuation. Am. J. Agric. Econ. 80, 64–75.
Alberini, A., Longo, A., Veronesi, M., 2006. Basic statistical models for stated choice studies. In: Kanninen, B.J. (Ed.), Valuing Environmental Amenities Using Stated Choice Studies. A Common Sense Approach to Theory and Practice. Springer, Dordrecht, pp. 203–227.
Arnold, M., Schwarzwälder, B., Beer-Tóth, K., Zbinden, M., Baumgart, K., 2009. Mehrwert naturnaher Wasserläufe. Untersuchung zur Zahlungsbereitschaft mit besonderer Berücksichtigung der Erschliessung für den Langsamverkehr. Bundesamt für Umwelt. Umwelt-Wissen 0912, 124.
Baranzini, A., Schaerer, C., 2011. A sight for sore eyes: assessing the value of view and land use in the housing market. J. Housing Econ. 20, 191–199.
Bateman, I., Day, B., Jones, A., Jude, S., 2009. Reducing gain-loss asymmetry: a virtual reality choice experiment valuing land use change. J. Environ. Econ. Manage. 58, 106–118.
Ben-Akiva, M., Swait, J., 1986. The Akaike likelihood ratio index. Transp. Sci. 20, 133–136.
Bierlaire, M., 2003. BIOGEME: a free package for the estimation of discrete choice models.
Birol, E., Karousakis, K., Koundouri, P., 2006. Using a choice experiment to account for preference heterogeneity in wetland attributes: the case of Cheimaditida wetland in Greece. Ecol. Econ. 60, 145–156.
Bishop, I.D., Stock, C., Williams, K.J., 2009. Using virtual environments and agent models in multi-criteria decision-making. Land Use Policy 26, 87–94.
Bliemer, M., Rose, J.M., 2005. Efficiency and Sample Size Requirements for Stated Choice Studies. Institute of Transport Studies and Logistics Working Paper.
Bosch, J.M., Hewlett, J.D., 1982. A review of catchment experiments to determine the effect of vegetation changes on water yield and evapotranspiration. J. Hydrol. 55, 3–23.
Boxall, P.C., Adamowicz, W.L., 2002. Understanding heterogeneous preferences in random utility models: a latent class approach. Environ. Resour. Econ. 23, 421–446.
Boyle, K.J., 2003. Contingent valuation in practice. In: Champ, P.A., Boyle, K.J., Brown, T.C. (Eds.), A Primer on Nonmarket Valuation. Kluwer Academic Publishers, Dordrecht, pp. 111–169.
Brauman, K.A., Daily, G.C., Duarte, T.K., Mooney, H.A., 2007. The nature and value of ecosystem services: an overview highlighting hydrologic services. Annu. Rev. Environ. Resour. 32, 67–98.
Bronstert, A., Niehoff, D., Bürger, G., 2002. Effects of climate and land-use change on storm runoff generation: present knowledge and modelling capabilities. Hydrol. Processes 16, 509–529.
Brouwer, R., Schaafsma, M., 2013. Modelling risk adaptation and mitigation behaviour under different climate change scenarios. Clim. Change 117, 11–29.
Calder, I.R., Aylward, B., 2006. Forest and floods: moving to an evidence-based approach to watershed and integrated flood management. Water Int. 31, 87–99.
Champ, P.A., Boyle, K.J., Brown, T.C., 2003. A primer on nonmarket valuation. In: Bateman, I.J. (Ed.), The Economics of Non-market Goods and Resources. Kluwer Academic Publishers, Dordrecht.
Christensen, J., Carter, T., Rummukainen, M., Amanatidis, G., 2007. Evaluating the performance and utility of regional climate models: the PRUDENCE project. Clim. Change 81, 1–6.
de Groot, R.S., Alkemade, R., Braat, L., Hein, L., Willemen, L., 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecol. Complexity 7, 260–272.
DeFries, R.S., Asner, G.P., Houghton, R.A., 2004. Ecosystems and land use change, Geophys. Monogr.. American Geophysical Union, Washington, DC.
Dijkstra, J., van Leeuwen, J., Timmermans, H., 2003. Evaluating design alternatives using conjoint experiments in virtual reality. Environ. Plann. B 30, 357–368.
Domencich, T.A., McFadden, D., 1975. Urban travel demand—a behavioral analysis, no. Monograph, 215.
Eckhardt, K., Breuer, L., Frede, H.-G., 2003. Parameter uncertainty and the significance of simulated land use change effects. J. Hydrol. 273, 164–176.
Ellison, D., Futter, N., Bishop, K., M., 2012. On the forest cover–water yield debate: from demand- to supply-side thinking. Global Change Biol. 18, 806–820.
Eshleman, K.N., 2004. Hydrological consequences of land use change: a review of the state-of-science. In: DeFries, R., Asner, G.P., Houghton, R.A. (Eds.), Ecosystems and land Use Change, pp. 13–29.
ESRI, 2010. ArcGIS 10, ⟨http://www.esri.com/⟩.
Fellmann, J.G., 1917. Die Verbauung der Kleinen Emme im Kanton Luzern. Buchdruckerei Räber und Cie., Luzern.
ForA, 2013. Federal Act on Forest.
FOWG, 2001. Federal Office for Water and Geology: Flood Control at Rivers and Streams. Guidelines of the FOWG, p.72.
Freeman, A.M., 2003. Economic Valuation: What and Why. A Primer on Nonmarket Valuation, 1-25.
Frei, C., 2006. Die Klimazukunft der Schweiz – Eine probabilistische Projektion, ⟨http://www.occc.ch/Products/CH2050/ch2050_scenario_d.html⟩ , ⟨http://www.meteoschweiz.ch⟩.
Frei, C., Schöll, R., Fukutome, S., Schmidli, J., Vidale, P.L., 2006. Future change of precipitation extremes in Europe: intercomparison of scenarios from regional climate models. J. Geophys. Res. Atmos. 111, D06105.
FSO, 2010. Szenarien zur Bevölkerungsentwicklung der Schweiz. 2010–2060. Federal Statistical Office FSO, Neuchâtel.
FSO, 2014. Federal Statistical Office FSO.
Gellrich, M., Baur, P., Koch, B., Zimmermann, N.E., 2007. Agricultural land abandonment and natural forest re-growth in the Swiss mountains: a spatially explicit economic analysis. Agric. Ecosyst. Environ. 118, 93–108.
Gerten, D., Lucht, W., 2012. Detection and Attribution of Changes in Water Resources, Changes in Flood Risk in Europe. CRC Press, pp. 422–434.
Gerten, D., Rost, S., von Bloh, W., Lucht, W., 2008. Causes of change in 20th century global river discharge. Geophys. Res. Lett. 35, L20405.
Goodess, C.M., 2003. Statistical and regional dynamical downscaling of extremes for European regions: STARDEX. EGGS, 25–29.
Grêt-Regamey, A., Bishop, I.D., Bebi, P., 2007. Predicting the scenic beauty value of mapped landscape changes in a mountainous region through the use of GIS. Environment and Planning B: Planning and Design 34, 50–67.
Hanley, N., Mourato, S., Wright, R.E., 2001. Choice modelling approaches: a superior alternative for environmental valuation? Journal of economic surveys 15, 435–462.
Hanley, N., Wright, R.E., Alvarez-Farizo, B., 2006. Estimating the economic value of improvements in river ecology using choice experiments: an application to the water framework directive. Journal of Environmental Management 78, 183–193.
Hensher, D.A., Greene, W.H., 2003. The mixed logit model: the state of practice. Transportation 30, 133–176.
Holmes, T.P., Adamowicz, W.L., 2003. Attribute-based methods. In: Champ, P.A., Boyle, K.J., Brown, T.C. (Eds.), A Primer on Nonmarket Valuation. Kluwer Academic Publishers, Dordrecht, pp. 171–219.
Hoyos, D., 2010. The state of the art of environmental valuation with discrete choice experiments. Ecol. Econ. 69, 1595–1603.

Huber, J., Zwerina, K., 1996. The importance of utility balance in efficient choice designs. J. Marketing Res., 307–317.
Hunziker, M., Kienast, F., 1999. Potential impacts of changing agricultural activities on scenic beauty—a prototypical technique for automated rapid assessment. Landscape Ecol. 14, 161–176.
Johnston, R.J., Swallow, S.K., Bauer, D.M., 2002. Spatial factors and stated preference values for public goods: considerations for rural land use. Land Econ. 78, 481–500.
Jones, J.A., Grant, G.E., 1996. Peak flow responses to clear-cutting and roads in small and large basins, Western Cascades, Oregon. Water Resour. Res. 32, 959–974.
Kanninen, B.J., 1993. Optimal experimental design for double-bounded dichotomous choice contingent valuation. Land Econ., 138–146.
Kim, Y., Band, L.E., Song, C., 2014. The influence of forest regrowth on the stream discharge in the North Carolina Piedmont Watersheds. JAWRA J. Am. Water Resour. Assoc. 50, 57–73.
Laing, R., Davies, A., Scott, S., 2005. Combining visualization with choice experimentation in the built environment, Visualisation for Landscape and Environmental Planning: Technology and Applications. Taylor & Francis, London, pp. 212–219.
Laing, R.A., Davies, A.-M., Miller, D., Conniff, A., Scott, S., Morrice, J., 2009. The application of visual environmental economics in the study of public preference and urban greenspace. Environ. Plann. B 36 (2).
LHG, 1992. Hydrologischer Atlas der Schweiz. Landeshydrologie und -geologie, BWG, 2051 Biel.
Louviere, J.J., Hensher, D.A., Swait, J.D., 2000. Stated Choice Methods: Analysis and Applications. Cambridge University Press.
LUSTAT, 2014.
Malczewski, J., 1999. GIS and Multicriteria Decision Analysis. John Wiley & Sons, Inc..
McFadden, D., 1973. Conditional logit analysis of qualitative choice behavior. In: Zarempka, P. (Ed.), Frontiers in Econometrics. Academic Press, New York, pp. 105–142.
McFadden, D., Train, K., 2000. Mixed MNL models for discrete response. J. Appl. Econom. 15, 447–470.
Meyerhoff, J., Liebe, U., 2009. Status quo effect in choice experiments: empirical evidence on attitudes and choice task complexity. Land Econ. 85, 515–528.
Molnar, P., Burlando, P., Kirsch, J., Hinz, E., Rowan, J., Duck, R., Werritty, A., 2006. Model Investigations of the Effects of Land-use Changes and Forest Damage on Erosion in Mountainous Environments. Sediment Dynamics and the Hydromorphology of Fluvial Systems, 589-600.
Morse-Jones, S., Bateman, I.J., Kontoleon, A., Ferrini, S., Burgess, N.D., Turner, R.K., 2012. Stated preferences for tropical wildlife conservation amongst distant beneficiaries: charisma, endemism, scope and substitution effects. Ecol. Econ..
Newell, L.W., Swallow, S.K., 2012. Real-payment choice experiments: valuing forested wetlands and spatial attributes within a landscape context. Ecol. Econ..
Nguyen, T.C., Robinson, J., Kaneko, S., Komatsu, S., 2013. Estimating the value of economic benefits associated with adaptation to climate change in a developing country: a case study of improvements in tropical cyclone warning services. Ecol. Econ. 86, 117–128.
O'Connell, P., Ewen, J., O'Donnell, G., Quinn, P., 2007. Is there a link between agricultural land-use management and flooding? Hydrol. Earth Syst. Sci. Discuss. 11, 96–107.
Olschewski, R., Bebi, P., Teich, M., Wissen Hayek, U., Grêt-Regamey, A., 2012. Avalanche protection by forests—a choice experiment in the Swiss Alps. For. Policy Econ. 17, 19–24.
Rehr, A.P., Williams, G.D., Levin, P.S., 2014. A test of the use of computer generated visualizations in support of ecosystem-based management. Mar. Policy 46, 14–18.
Rid, W., Profeta, A., 2011. Stated preferences for sustainable housing development in Germany—a latent class analysis. J. Plann. Edu. Res. 31, 26–46.
Rose, J.M., Masiero, L., 2010. A comparison of the impacts of aspects of prospect theory on WTP/WTA estimated in preference and WTP/WTA space. EJTIR, 330–346.
Samuelson, W., Zeckhauser, R., 1988. Status quo bias in decision making. J. Risk Uncertainty 1, 7–59.
Schädler, B., Frei, C., Grebner, D., Willi, H.P., 2007. Grundlagen zum Klima. Wasser Energ. Luft 1/2007, 58–59.
Schläpfer, F., 2008. Contingent valuation: a new perspective. Ecol. Econ. 64, 729–740.
Schläpfer, F., 2011. Access to party positions and preference formation: a field experiment. Swiss Polit. Sci. Rev. 17, 75–91.
Schläpfer, F., Schmitt, M., A., R., 2008. Competitive politics, simplified heuristics, and preferences for public goods. Ecol. Econ. 65, 574–589.
Schmidli, J., Goodess, C.M., Frei, C., Haylock, M.R., Hundecha, Y., Ribalaygua, J., Schmith, T., 2007. Statistical and dynamical downscaling of precipitation: an evaluation and comparison of scenarios for the European Alps. J. Geophys. Res. Atmos. 112, D4.
Schnorbus, M., Alila, Y., 2004. Forest harvesting impacts on the peak flow regime in the Columbia Mountains of southeastern British Columbia: an investigation using long-term numerical modeling. Water Resour. Res. 40, W05205.
Schoonover, J.E., Lockaby, B.G., Helms, B.S., 2006. Impacts of land cover on stream hydrology in the West Georgia Piedmont, USA. J. Environ. Qual. 35, 2123–2131.
Stadelmann, P., Lovas, R., 2000. Flussgebietsplanung für einen voralpinen Fluss in der Schweiz. Kleine Emme im Kanton Luzern. In: Schweizerischer Verein des Gas- und Wasserfaches SVGW (Ed.), Zürich, p. 24.
Tong, S.T.Y., 1990. The hydrologic effects of urban land use: a case study of the little Miami River Basin. Landscape Urban Plann. 19, 99–105.
Train, K.E., 2003. Discrete Choice Methods with Simulation. Cambridge University Press, Cambridge, UK.
Vecchiato, D., Tempesta, T., 2013. Valuing the benefits of an afforestation project in a peri-urban area with choice experiments. For. Policy Econ.' 26, 111–120.
Vischer, D.L., 2003. Die Geschichte des Hochwasserschutzes in der Schweiz. Von den Anfängen bis ins 19. Jahrhundert. In: BAFU, B.f.U. (Ed.), 2003. Berichte des BWG. Serie Wasser BWGW, Bern, p. 209.
Water Agenda (WA21), 2011. Watershed Management. Guiding Principles for Integrated Management of Water in Switzerland, Bern, p. 20.
WBG, 1991. Federal Law on Flood Control (Wasserbaugesetz).
Wheater, H., Evans, E., 2009. Land use, water management and future flood risk. Land Use Policy 26 (Suppl. 1), S251–S264.
Zhang, Y.K., Schilling, K.E., 2006. Increasing streamflow and baseflow in Mississippi River since the 1940s: effect of land use change. J. Hydrol. 324, 412–422.