Optimizing biodiversity protection projects: A problem on various scales

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geboren in Lich

Angenommene Dissertation zur Erlangung des akademischen Grades eines Doktors der Wirtschafts- und Sozialwissenschaften

Fachbereich 7: Natur- und Umweltwissenschaften
Universität Koblenz-Landau

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Tag der Disputation: 30.08.2022

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Abbreviations

BIC	Bayesian Information Criterion
Bti	Bacillus thuringiensis subsp. israelensis
CAP	EU-Common Agricultural Policy
cc	A combination of the focal crop field and an adjacent other crop field
CE	Choice Experiments
cg	A combination of the focal crop field and an adjacent grassy SNH
cgw	A combination of the focal crop field, an adjacent grassy SNH and an adjacent woody SNH
ColAvail	The availability of yellow, white, or purple features in the landscape, which usually originate from flowers
CVM	Contingent valuation method
cw	A combination of the focal crop field and an adjacent woody SNH
GMCA	German Mosquito Control Association
Grassy	Combination with or without grassy element
Green	the amount of green vegetation in the picture
LCM	latent class model
MLN	mixed logit model
MNL	multinomial logit
NoVeg	the amount of bare soil, gravel or rocks in the depicted combination
NSG	Naturschutzgebiet
OR	Odds ratio
Ordered	ordered structure in the depicted combination
QuESSA	Quantification of Ecological Services for Sustainable Agriculture
SBDC	Single Bounded Dichotomous Choice
Sig	Significance
SNH	Semi-natural habitat
WFD	Water framework directive
Woody	Combination with or without woody element
WTA	Willingness to accept
WTP	Willingness to pay

Abstract

The decline of biodiversity can be observed worldwide and its consequences are alarming. It is therefore crucial that nature must be protected and, where possible, restored. A wide variety of different project options are possible. Yet in the context of limited availability of resources, the selection of the most efficient measures is increasingly important. For this purpose, there is still a lack of information. This pertains, as outlined in the next paragraph, in particular, to information at different scales of projects.

Firstly, there is a lack of information on the concrete added value of biodiversity protection projects. Secondly, there is a lack of information on the actual impacts of such projects and on the costs and benefits associated with a project. Finally, there is a lack of information on the links between the design of a project, the associated framework conditions and the perception of specific impacts. This paper addresses this knowledge gap by providing more information on the three scales by means of three empirical studies on three different biodiversity protection projects in order to help optimize future projects.

The first study “Assessing the trade-offs in more nature-friendly mosquito control in the Upper Rhine region” examines the added value of a more nature-friendly mosquito control in the Upper Rhine Valley of Germany using a contingent valuation method. Recent studies show that the widely used biocide Bti, which is used as the main mosquito control agent in many parts of the world, has more negative effects on nature than previously expected. However, it is not yet clear whether the population supports a more nature-friendly mosquito control, as such an adaptation could potentially lead to higher nuisance. This study attempts to answer this question by assessing the willingness to pay for an adapted mosquito control strategy that reduces the use of Bti, while maintaining nuisance protection within settlements. The results show that the majority of the surveyed population attaches a high value to a more nature-friendly mosquito control and is willing to accept a higher nuisance outside of the villages.

The second study “Inner city river restoration projects: the role of project components for acceptance” examines the acceptance of a river restoration project in Rhineland-Palatinate, Germany. Despite much effort, many rivers worldwide are still in poor condition. Therefore, a rapid implementation of river restoration projects is of great importance. In this context, acceptance by society plays a fundamental role, however, the factors determining such acceptance are still poorly understood. In particular, the complex interplay between the acceptance or rejection of specific project components and the acceptance of the overall project require further exploration. This study addresses this knowledge gap by assessing the acceptance of the project, its various ecological and social components, and the perception of real and fictitious costs as well as the benefits of the components. Our findings demonstrate that while acceptance of the overall project is generally rather high, many respondents reject one or more of the project's components. Complementary social project components, like a playground, find less support than purely ecological components. Overall, our research shows that complementary components may increase or decrease acceptance of the overall project. We, furthermore, found that differences in the acceptance of the individual components depend on individual concerns, such as perceived flood risk, construction costs, expected noise and littering as well as the quality of communication, attachment to the site, and the age of the respondents.

The third study “What determines preferences for semi-natural habitats in agrarian landscapes? A choice-modelling approach across two countries using attributes characterizing vegetation” investigates people's aesthetic preferences for semi-natural habitats in agricultural landscapes. The EU-Common Agricultural Policy promotes the introduction of woody and grassy semi-natural habitats

(SNH) in agricultural landscapes. While the benefits of these structures in terms of regulating ecosystem services are already well understood, the effects of SNH on visual landscape quality is still not clear. This study investigates the factors determining people's visual preferences in the context of grassy and woody SNH elements in Swiss and Hungarian landscapes using picture-based choice experiments. The results suggest that respondents' choices strongly depend on specific vegetation characteristics that appear and disappear over the year. In particular, flowers as a source of colours and green vegetation as well as ordered structure and the proportion of uncovered soil in the picture play an important role regarding respondents' aesthetic perceptions of the pictures.

The three empirical studies can help to make future projects in the study areas of biodiversity protection more efficient. While this thesis highlights the importance of exploring biodiversity protection projects at different scales, further analyses of the different scales of biodiversity protection projects are needed to provide a sound basis to develop guidance on identifying the most efficient biodiversity protection projects.

Zusammenfassung

Der Rückgang der Biodiversität ist weltweit sichtbar und seine Folgen alarmierend. Um diesem Prozess entgegenzuwirken ist es von entscheidender Bedeutung, die Natur zu schützen und, wo möglich, wiederherzustellen. Es gibt eine Vielzahl vorstellbarer Projekte. Angesichts der begrenzten Verfügbarkeit von Ressourcen, wird es jedoch immer wichtiger, die effizientesten Maßnahmen auszuwählen. Hierfür fehlt es allerdings noch an hinreichenden Informationen. Dabei fehlen, wie im Folgenden erläutert, Informationen auf unterschiedlichen Projektebenen.

Zum einen mangelt es an Informationen über den konkreten Mehrwert von Projekten zum Schutz der Biodiversität. Zum anderen fehlt es an Informationen über die tatsächlichen Auswirkungen solcher Projekte und über die mit dem jeweiligen Projekt verbundenen Kosten und Nutzen. Schließlich fehlen auch Informationen über die Zusammenhänge zwischen der Gestaltung eines Projekts, den zugehörigen Rahmenbedingungen und der Wahrnehmung einzelner Auswirkungen. Diese Arbeit trägt ihren Teil zur Schließung der beschriebenen Wissenslücke bei. Anhand von drei Publikationen über drei Projekte zum Schutz der Biodiversität erschließt sie neue Informationen zu den beschriebenen drei Ebenen von Projekten und kann dazu beitragen, zukünftige Projekte zu optimieren.

In der ersten Veröffentlichung "Assessing the trade-offs in more nature-friendly mosquito control in the Upper Rhine region" wird der Mehrwert einer naturverträglicheren Mückenbekämpfung im deutschen Oberrheintal mit Hilfe einer Contingent Valuation Methode untersucht. Neuere Studien zeigen, dass das weit verbreitete Biozid Bti, das in vielen Teilen der Welt als Hauptmittel zur Mückenbekämpfung eingesetzt wird, mehr negative Auswirkungen auf die Natur hat als bisher angenommen. Noch ungeklärt ist, ob die Bevölkerung eine naturfreundlichere Mückenbekämpfung unterstützt, da eine solche Anpassung möglicherweise zu einer höheren Belästigung durch Mücken führen könnte. Die vorliegende Studie hat sich zum Ziel gesetzt, diese Frage zu beantworten, indem sie die Zahlungsbereitschaft für eine angepasste Mückenbekämpfungsstrategie ermittelt, die den Einsatz von Bti reduziert und gleichzeitig den Schutz vor Belästigungen innerhalb von Siedlungen aufrechterhält. Die Ergebnisse zeigen, dass die Mehrheit der befragten Bevölkerung einen hohen Wert auf eine naturfreundlichere Mückenbekämpfung legt und bereit ist, eine höhere Belästigung außerhalb der Dörfer in Kauf zu nehmen.

Die zweite Veröffentlichung "Inner city river restoration projects: the role of project components for acceptance" untersucht die Akzeptanz eines Projekts zur Flussrenaturierung in Rheinland-Pfalz. Trotz

großer Anstrengungen befinden sich viele Flüsse weltweit noch immer in einem schlechten Zustand. Daher ist eine schnelle Umsetzung von Flussrenaturierungsprojekten von großer Bedeutung. In diesem Zusammenhang spielt die Akzeptanz in der Gesellschaft eine grundlegende Rolle, wobei die Faktoren, die diese Akzeptanz bestimmen, noch wenig bekannt sind. Insbesondere das komplexe Zusammenspiel zwischen der Akzeptanz oder Ablehnung spezifischer Projektkomponenten und der Akzeptanz des Gesamtprojekts muss weiter erforscht werden. Die vorliegende Studie vermittelt ein tieferes Verständnis dieses Zusammenspiels, indem sie die Akzeptanz des spezifischen Projekts, seiner verschiedenen ökologischen und sozialen Bestandteile sowie die Wahrnehmung der realen und fiktiven Kosten und Nutzen der Bestandteile untersucht. Unsere Ergebnisse zeigen, dass die Akzeptanz des Gesamtprojekts im Allgemeinen zwar recht hoch ist, viele Befragte jedoch eine oder mehrere Komponenten des Projekts ablehnen. Ergänzende soziale Projektkomponenten, wie ein Spielplatz, finden weniger Unterstützung als rein ökologische Komponenten. Insgesamt zeigen unsere Untersuchungen, dass ergänzende Komponenten die Akzeptanz des Gesamtprojekts erhöhen oder verringern können. Darüber hinaus zeigen wir, dass die Unterschiede in der Akzeptanz der einzelnen Komponenten von individuellen Anliegen abhängen, wie dem wahrgenommenen Hochwasserrisiko, den Baukosten, dem erwarteten Lärm und der Vermüllung sowie der Qualität der Kommunikation, der Verbundenheit mit dem Standort und dem Alter der Befragten.

Die dritte Publikation "What determines preferences for semi-natural habitats in agrarian landscapes? A choice-modelling approach across two countries using attributes characterising vegetation" untersucht die ästhetischen Präferenzen der Menschen bezüglich naturnaher Habitate in den Agrarlandschaften. Die gemeinsame Agrarpolitik der EU fördert die Einführung von naturnahen Gehölz- und Wiesenlebensräumen bzw. semi-natural habitats (SNH) in Agrarlandschaften. Während der Nutzen dieser Strukturen in Bezug auf die Regulierungsleistungen bereits gut bekannt ist, ist das Verständnis der Auswirkungen von SNH auf die visuelle Landschaftsqualität noch relativ unklar. Anhand von bildbasierten Choice-Experimenten untersucht diese Studie die Faktoren, die die visuellen Präferenzen von Menschen in Bezug auf SNH-Elemente in Schweizer und ungarischen Landschaften bestimmen. Die Ergebnisse zeigen, dass die Präferenzen der Befragten stark von bestimmten Vegetationsmerkmalen abhängen, die im Laufe des Jahres erscheinen und verschwinden. Insbesondere Blumen als Farbquelle und grüne Vegetation sowie die geordnete Struktur und der Anteil des unbedeckten Bodens im Bild spielen eine wichtige Rolle in der ästhetischen Wahrnehmung der Befragten.

Die drei Veröffentlichungen können dabei helfen, Projekte zum Schutz der biologischen Vielfalt in den untersuchten Bereichen künftig effizienter zu gestalten. Wünschenswert für einen effektiven Schutz der Biodiversität wäre die Entwicklung von Leitlinien zur Ermittlung der effizientesten potentiellen Projekte. Die vorliegende Arbeit unterstreicht, wie bedeutsam es in dieser Hinsicht ist, Projekte zum Biodiversitätsschutz auf verschiedenen Ebenen zu untersuchen. Um eine solide Basis für allgemeine Leitlinien zu schaffen, sind allerdings weitere Analysen der verschiedenen Ebenen von Projekten notwendig.

Author Contributions

1) Assessing the trade-offs in more nature-friendly mosquito control in the Upper Rhine region (Weiß, Allgeier, Brühl, & Frör, to be published)

I. Sören Bo Weiß: Conceptualization, Methodology, Validation, Formal analysis, Data Curation, Writing - Original Draft, Visualization. Share of contribution: 80%
II. Stefanie Allgeier: Conceptualization, Methodology, Investigation, Data Curation, Writing - Original Draft, Project administration
III. Carsten Brühl: Writing - Original Draft, Funding acquisition
IV. Oliver Frör: Conceptualization, Methodology, Writing - Original Draft, Supervision, Funding acquisition

2) Inner city river restoration projects: the role of project components for acceptance (Weiß, Schilling, & Frör, to be published)

I. Sören Bo Weiß: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Visualization, Project administration, Funding acquisition. Share of contribution: 90%
II. Janpeter Schilling: Conceptualization, Supervision
III. Oliver Frör: Conceptualization, Methodology, Writing - Review & Editing, Supervision, Funding acquisition

3) **What determines preferences for semi-natural habitats in agrarian landscapes? A choice-modelling approach across two countries using attributes characterizing vegetation (Schüpbach, Weiß, Jeanneret, Zalai, Szalai, & Frör, published 2021)**

I. Sören Bo Weiß: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - Original Draft, Writing - Review & Editing. Share of contribution: 60%
II. Beatrice Schüpbach: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Project administration, Funding acquisition
III. Philippe Jeanneret: Investigation, Writing - Original Draft, Writing - Review & Editing
IV. Mihály Zalai: Investigation, Writing - Original Draft, Writing - Review & Editing
V. Márk Szaalai: Investigation, Writing - Original Draft, Writing - Review & Editing
VI. Oliver Frör: Conceptualization, Methodology, Writing - Original Draft, Writing - Review & Editing, Supervision

Acknowledgements

First and foremost, I would like to thank Oliver Frör, who supervised my thesis and made it possible in the first place. The opportunities provided by him over the years have helped me to develop and sharpen my understanding both conceptually and methodologically. Furthermore, I would like to thank my second examiner Tobias Börger, who paved the way for the dissertation when he advised me on the statistical methods used for choice experiments for my master thesis, and who continued to advise me afterwards. I would also like to thank my colleague Melanie Ströbel, without whose moral support this work would probably never have been completed and who contributed significantly to the success of the work through many discussions. Also, I would like to thank Paul Averbeck, who has kept me company in the office and over the years helped in numerous discussions to draw the right conclusions. Furthermore, I would also like to thank Lucas Streib, Berend Barkela and Jonathan Juppke for helping me with the visualization. Furthermore, I would like to thank Beatrice Schüpbach for her collaboration on one of the empirical studies. Finally, but most importantly, I would like to thank my family Melanie and Jarne, my mother Regine and my sister Svea, who have had my back and kept me sane and who, as always, made their contribution at the last minute in the form of excellent proofreading. And I would like to thank my father Werner, who in many ways shaped my thinking and was certainly part of my motivation.

1. Background and research question

The changes mankind has made to the environment are so severe that a new Earth Age has been proclaimed: the Anthropocene (Crutzen, 2002). Hooke & Martín-Duque (2012) estimate that humans have already modified over 50% of the Earth's surface. As little as 23% of land remain in a state of ‚wilderness'; for oceans, changes are even more severe with only 13% in such a state (Jones et al., 2018; Watson et al., 2016). Since the 17th century, up to 87% of all wetlands have been lost (Davidson, 2014), with a 31% decline of the global natural WET index in the period between 1970 and 2008 (Dixon et al., 2016). Likewise, the proportion of larger areas of contiguous forest is steadily declining (Potapov et al., 2017); the area covered by forest has decreased by 32% since industrialization (Purvis et al., 2019). Significant changes are also evident in the sea. For example, the area of seagrass meadows has declined by 29% (Waycott et al., 2009), and the cover of coral reefs by 42%, according to expert estimates (Eddy, Cheung, & Bruno, 2018).

Numerous scientists have highlighted that the human-induced changes can have dramatic consequences, as several planetary boundaries have been exceeded and others are about to be exceeded (e.g. Rockström et al., 2009a, 2009b; Steffen et al., 2015). Planetary boundaries define limits of action that humanity has with respect to key processes of the Earth System without significantly worsening conditions for humans. The concern is that the Holocene, which provided relatively good conditions for humankind in terms of temperature, freshwater availability and other biogeochemical fluxes, is now transitioning to a more volatile phase that, due to human intervention, provides much poorer conditions for societies (Rockström et al., 2009a, 2009b; Steffen et al., 2015). The planetary boundaries currently include 9 processes: climate change, stratospheric ozone depletion, ocean acidification, biosphere integrity, biogeochemical flows, land system change, freshwater use, atmospheric aerosol loading and novel entities (Steffen et al., 2015). The boundaries for four of the processes have already been exceeded; climate change, biosphere integrity, biogeochemical flows, and land system change, with more boundaries about to be crossed (Newbold et al., 2016; Steffen et al., 2015). Besides the process of climate change, the integrity of the biosphere is of particular importance due to its fundamental role (Steffen et al., 2015).

According to Steffen et al. (2015), biosphere integrity is determined by two factors, genetic diversity and functional diversity. Genetic diversity describes the ability of the biosphere to adapt to change, while functional diversity describes the role of the biosphere in the Earth system, taking into account different components of biodiversity. Biodiversity is thus a central component of biosphere integrity. The causes of biodiversity decline are diverse and can be attributed to the following direct factors, according to IPBES (2019): changes in land use, exploitation of animals, plants and other organisms, climate change, pollution, and invasion of alien species. The effects of changes in land use are most important for biodiversity (Newbold et al., 2016). The main cause of land use changes is the expansion in agricultural and settlement areas (Foley et al., 2005). Agriculturally used fields and pastures now account for over 1/3 of the land area; settlement areas have doubled in the period 1992 - 2015 (Balvanera et al., 2019). This resulted in a reduction of forests, wetlands, grassland, and other habitats. Among these, impacts on grassland biodiversity are greatest (Newbold et al., 2016). However, according to IPBES (2019), land use changes also include landscape fragmentation, intensification of cultivation, and land degradation. One of the consequences of continued fragmentation is that in 2013, only 20% of the global forest areas are part of a contiguous area of at least 500km^2 (Potapov et al., 2017). Intensification, in turn, has a direct effect on species diversity, but it can also lead to degradation of the affected areas. Already, 12% of the world's agricultural land (cropland and pasture) is degraded and shows lower primary production (van der Esch et al., 2017). According to IUCN (2021), the effects of all these developments on flora and fauna are clearly apparent and numerous authors are now talking about the 6th mass extinction (e.g. Chapin III et al., 2000; Dirzo et al., 2014; Pievani, 2014).

According to IUCN (2021), 897 species (0.6% of species studied) have become extinct since 1500, although scientists believe that this number is actually much higher (Cox et al., 2022; Scheffers, Joppa, Pimm, & Laurance, 2012; Stork, 2010). In total, over 1,000,000 animal and plant species may be at risk of extinction – that is 1 in 8 species or 14% of all animal and plant species (Purvis et al., 2019). The consequences of biodiversity loss are manifold. It can cause ecosystems to tip into an undesirable state (Oliver, 2016). It can also affect global processes, such as the climate and the acidity of oceans. As a consequence, planetary boundaries are drawn even tighter (Rockström et al., 2009a). Ultimately, the loss of biodiversity also leads to a decline in human well-being (IPBES, 2019; Millenium Ecosystem Assessment, 2003).

The question that arises in view of these developments is: how could it have come to this at all? The dramatic decline in biodiversity is primarily due to the fact that the decisions behind the drivers described earlier did not take into account their negative effects. Costs and benefits that are not considered in decisions are commonly known as externalities (Pigou, 1920). Unaccounted costs are considered negative externalities and unaccounted benefits are considered positive externalities. From an economic point of view, externalities lead to market failures, as decision makers act on the basis of wrong or incomplete information (Hussen, 2013). It is for this reason that numerous scientists have demanded that current, but also future, ecological and social consequences of biodiversity loss need to be taken into account in decision-making (e.g. Chapin III et al., 2000; Constanza et al., 1997).

There are two reasons why the negative effects on biodiversity associated with a decision have not been adequately considered in the past. The first reason is that decision making takes into account only those effects that are of interest to the decision maker. In line with the concept of Homo economicus, it is generally assumed that people try to maximize their utility when making decisions (Spranger, 1966). While individuals primarily focus on their own utility, companies focus on the utility of their owners or investors, and governments are supposed to focus on the utility of their citizens. Governments have the responsibility to establish regulations that ensure that all impacts are taken into account, thereby internalizing potential externalities. Accordingly, all actors influence biodiversity through their actions, with the regulatory framework adopted by governments determining whether or not externalities occur.

In order to make government interventions to protect biodiversity as efficient as possible, some governments now require cost-benefit analyses (Pearce, Atkinson, & Mourato, 2006). A crucial problem is that, in most cases, policymakers focus on local impacts and overlook global implications. For example, the price of meat usually does not reflect the negative impact on biodiversity of the production of animal feed (e.g. rainforest clearing). Global agreements, such as the Paris Agreement (UNFCCC, 2015) or the Sustainable Development Goals (United Nations, 2015), attempt to address this issue by forcing governments to take responsibility beyond their borders. The second reason why negative effects are overlooked is simply a lack of knowledge. Many findings regarding the impacts on biodiversity are fairly new and many impacts, such as those from climate change, land-use and neophytes (Auffret & Thomas, 2019) or pharmaceutical use (Lyons, 2014), are not yet fully understood. However, in order to internalize all externalities associated with a decision, it is necessary to know, first, all positive and negative effects associated with a decision and, second, their magnitude. Only when this information is given, the most efficient decisions that generate the greatest added value with the limited resources available can be identified (Pearce et al., 2006).

Decision-makers are therefore currently faced with a dilemma: they are caught between the need for urgent action and insufficient information on which decision-making can be based. Thus, while it seems obvious that biosphere integrity can only be maintained by conserving and restoring nature (e.g.

Fischer & Lindenmayer, 2007; Newbold et al., 2016; Oliver, 2016), which value a specific action has, and which action is most efficient in this regard, remains to be determined on a case-by-case basis.

This task of identifying the most efficient measure is particularly challenging due to the complexity of the options for protecting biodiversity and the diverse impacts. In order to determine the best projects, information is needed on all impacts and related interrelationships and thus on different scales of a project. Information on different scales is valuable to decision makers because it allows more detailed consideration of spatial, temporal or causal detail as scale becomes finer (Millenium Ecosystem Assessment, 2003).

The basic prerequisite for the implementation of a project is that the benefits of a project, e.g. in terms of protected species, exceed the costs of its implementation. The added value of a project therefore represents the overarching information needed to identify the most efficient biodiversity protection measures and thus the top scale of information needed. Information is also needed on the different impacts of projects and their components, which depend not only on the measures but also on the framework conditions. Information on impact is important because the added value of a project is ultimately a product of its impact, and optimization must therefore be guided by it. This information describes the middle scale of information that is needed. Finally, for accurate planning, information is needed on the individual impacts and the question of what exactly is perceived as a cost and what is perceived as a benefit, which describes the bottom scale of necessary information.

Table 1: Empirical studies and research questions

Empirical studies	Scales	Research Question	Method used
Assessing the trade-offs in more nature-friendly mosquito control in the Upper Rhine region	The added value of a project (top scale)	Do the benefits of nature conservation outweigh the costs, i.e. increased nuisance in these areas?	Contingent Valuation Method
The role of project components for acceptance of inner-city river restoration projects	The different impacts of a project (middle scale)	How high is the acceptance of the river restoration project and its individual components and which factors explain the acceptance of the components?	Measuring Acceptance
What determines preferences for semi-natural habitats in agrarian landscapes? A choice-modelling approach across two countries using attributes characterizing vegetation	Link between the measure and an individual impact (bottom scale)	Which characteristics explain people's aesthetic preferences, and how do seasons influence the vegetation characteristics of a restricted number of crop and grassy or woody SNH combinations and how does this impact preference statements in choice experiments?	Choice Experiment

This thesis addresses the complex issue of determining the most efficient projects to protect biodiversity and attempts to close the existing knowledge gap regarding the need for information on the different scales of a project. To this end, three different biodiversity conservation projects are analyzed in three separate empirical studies, each with a focus on one of the three scales described (table 1). All three studies are part of projects conducted in the Environmental Economics working group at the University of Koblenz-Landau, in which the doctoral student was the lead researcher and which fall within the conceptual framework described in the paper. The first study examines the added value of nature-friendly mosquito control. The second study explores perceived impacts of different

components of a river restoration project. The third study investigates the relationship between two types of measures to increase biodiversity in agriculture with a focus on perceived aesthetics. The results of the three studies should help to better understand the complex interrelationships that determine the added value of a project. This involves examining the influence of different projects, but also combinations of ecological and social measures as well as seasonal, geographic and socio-demographic conditions, and finally the available information about a project on the perceived real and fictitious costs and benefits that people associate with a project.

The subsequent work is structured as follows. In order to place the three studies in context, chapter 2 first describes the background of the studies and the related research questions. Following this, chapter 3 provides an overview of the various factors that determine the complex task of identifying the most efficient biodiversity conservation project. For this purpose, a brief insight into the theory of utility and the added value of a project is given. This is followed by an overview of the different types of measures and the various circumstances that finally determine the perceived impacts of a project. Potential impacts are explained in the subsequent section. Next, methods are presented that are suitable for investigating the three scales described. Chapter 4 contains a description of the methods used in the three studies. In the fifth chapter the three original studies are presented. The sixth chapter synthesizes the results of the studies and discusses them with regard to the superordinate problem and in the seventh chapter an outlook is given.

2. Empirical Background

The first study “Assessing the trade-offs in more nature-friendly mosquito control in the Upper Rhine region” (Weiß, Allgeier, Brühl, & Frör, to be published) examines the added value of changes to mosquito control practices for the protection of biodiversity in floodplains. The focus in this context is on the Rhine floodplains, which are among the most species-rich areas in Germany (Ackermann et al., 2012). As these areas are repeatedly flooded, large numbers of floodwater mosquitoes hatch. These areas have been treated with the biocide Bti for decades (Becker, Ludwig, & Su, 2018); treatment is mostly in protected areas (Brühl et al., 2020). By now, numerous studies have revealed that Bti not only kills the larvae of mosquitoes but also has a negative effect on other animals, especially chironomids (Allgeier, Friedrich, & Brühl, 2019; Allgeier, Kästel, & Brühl, 2019; Boisvert & Boisvert, 2000; Jakob & Poulin, 2016; Kästel, Allgeier, & Brühl 2017; Poulin, Lefebvre, & Paz, 2010; Theissinger et al. 2018), which has led to a rethinking of current control practices. Accordingly, decision-makers are currently faced with the question of how the population perceives alternatives to current control. The research question of this paper is therefore: do the benefits of nature conservation outweigh the costs, i.e. increased nuisance in these areas?

The second study “Inner city river restoration projects: the role of project components for acceptance” (Weiß, Schilling, & Frör, to be published) examines acceptance and associated costs and benefits of a watercourse restoration project. The focus is on an urban river restoration project in the town of Bad Bergzabern in Rhineland-Palatinate, Germany, whose planning had been completed but not yet implemented at the time of the study. Water bodies are of high importance due to their functions, but are in poor condition worldwide (Everard & Moggridge, 2012; Millennium Ecosystem Assessment, 2005; United Nations 2021). In Europe, only 41% of rivers have a good status, in Germany only 7% (European environmental agency, 2018). The Water Framework Directive therefore obliges EU Member States to achieve good ecological status for their water bodies by 2027. The river restoration project studied for this paper is part of this effort and consists of four components, two ecological and two social. The central part of the project is the reopening and restoration of the river in a spa garden, which is complemented by the reopening and restoration of a previously unused area, the reopening of the river on the site of a car park and its redesign and the construction of a playground. The approach pursues the research question: how high is the acceptance of the river restoration project and its individual components, and which factors explain the acceptance of the components?

The third study “What determines preferences for semi-natural habitats in agrarian landscapes? A choice-modelling approach across two countries using attributes characterizing vegetation” (Schüpbach, Weiß, Jeanneret, Zalai, Szalai, & Frör 2021) examines people's aesthetic preferences for measures to increase biodiversity in the agricultural landscape. The background to the study is current efforts to promote biodiversity in agricultural landscapes through semi-natural habitats; yet the effects of structures, such as hedgerows and low input grassland, are not yet fully understood. It is now widely acknowledged that, hedges can protect against erosion and contribute to pest control (Marshall & Moonen, 2002; Matson et al., 1997), but it is unclear, how such structures affect the aesthetics of the landscape. The research question here is: which characteristics explain people's aesthetic preferences and how do seasons influence the vegetation characteristics of a restricted number of crop and grassy or woody SNH combinations and how does this impact preference statements in choice experiments?

3. The factors determining the added value of a project

The added value of a biodiversity protection project depends first and foremost on its individual design. The respective framework conditions have an influence on the design options, but also on the perception of the impacts. For scientists, the available methods limit the possibilities of investigating these interrelationships. The focus is here, therefore, always on people's preferences, which provide information about the added value of a project. The next chapter will therefore first describe the importance of people's preferences for the added value of a project. The following chapters then go into more detail about projects and their framework conditions, potential impacts and finally the methods for assessing people's preferences.

3.1. People's preferences and the added value of a project

Biodiversity protection measures have an impact on people's well-being, as they have an influence on people's health, but also their material needs (Millenium Ecosystem Assessment, 2003). People assign utility to all goods and services and seek to maximize it through their decisions. In theory, the utility of an individual in situation A is higher than in situation B if he or she prefers A over B (Pearce et al., 2006). For instance, if a person is faced with the choice of exchanging an apple for a pear, he or she considers his or her preferences in this regard, i.e. how high the utility of both fruits is for him or her. If the utility of the pear is greater than that of the apple, he or she trades; if the utility is lower, he or she does not trade. If the utility is equal, he or she is indifferent with respect to the decision. When people make a trade, it can be assumed that they increase their utility and that the exchanged good or situation has a higher utility than the good or situation they give up. The respective decision describes people's preferences with respect to the traded goods and the utility they derive from them over time (Varian, 2011).

The gain in utility from choosing one alternative over the other describes the added value of the decision for the person. However, how high the added value is cannot be determined on the basis of the trade, since it is only known that the utility is at least as high as that of the good or service that the person has given up (Varian, 2011). The added value of a biodiversity protection project follows the same rules: The added value is the difference between the utility of the current state of nature and the utility associated with the change. The two situations differ in that such projects focus not only on the benefits of individual people, but of all people affected by a project. Accordingly, the added value of a biodiversity protection project is usually described in terms of the preferences of all the people affected. It is assumed that a project has an added value for people if the sum of benefits exceeds its costs (Varian, 2011). This is based on the assumption that the beneficiaries of a project could hypothetically compensate the losers and there would still be a net profit left. Such a condition follows the Kaldor Hicks criterion and can thus be considered Pareto optimal, since the change can achieve an improvement without worsening the situation of any of the affected people (Pearce et al., 2006).

People's preferences, and thus the utility of a project, reflect the values that people attach to a good (Varian, 2011). For example, people may value fish in a restored stream because they can catch and eat it (i.e. direct use value), but also because the fish feeds on mosquito larvae and they thus benefit from it indirectly because they are less bothered by mosquitoes (i.e. indirect use value) (Kumar, 2010). However, it can also be of value to people to know that the fish is living in the stream again even though they are not using it directly or indirectly, but they are happy that they or others have the option to catch and eat the fish in the future or benefit from it eating mosquitoes (option value). Furthermore, people may value the fact that fish live in the stream again at all (existence value) or that the species is preserved for future generations (legacy value). The sum of all values that can be assigned to a good is described by the total economic value (Kumar, 2010). The total economic value of a good is thus composed of use and non-use values. Direct and indirect use value can clearly be

counted as use values, existence value and bequest value are non-use values. The option value, on the other hand, can be counted as either a use value or a non-use value, depending on whether people see the option for themselves personally or for others in the future (Pearce et al., 2006).

For the assessment of biodiversity protection projects, the questions that beg to be asked are: what values do the impacts have for people and are the costs associated with a measure lower than the resulting benefits? Ultimately, however, the design of the specific project and the associated framework conditions determine which impacts are perceived at all. Both aspects are therefore described in more detail in the next section.

3.2. Project design and framework conditions

In the end, the added value of a project is determined by people's perception of the costs and benefits. What exactly people perceive, however, depends on the type and design of the respective project, as well as on the associated framework conditions. Both together form the top scale that can be observed with regard to the added value of a project. These factors are crucial, as they determine the project's scope for design and thus also represent levers in terms of efficiency.

3.2.1. Project design

There are countless different measures to protect biodiversity (IPBES, 2019). Any human intervention that raises the question of whether or not a part of nature should be preserved is a potential measure. Examples could be the construction of a road or a house, but also a new LNG terminal. The possible measures that pursue the goal of restoring parts of nature are equally diverse. Likewise, there are numerous possible measures that pursue the goal of restoring parts of nature and there are often several alternatives to achieve a given goal, both technically and in terms of design. For example, hedges or flower strips can be planted to increase biodiversity in agriculture, but a more extensive cultivation could also be chosen. Similarly, the course of a river can be extensively altered by mechanical means or the measure can consist of small initial interventions, and trust that over a longer period of time natural erosion processes will restore the desired condition on their own. The possibility to complement biodiversity protection measures with measures of social nature, adds to complexity. For example, in urban areas, river restoration projects are often complemented by social measures such as a playground. Each project option can thereby result in potentially different impacts, which may or may not be appreciated by the population. The combination of measures can be expected to lead in turn to an increase in the number of project impacts. It should be noted that the impacts of individual measure components may also influence each other.

3.2.2. Framework conditions

The impacts and thus the perceived costs and benefits of a project depend not only on the measure(s) themselves, but also on framework conditions (Johnston et al., 2017). Probably the most fundamental framework condition is the initial situation from which a project starts. For example, a river can be restored inside but also outside of a village; the river could also be different in terms of climate and geography, and, thus, also with regards to structure and the animals and plants found there. Ownership structures also play a role, with differences between private and public ownership being the most decisive in this respect (Becker, Klagge, & Naumann, 2021). Furthermore, socio-demographic factors of the people affected by the project, such as age, gender, income, education, and cultural aspects have an effect on the perception of impacts. These socio-demographic factors are of particular relevance, since they can directly explain people's preferences heterogeneity (Johnston et al., 2017). Depending on the aspects outlined above, the initial situation can be very different on a local, regional and also on a global scale.

In addition to the initial situation, at what point in time a project is assessed plays an important role with regard to the perception of the project's impacts. Since the added value of a project results from the utility people experience over the entire project period, whether a project develops and perceptions change over time is relevant. Several studies have shown that the perception of a project is related to the factor of time. For example, Buijs (2009) and Aberg & Tapsell (2013) found that satisfaction with a project increases over the long term. Furthermore, Aberg, & Tapsell (2013) demonstrated that satisfaction initially decreases after implementation, because the expected outcome of the project was not yet visible. Wolsink's (2007) findings suggest that the acceptance of a project follows a U-curve; a relatively high acceptance at the beginning of a project decreases with the participation of people in the selection of the specific setting of a project location and then increases again after the implementation of the project. It can be assumed that people start to attribute utility to a project as soon as they learn about the project, whereas the perceived impacts are still fictitious at that moment. Expected impacts and associated utility do not have to correspond to reality at this point in time and may also reflect unfounded concerns or hopes of people. Once the planning process is completed, the opportunity for people to influence the project ends, and a new phase, the implementation phase, of the project begins. As soon as the project is implemented, the impacts become real and can then be compared against people's expectations. The effects directly related to the construction phase become apparent first. Once construction is completed, most of these impacts are no longer relevant, and the long-term effects of the planned project gradually come to bear. Depending on the project, impacts can occur with a delay. As a consequence, project phases can be assessed differently over time. This particularly applies to biodiversity-related impacts, since plants have to grow first and animals have to recolonize a new habitat, for example. In addition, seasonal effects influence the perception of vegetation in particular, and therefore some effects are only visible temporarily and with great variations throughout the year. These changes over time highlight the importance of taking into account people's preferences over the entire project period when determining the added value of a project.

Furthermore, the information available on a project has an influence on how its impacts are perceived (Johnston et al., 2017). Up to the moment at which a project is implemented, the perception of its impacts is based primarily on the information available and on the opportunities to participate and influence the project. With regard to the information, most relevant for the perception of impacts is the information that is given about the project in the first place, as it is the basis for what can be perceived at all (Bateman et al., 2002; Hensher, Rose, & Greene, 2005; Johnston et al., 2017). Experiences that people already have with comparable projects play a role, as these provide a frame of reference. Depending on the purpose, participation opportunities can offer the population a source of information as well as a channel to influence the impacts of a project and the personal added value. Involvement of the population should, by now, be an integral part of river restoration projects in Europe (European Parliament, 2014). The role of information and participation changes over the course of a project. While participation only plays a role at the very beginning, information about a project can constantly influence perceived impacts. Thus, once the project is implemented and real impacts are experienced, information can still be crucial, as it can be used to identify real impacts and disprove fictional ones. Information and participation are particularly important because decision-makers have a strong influence on both the information people receive about the design of a project and its impacts, and the participation process.

The acceptance of a project also has a decisive effect on its added value. If parts of the population strictly reject a project on the basis of individual impacts, this may jeopardize the implementation in general and thus make the generation of an added value questionable (Kondolf & Yang, 2008; Schively, 2007). The factors influencing the acceptance of a project are very similar to those of the added value.

A widely used approach to explain acceptance is the concept of NIMBY (not in my back yard), which assumes that the acceptance of a project is due to personal utility maximization (Becker, Klagge, & Naumann, 2021). Doubts about this concept have led more recent explanatory approaches to distinguish between different types of acceptance. One of these approaches is that of Wüstenhagen, Wolsink, & Bürer (2007), which divides acceptance into three dimensions: socio-political, market and social acceptance. Community acceptance takes into account the opinion of local stakeholders on a specific project and is therefore most relevant for concrete biodiversity protection projects and at the focus of this paper. According to Becker, Klagge, & Naumann (2021), community acceptance is a function of (1) the perceived costs and benefits of a project, (2) perceived procedural and distributional justice and trust, (3) landscape change, place attachment and identity, (4) ownership structure, and (5) other contextual factors. While factors 4 and 5 describe framework conditions that may also play a role with regard to the added value of a project and have already been mentioned in this chapter, the first three factors describe all potential impacts associated with a project. The next chapter will address these in detail.

In summary, we can argue that the design of the project as well as the associated framework conditions determine the utility that people can experience through a project. However, the concrete impacts and associated costs and benefits that people perceive must be determined on an individual basis. The different impacts that people may associate with a biodiversity protection project are described in more detail in the next chapter.

3.3. Potential impacts of a project – costs and benefits

As described in the previous section, both, design of a project and framework conditions determine the impacts that a project has. However, the decisive factor is ultimately which impacts of a project people perceive, since only these have an effect on their utility and the added value of the project. While the design of a project and the associated framework conditions describe the top scale of a project, the different impacts describe the middle scale.

The impacts that people assign to a project can theoretically be real impacts, but they can also be fictitious in nature. Which specific impacts of a project people perceive is largely determined by the information that is available about the project and the associated impacts (Bateman et al., 2002; Hensher et al., 2005; Johnston et al., 2017). Information can be distributed by the official authorities responsible for the project in the form of press releases, but also at information or participation events. Also, the press in itself can distribute information about planned or implemented projects. Furthermore, there are private channels that can provide information about real as well as fictitious effects of a project. The communication of a project, but also whether and how the population is involved in a project, also have an impact on whether a project and the associated decision, as well as the use of resources for a project, are considered as fair (Becker, Klagge, & Naumann, 2021). Information about a project therefore has a very important role to play, both, in terms of its influence on the perception of all other real or fictitious impacts, and in terms of impact on the fairness associated with a project.

3.3.1. Real impacts

Real impacts can be very diverse and can be associated with all parts of the project. Firstly, the procedural and distributive justice perceived with regard to a project can be considered as a real impact (Becker, Klagge, & Naumann, 2021). Furthermore, the use of resources for the measures associated with a project has an impact (Deffner & Haase, 2018), as they can no longer be used for other projects. As such, planning consumes resources, areas to be protected may have to be acquired first, and the work to restore it also requires resources. Additionally, many measures have to be

monitored and maintained on a permanent basis, which also ties up resources that are then no longer available for other purposes.

Furthermore, the implementation process of a project is associated with specific impacts. Measures that involve substantial interventions and the use of heavy machinery may have an impact on the noise level, for example. Yet not all interventions cause noise; the closure of a road can also lead to a decrease in noise levels. The implementation phase may result in other temporary restrictions on the use of an area and cause numerous other impacts; these depend on the nature of the intervention.

Due to the focus of biodiversity conservation projects on the respective ecosystems and their functions, the impacts in this area are often diverse (IPBES, 2019). The influence on the various functions can have both positive and negative impacts. The benefits that people derive directly or indirectly from ecosystems are commonly referred to as ecosystem services (Millenium Ecosystem Assessment, 2003), where services include both goods and services provided by an ecosystem (Constanza et al., 1997; Daily, 1997). Ecosystem services are classified into the four categories of provisioning, regulating, cultural, and supporting services based on the function of an ecosystem (Kumar, 2010). Provisioning services describe the ability of ecosystems to provide goods. For example, ecosystems can be protected or restored to provide food in the form of animals and plants, materials such as wood, silk or cotton, but also fresh water, fuel, genetic resources, natural medicine or ornamental objects. In addition to these very direct services, ecosystems can also have a regulating effect that impact people's lives. Regulating services include the regulatory impact of ecosystems on climate and water, the potential to maintain air and water quality, erosion and storm protection, plant pollination, as well as the natural control of pests and human diseases. Cultural services have an impact on non-material values such as the recreation, inspiration, attachment to place, the social relationships of people as well as spirituality and religion. Most of these "cultural" impacts are provided not only by ecological measures, but can also be provided by complementary social ones. Supporting services, in turn, form the basis for all other three services and are usually not taken into account with regard to the added value of a project in order to avoid a double counting (Kumar, 2010). The effects of supportive services tend to be indirect or occur over a very long period of time compared to the other three services. These services include primary production, soil formation, nutrient cycling, water cycling, and habitat provision.

3.3.2. Fictitious impacts

Since perceptions of a project's impact, and thus the associated costs and benefits, are subjective, they need not correspond to reality. Fictitious impacts may be theoretically conceivable, such as people's concerns that the reopening of a river could lead to children drowning, but in reality they may be largely unfounded. Real impacts may also be misjudged and thus turn into fictitious impacts. Impacts that provide benefits in reality can be perceived as costs and vice versa. For example, people may be concerned that a river restoration project will result in a higher flood hazard, even though in reality the hazard is decreased. People may also associate a project with consequences that have nothing whatsoever to do with reality. Accordingly, what people associate with a project and what they perceive as costs and benefits encompasses all real effects, but also all concerns and hopes that people associate with a project.

3.3.3. The trade-off between different goals

The variety of perceived impacts associated with a project is often due to the fact that people have competing interests that influence perceptions. Thus, not only are the resources spent on a project no longer available, projects may also have a direct impact on these other and sometimes even conflicting interests. The protection of biodiversity on agricultural land showcases this problem very clearly.

Biodiversity conservation measures in agriculture often result in land being taken out of use. This, in turn, means that less land can be used to grow foodstuff, which represents a conflict with the food security goal of the Sustainable Development Goals (United Nations, 2015). Campbell et al. (2017), for example, assume that global hunger can only be defeated if even more land is made usable in the future, as population numbers rise. This highlights the challenges faced by decision makers regarding biodiversity conservation and the identification of associated costs and benefits. Overarching goals such as the compliance with the planetary boundaries and the associated preservation of biodiversity and the Sustainable Development Goals must necessarily be thought of together, since one cannot be achieved without the other (Raworth, 2012). However, the same applies ultimately to all goals pursued by people affected by a project. Maximizing the added value of a project always means making trade-offs for different goals represented in the population.

Which impacts of a project are perceived by the population ultimately depends on the design and the associated framework conditions that have already been described in chapter 2.2. In this context, it is important to understand a project at the level of different impacts, but it is also to understand how individual impacts differ with respect to different projects. Both levels of information are of interest to decision makers as they enable better planning of projects. A better understanding of the interrelationships in these cases requires more research, whereby the focus and the method used ultimately decide which linkages are uncovered. The methods available and their advantages and disadvantages are described in the next chapter.

3.4. Methodology

There are various analytical approaches to investigate biodiversity protection projects (Kumar, 2010). Depending on methodological design, an analysis can provide information about different scales of a project. As in the first study, the focus can be on the design and framework of a project and the associated added value. The focus can also be on the different costs associated with a project and its components, as in the case of the second study. And finally, as in the third study, the focus can also be on the interrelationships that explain the single impacts.

Determining the added value of a project requires special methods. This is because the costs and benefits associated with a project must be measured in the same unit (Pearce et al., 2006). The utility that a person associates with a good can be measured, as described in chapter 3.1., on the basis of their trading behavior and the preferences expressed in the process. Since purchasing decisions follow the same rules, it has become widely accepted to measure the costs and benefits of projects in monetary terms (Rus, 2021). This has the advantage that the implementation costs are already described in the required units and therefore do not need to be translated. Furthermore, a monetary valuation of all impacts suits decision makers, as economic impacts are easier for them to interpret (Oliver, 2016).

In the following sections, the most basic methods capable of analyzing the added value of a project are presented first, followed by the two available methods that address basic problems of the first mentioned methods and are the basis of the first and third study. Next, the method of acceptance measurement used in the second study is presented, which does not assess the added value of a project, but is able to take into account other problems that exist with regard to the analysis of the different levels of a project.

3.4.1. Revealed Preference Methods

All impacts of a project that affect goods or services traded on markets can be assigned monetary values relatively easily. Accordingly, such impacts of a project can be assessed using this information (Barbier, Acreman, & Knowler, 1997). Usually, these are impacts on things to which humans attach a direct use value, such as fish or building materials. However, many impacts are not traded on markets although they have a direct or indirect use value. Examples of such direct use values are the recreational value people gain from experiences in nature and the aesthetic value of a landscape. Examples of indirect use values that are not traded on markets are the natural flood protection resulting from floodplains or the regulation of temperature by vegetation.

The value of such effects can be determined using revealed preference methods. These methods have in common that they use the preferences for other goods or services traded on markets to determine the value of the impact under study. Methods that are frequently used in this regard are the travel cost method, the hedonic pricing method, the replacement cost method, or the avoidance cost method (Birol, Karousakis, & Koundouri, 2006; Hanley & Barbier, 2009; Pearce et al., 2006). The travel cost method assumes that a person's trip expenditures to a specific place can serve as an indicator of the recreational value that person perceives (Börger et al., 2022; Czajkowski et al., 2015; Hanley & Barbier, 2009; Pearce et al., 2006). The method of hedonic pricing assumes, for example, that the price of an apartment depends, among other things, on the view and thus on the aesthetics of the surroundings, and that the proportion of the price that can be attributed to this aspect in turn describes the value of the view (Garrod & Willis, 1992; Hanley & Barbier, 2009; Pearce et al., 2006; Tyrväinen, 1997). The replacement cost method considers the expenditure that must be made to replace, for example, the cooling impact of vegetation with a technical alternative, such as air conditioning, as an approximation of the value of this function (Jackson, Finn, & Scheepers, 2014; Notaro & Paletto, 2012; Pearce et al., 2006). The avoidance cost method assumes that, for example, the damage to infrastructure prevented by the natural flood protection of a river can be used to understand the value of this service (Abdalla, 1994; Birol et al., 2006). A major advantage of these methods is that preferences can be measured using market data. Unfortunately, such methods are not applicable to all types of impacts and only consider use values, while they cannot take into account non-use values. The second point is the most important, as it inevitably leads to an underestimation of the value of the impact. The three studies therefore did not use these methods.

3.4.2. Stated Preference Methods

Only the contingent valuation method (CVM) and the method of choice experiments (CE), which belong to the stated preference methods, are currently able to assess use and non-use values and, thus, the total economic value of a project (Johnston et al., 2017). Also, only these methods are able to assign a value to public goods and other impacts that cannot be valued by revealed preference methods using available market data. However, like revealed preference methods, they follow the idea of determining the value of an environmental good or project on the basis of a market. The difference is that the two stated preference methods simulate this market on which people are supposed to state their preferences.

A distinction is made between people's willingness to pay (WTP) for a change in public goods due to a proposed project and their willingness to accept compensation (WTA) for a change (Johnston et al., 2017; Pearce et al., 2006). The respondents' WTP for a project that improves environmental quality can be assessed, just as well as the WTP to prevent a project that would lead to a degradation of environmental quality. It is also possible to determine the willingness of people to accept compensation for not implementing a project that would improve environmental quality or for implementing a project that leads to a deterioration of environmental quality. Since a deterioration of

the environmental quality is usually valued higher than the renunciation of an improvement, the different approaches do not come to the same result (Kim, Kling, & Zhao, 2015). The evaluation of the WTP is now generally preferred (Johnston et al., 2017; Pearce et al., 2006). A basic requirement of the methods is that the respondents' statement about their WTP or WTA requires credible consequences, which is why the use of the methods is actually limited to the ex-ante evaluation of projects.

A central component of both CVM and CE is a project scenario and a payment scenario. The project scenario serves to explain the current situation to interviewees (i.e. potential buyers); it also presents planned change, and product. The payment scenario explains why and how people should pay for this product in the first place. Both aspects are of crucial importance for the validity of the results obtained: the project scenario must ensure that all people have the same product in mind and understand its impacts; the payment scenario must be credible to ensure that respondents express their true preferences (Johnston et al., 2017). For a detailed overview of the methods and their application, see Alberini & Kahn (2009), Bateman et al. (2002), Carson & Hanemann (2005), Frör (2007), Hensher et al. (2005), and Johnston et al. (2017).

3.4.2.1. Differences between the Contingent Valuation Method and Choice Experiments

The main difference between the two methods is that the contingent valuation method assesses the added value of a specific project, while choice experiments can assess the value of different project variants and single components of projects (Hensher et al., 2005; Johnston et al., 2017).

Choice experiments offer the possibility to analyze preferences relating to different impacts of a project (Hensher et al., 2005). In choice experiments, participants are repeatedly asked to choose between different options, with each option representing a theoretical project variant. Each option is composed of different attributes that describe a project's impacts. For example, a planned project to increase biodiversity in agriculture may include attributes, such as the planting of hedges or low input grassland. Both are associated with costs for implementation that are a further attribute. The task of the respondents is to trade off options against each other in terms of their utility and to select the variant that, from their point of view, provides the greatest added value (Hensher et al., 2005). To ensure that respondents are not forced to choose a change, one of the options offered is usually the status quo (Johnston et al., 2017). This option does not involve any costs or additional measures, but rather maintains the current state. For analytical purposes, respondents are usually faced with the task of choosing between different options several times (Hensher et al., 2005). In this setting, attributes, and thus impacts, always differ between the options presented. The level of detail of the presented impacts ultimately depends on the objective. The analysis may focus on people's preferences for hedges and low input grassland in general, but it can also aim to better understand preferences for different variants of hedges and low input grassland on a single type of impact as in study 3.

According to Johnston et al. (2017), whether the contingent valuation method or a choice experiment is better suited to assess the added value of a project depends on various factors. First, this is dependent on the information needs of the decision makers. If they are only interested in the added value of a project, the CVM method is more suitable; if they are also interested in the perception of the different impacts, CE is more suitable. Furthermore, suitability depends on whether respondents perceive the good as a whole or the individual impacts, and whether the respondents are cognitively capable of evaluating a project on the basis of different complex attributes at all.

3.4.2.2. The limitations of the Contingent Valuation Method and Choice Experiments

There are numerous problems associated with the two methods (Bateman et al., 2002; Hensher et al., 2005; Johnston et al., 2017). Most of the problems are due to the hypothetical nature of the methods

and have their origin in the scenarios or the process of capturing the willingness to pay. Among the best-known issues are comprehension and credibility problems relating to the project and payment scenario as well as interviewer's bias, strategic behavior, influence of social desirability, and protest behavior regarding the willingness to pay (Bateman et al., 2002; Hensher et al., 2005; Johnston et al., 2017; Pearce et al., 2006). The scenario problems are particularly relevant in that they define the limits of where the methods can be used and are, therefore, detailed next.

The prevalence of comprehension problems depends, to a large part, on the cognitive abilities of respondents. For example, if respondents cannot absorb the information about a project, their assessment might be based on only some of the relevant impacts (Börger, 2016; Campbell, Hensher, & Scarpa, 2011; Scarpa, Zanoli, Bruschi, & Naspetti, 2013). People's cognitive abilities, thus, limit the amount of information that can be conveyed about a project. This means that any assessment of the added value of projects has to be based on (partly) superficial information. This is, in particular, the case for biodiversity protection projects, which have complex impacts that cannot be conveyed to the respondents in detail. For choice experiments, limitations regarding cognitive ability restrict the number of attributes and thus the number of impacts of a project that can be studied (Bateman et al., 2002; Hensher et al., 2005; Johnston et al., 2017). As a consequence, projects are described in terms of overarching impacts so that the most important impacts can be considered at all in the assessment of added value (Brouwer et al., 2016; Hanley, Wright, & Alvarez-Farizo, 2007). For example, a biodiversity protection project that includes the planting of woody structures can have an impact on a wide variety of birds and insects, aesthetics, but also on agricultural yields. Since the complex impacts would be far too complicated and detailed to explain to respondents, a differentiated assessment of such impacts in terms of the added value of a project is not possible based on a single study. People's preferences for detailed impacts of specific projects, consequently, often remain unknown.

Another problem of CVM and CE studies is that they simulate two essential factors. Firstly, the provision of information on the impacts of the project is simulated; all respondents are provided with the same standardized information (Johnston et al., 2017). The standardized dissemination of information does not at all correspond with reality, in which access to information varies greatly within the population and the constant flow of information can change perceptions of a project's impacts over time. Secondly, the two methods simulate participation in the process of decision-making (Johnston et al., 2017). The simulated participation of people in project decisions does not correspond to reality. In reality, participation is not offered for every project and only a fraction of the population makes use of such offers. Both factors, however, play a decisive role with regard to the added value of a project. On the one hand, they determine which impacts of a project are perceived at all. On the other hand, they influence whether the procedure of the project and the distribution of costs and benefits associated with the project is considered to be fair. This in itself is an impact of a project that can have a direct effect on the added value. Furthermore, the careful selection of information on a project scenario leads to a focus on real impacts. Nevertheless, fictitious concerns and hopes can also shape preferences, since the respondents may refer to their own experiences in addition to the information given in the scenarios.

The assumptions made regarding information flow and participation place limitations on the transferability of results. In any case, CVM and CE describe only a snapshot. And, due to their hypothetical nature, the methods do not allow tracing how added value and the perception of a project’s impacts change over time. What is more, in reality, there are not only two states of a project but, as described in chapter 3.2.2, different phases of projects that differ in terms of their impact and probably also their added value. This limits the predictive power of the methods in terms of the added value of a project over its entire lifetime.

One of the main shortcomings of CVM and CE is that, due to their hypothetical nature, they can only provide a snapshot. This means that the methods cannot take into account the impacts or added value of the different phases of a project. Furthermore, they cannot take into account actually perceived justice, nor the influence that actual information about and participation in a project has on the perception of other impacts associated with a project. Other methods are needed to close these information gaps.

3.4.2.3. Valuing acceptance as an alternative to classical stated preference methods

Stated preference methods, like CVM and CE, are similar with respect to data collection – they can be used for measuring acceptance and its associated factors. All three approaches use a survey to collect data on people's preferences relating to a project, with the first two focusing on WTP and the last on acceptance.

According to Becker, Klagge, & Naumann (2021), acceptance of a specific project is composed on the basis of 5 factors: (1) the *perceived costs and benefits* of a project, (2) *perceived procedural and distributional justice and trust*, (3) *landscape change, place attachment and identity*, (4) *ownership structure*, and (5) *other contextual factors*. The individual impacts, which determine the added value of a project in the form of costs and benefits, are considered as separate factors by Becker, Klagge, & Naumann (2021) that determine acceptance. Accordingly, the factor *perceived costs and benefits* of a project does not include all costs and benefits described in chapter 3.3. that determine the added value of a project, as these are partly captured by the two factors *perceived procedural and distributional justice and trust*, and *landscape change, place attachment and identity*. In this way, the course of a project, as well as the participation in the associated processes and thus the perceived procedural justice, and the perceived justice with regard to the distribution of costs and benefits, which also determine the added value of a project as a direct impact, are seen as a separate factor that explains the acceptance of a project. The factor *landscape change, place attachment and identity* is in turn composed of several impacts of a project that belong to the cultural ecosystem services already mentioned in the chapter 3.3.1. These impacts include implications of changes in landscape appearance on aesthetics and on people's attachment to a place. A difference between the factors that determine acceptance and added value is the trust people have in decision-makers, which is part of the factor *perceived procedural and distributional justice and trust*. Trust has, if any, only an influence on the perception of impacts associated with a project, but is not in itself an impact that contributes to the added value of a project as a cost or benefit. The last two factors, *ownership structure* and *other contextual factors*, describe the framework conditions of a project, which might also be relevant for determining the added value of a project and are described in chapter 3.2.2. While the factors that determine acceptance and added value of a project are very similar, there is a difference in terms of the people that should be considered. While in terms of acceptance only directly affected people are relevant, to determine the added value of a project all people whose utility is affected by the project should be taken into account, regardless of where they live.

Measuring acceptance is, for several reasons, a valuable alternative to CVM and CE when it comes to identifying the most effective biodiversity protection projects. Firstly, because it can fill the information gaps that exist due to the limitations of CVM and CE. A key advantage of acceptability measurement over CVM and CE is that it does not require a hypothetical scenario. Instead, it identifies people's preferences for concrete and real projects, which offers the opportunity to study people's preferences at different stages of a project (Wolsink, 2007), which also takes into account the real consequences in terms of information dissemination and participation that has taken place. Consequently, by measuring acceptance, real preferences and not those based on hypothetical projects can be determined, which provides information about all conceivable impacts and framework

conditions of a project. This is particularly valuable as the factors that determine the added value of a project and its acceptability are very similar. Finally, it is important to understand acceptance, as it determines whether a project can be implemented at all.

The methods presented above show the possibilities and limitations of what can be investigated at all with regard to biodiversity protection projects. Unfortunately, the complex interrelationships between the design of a project, the associated framework conditions and the different impacts and finally the added value of a project cannot be captured with a single method. As a result, it is not possible to analyze the different scales of a project at the same time. Instead, the desired scale of a project determines the suitable method. For the purpose of this thesis, three different biodiversity conservation projects were analyzed. Each represents one of the three scales and for each, a distinct method was employed.

4. Method selection and application

The main part of this thesis contains three empirical studies on three different sub-areas of biodiversity conservation. Each study focuses on one of the described scales, each applies different methods. In the first study "Assessing the trade-offs in more nature-friendly mosquito control in the Upper Rhine region" (Weiß, Allgeier, Brühl, & Frör, to be published), a contingent valuation method is used to determine the added value of a more nature-friendly mosquito control project, taking into account individual costs and benefits as well as socio-demographic factors. The second study "Inner city river restoration projects: the role of project components for acceptance" (Weiß, Schilling, & Frör, to be published) uses the Measurement of Acceptance to examine the perception of real and fictitious costs and benefits of various ecological and social components of a river restoration project. It also addresses the influence of perception on the acceptance of project components, taking into account the socio-demographic framework conditions. The third study "What determines preferences for semi-natural habitats in agrarian landscapes? A choice-modelling approach across two countries using attributes characterising vegetation" (Schüpbach, Weiß, Jeanneret, Zalai, Szalai, & Frör 2021) investigates the relationship between hedgerows and low input grassland and different geographic and socio-demographic conditions on the perceived aesthetics of a landscape using a choice experiment.

The first study examines the willingness to pay for more nature-friendly mosquito control using the contingent valuation method. The WTP was determined with the help of standardized personal interviews with households in villages along the Upper Rhine, using a single bounded dichotomous choice format. The average willingness to pay was calculated on the basis of a standard logistic regression model. The project scenario investigated for the protection of biodiversity in the floodplains combines two measures, an ecological and a social one. The ecological measure is a stop of Bti application in areas of particular value for nature. The social measure is a compensation for increased negative effects of increasing mosquito numbers, as the use of Bti is reduced. This compensation takes the form of technical mosquito traps to protect against nuisance in settlements. The payment scenario assumes that the more nature-friendly mosquito control will be financed through municipal levies, which already finance mosquito control.
The scenario is associated with costs and benefits for people. On the one hand, the scenario studied has the benefit for people that the animals affected by Bti are better protected. On the other hand, the scenario leads to a loss of benefit: more mosquitoes and, therefore, increased nuisance is expected, at least outside of settlements; additionally, there will be financial costs for the population for technical traps. The research question explored in this paper asks whether the benefits generated by the scenario in terms of biodiversity protection outweigh the costs of higher nuisance but also higher financial costs.

The second study examines the acceptance of both the overall project and the components of the river restoration project, and investigates the links between the acceptance of the overall project and its components. In addition to acceptance, several factors are surveyed to investigate their influence on the acceptance of the four project components. These factors include the concerns that people associated with the project in the run-up to the study, perceived information about and participation in the project, people's attachment to the affected area, and socio-demographic characteristics. The first three factors can be understood as costs that the population associates with the project, whereas the socio-demographic characteristics of the respondents are part of the framework conditions of the project. Data were collected using standardized personal interviews with households in the municipality of Bad Bergzabern. The analysis of the acceptance correlation was based on a group comparison, while the influence of the factors on the acceptance of the components was analyzed using binary logistic regression models.

The study provides an insight into a phase of a real project that cannot be investigated by CVM or CE. On the one hand, the potential participation of the population with regard to the project under study had already been completed. On the other hand, a lot of information about the project was already in circulation. This circumstance makes it possible to examine the project and its impacts under real framework conditions with regard to participation and information. In addition, the phase of a project directly before implementation offers a special insight into people's concerns and consequently potential real and fictitious costs, as these could not yet be matched with reality.

The third study uses a choice experiment to investigate the effects of two semi-natural habitats (hedgerows and low input grassland) on perceived aesthetics; the framework conditions of the two habitats vary in terms of location (country) and season. An online panel in Switzerland and Hungary was used to conduct standardized interviews on people's preferences. The statistical analysis was carried out with the help of a latent class model that divides the respondents into groups of equal preferences, whereby socio-demographic variables of the respondents were taken into account in addition to the analyzed attributes. The project scenario did foresee the assessment of different landscape combinations consisting of crop, grassy and woody elements. The respondents were presented with four pictures, from which they had to choose the one they found most aesthetic. A payment scenario and thus a monetary evaluation of aesthetics was omitted in order to rule out bias and to capture only aesthetic preferences.
The four pictures always contained the same combinations of the elements, crop crop, crop grassy, crop woody and crop grassy woody. In order to illustrate the seasonal variation of the landscape and its impact on aesthetics, image combinations were created for three different seasons in Switzerland and for four different seasons in Hungary. Interviewees were presented with country-specific images that reflected the typical climatic, geological and pedological conditions of the two countries. In order to better explain the preferences behind the superordinate attributes of crop, grassy and woody, we used the existing literature (Junge et al., 2015; Lindemann-Matthies & Bose, 2007; Lindemann-Matthies, Junge, & Matthies, 2010) to determine additional attributes that describe these aspects. These attributes were not presented to the respondents, but only used for the analysis of the stated preferences. The attributes used were, order structure, the amount of bare soil, gravel or rocks, the amount of green vegetation, the availability of yellow, white, or purple features in the landscape which usually originate from flowers, and initial semi-natural habitat structures woody and grassy.
The study helps to better understand whether people perceive structures that are beneficial for biodiversity, such as hedgerows and low input grassland, as aesthetic and how these preferences can be explained in detail.

5. Empirical Studies

5.1. Assessing the trade-offs in more nature-friendly mosquito control in the Upper Rhine region

5.1.1. Introduction

In many regions across the world, the existence of mosquitoes poses a health threat to humans. Consequently, actions are undertaken to reduce or even eradicate mosquito populations near human settlements. Such mosquito control has a long history and is currently pursued by a wide variety of means. The reasons for mosquito control are two-fold: either because of the diseases they transmit, or because of nuisance, or both. In Europe, the risk of diseases, due to migratory birds, globalization, and climate change, is increasing (Becker, 2008; Hernández-Triana et al., 2014; Sambri et al., 2013), however, the most common reason for large-scale control of mosquitoes is still nuisance (Brühl et al., 2020). Though nuisance caused by mosquitoes seems unimportant to human health compared to the transmission of diseases such as Malaria or the West Nile Virus, several studies have highlighted its relevance for households. For example, Halasa et al. (2014) showed that avoiding nuisance caused by biting mosquitoes is of equal importance to the public as neighborhood safety. Dickinson & Paskewitz (2012) found that the control of mosquito nuisance is considered more important than the control of health risks associated with mosquitoes.

Besides these reason for mosquito control, the perceived benefit to households also depends on the method of control. For a long time, control was based on chemical insecticides. This had negative effects on human health and the environment (Boisvert & Boisvert, 2000; Brühl et al., 2020) and led to criticism (Coetzee & Koekemoer, 2013; Hemingway & Ranson, 2000; van den Berg, Yadav, & Zaim, 2015). As early as 1976, the bacterium Bacillus thuringiensis subsp. israelensis (Bti) was identified as a viable alternative (Goldberg & Margalit, 1977). By now, the biological insecticide Bti is used worldwide, as it is considered environmentally friendly due to its alleged low impact on so-called non-target organisms (Becker et al., 2010; Boisvert & Boisvert, 2000). This is especially important in temperate latitudes, where nuisance mosquito species breed in wetlands, that are recognized as ecologically sensitive areas (Becker, 1998). Several studies have shown that the value of control by far exceeds the costs (Bithas, Latinopoulos, Kolimenakis, & Richardson, 2018; Farmer, Redfern, Meisch, & Inman, 1989; Halasa et al., 2014; John, Walsh, & Moore, 1992; Mwebaze et al., 2017; von Hirsch & Becker, 2009). With respect to Bti, both John, Stoll, & Olson (1987) and von Hirsch & Becker (2009) were able to show that the households' benefits significantly exceed treatment costs. This is not surprising, since further studies have shown that people place a high value on an environmentally friendly treatment of mosquitoes (Dickinson & Paskewitz, 2012; John et al., 1987; Westerberg, Lifran, & Olsen, 2010).

There has been evidence for some time that, contrary to the initial assumption, Bti has negative effects on non-target organisms (Boisvert & Boisvert, 2000). Recent studies now indicate that the effects are greater than previously expected and, therefore, reason for concern. For example, Allgeier, Kästel, & Brühl (2019), Jakob & Poulin (2016), Kästel, Allgeier, & Brühl (2017) and Theissinger et al. (2018) demonstrated negative effects on chironomid midges. The negative effects of Bti on chironomids are of particular concern when Bti is used in protected areas (Brühl et al., 2020; Lagadic, Roucaute, & Caquet, 2014; Schäfer & Lundström, 2014). The use of Bti in such areas is not only a problem because of the general decline of insect numbers (BfN, 2022), but also because chironomids, besides mosquitoes, are an important food source for many other animals (Allgeier, Friedrich, & Brühl, 2019; Armitage, Cranston, & Pinder, 1995; DuRant & Hopkins, 2008; Quiroz-Martínez & Rodríguez-Castro, 2007). Several studies have shown that the decline of chironomids can also have negative effects on

other species like amphibians, birds, and dragonflies as food chains are disrupted (Boisvert & Boisvert, 2000; Jakob & Poulin, 2016; Poulin, Lefebvre, & Paz, 2010). From a scientific point of view, the current treatment practice of large scale aerial Bti applications therefore seems outdated and several scientists are calling for the application of Bti to be adapted to these new findings (Boisvert & Boisvert, 2000; Brühl et al., 2020; Poulin, Lefebvre, & Paz, 2010). It remains unclear, however, how people will evaluate the new evidence on the environmental impact of Bti and how they would value an adapted mosquito control that better protects nature. The latter is important to know since, most likely, any adapted mosquito control that forgoes treatment in sensitive areas to protect non-target midges would also come at a cost ultimately to be borne by private households. The question that needs to be raised is whether the benefits resulting from the protection of nature can outweigh the related costs, both monetary due to higher efforts and less well-being due to higher nuisance in these areas.

This study attempts to answer this question by assessing the willingness to pay (WTP) of private households in the affected areas for an adapted mosquito control strategy. This strategy avoids the use of Bti within areas of high ecological value, while maintaining nuisance protection within settlements. For households, this scenario would lead to an additional benefit compared to the status quo, i.e. nature would be better protected in ecologically sensitive areas. The costs for households are two-fold: (1) any adapted and more nature-friendly control would imply higher efforts for within-settlement protection and, consequently higher costs; and (2) the nuisance level outside of settlements increases to some extent due to a higher mosquito burden. To determine the net value of such a scenario to the population of the affected areas, a contingent valuation survey (CVM) was conducted in the Upper Rhine Valley of Germany, where intensive mosquito control employing Bti has taken place in the Rhine floodplains for many years.

We expect that WTP of survey respondents for adapted mosquito control will depend on various socio-demographic factors, but most importantly on people's attitudes towards the environment and mosquitoes, as it is these two topics that directly affect perceived benefits and costs. Several authors have already demonstrated the influence of socio-demographic variables on the WTP for mosquito control. Previous studies have shown that gender (Halasa et al., 2014), age (Dickinson et al., 2016; Farmer et al., 1989; Mwebaze et al., 2017; von Hirsch & Becker, 2009), income (Dickinson et al., 2016; Farmer et al., 1989; John et al., 1987; John et al., 1992; Mwebaze et al., 2017), education (Dickinson et al., 2016; Farmer et al., 1989; John et al., 1987), and duration of residence (Farmer et al., 1989; von Hirsch & Becker, 2009) have an influence. Several authors assume an influence of place of residence, although this influence has not yet turned out to be significant (Halasa et al., 2014; John et al., 1992; Reiling, Boyle, Cheng, & Phillips, 1989). In terms of respondents' attitudes towards the environment, Dickinson et al. (2016), John et al. (1987), and Ingabire et al. (2017) have shown that respondents' concerns about negative impacts of mosquito control on the environment have an influence on WTP. Regarding the attitude of the respondents towards mosquitoes, evidence highlights that the sensitivity towards mosquitoes (Dickinson et al., 2016; von Hirsch & Becker, 2009), the satisfaction with the current mosquito control (Farmer et al., 1989; von Hirsch & Becker, 2009), the implementation of personal mosquito control measures (John et al., 1987; Reiling et al., 1989; von Hirsch & Becker, 2009), and the time people spend outside (Brown, Dickinson, & Paskewitz, 2016) have an influence on the WTP.

In addition to these already known influences, we assume that the acceptance of the described scenario by households depends essentially on the willingness to tolerate more mosquitoes outside of settlements. This is the crucial trade-off for households, as here the attitude towards the environment has to be weighed against the attitude towards mosquitoes. Also, we assume that the insight of households to reconsider and develop the current practice plays a significant role. We further assume that the perceptions of mosquitoes depend not only on the amount of time people spend outside

(Brown, Dickinson, & Paskewitz, 2016), but also on the activities themselves, as these determine where and how people are exposed to mosquitoes.

In order to test these hypotheses and to determine the added value of a more nature-friendly mosquito control, a CVM survey with 318 personal interviews was conducted with households in the Upper Rhine region in Germany.

The paper is structured as follows. First, the study area and the mosquito control practiced there are presented. Subsequently, the costs and benefits that result from mosquito control for households and the trade-off decision that would result from better protection of nature are explained. The contingent valuation study and statistical analysis will then be presented. Afterwards, the results will be shown and discussed.

5.1.2. Methods

5.1.2.1. Mosquito control in the Upper Rhine region

With the aim to determine household preferences for a more nature-friendly mosquito control strategy, a contingent evaluation study was conducted in the Upper Rhine Valley of Rhineland-Palatinate, Germany (figure 1). The Upper Rhine Valley with its floodplains and wetlands is one of the most species-rich areas in Germany (Ackermann et al., 2012) and numerous aquatic as well as terrestrial habitats are classified as Natura 2000 sites or National Naturschutzgebiete (NSG) and are accordingly protected. Each year, there is an average of 5 (1 to 11) flood events in these areas, resulting in large numbers of floodwater mosquitoes (especially Aedes vexans > 90%) hatching (Becker, Ludwig, & Su, 2018).

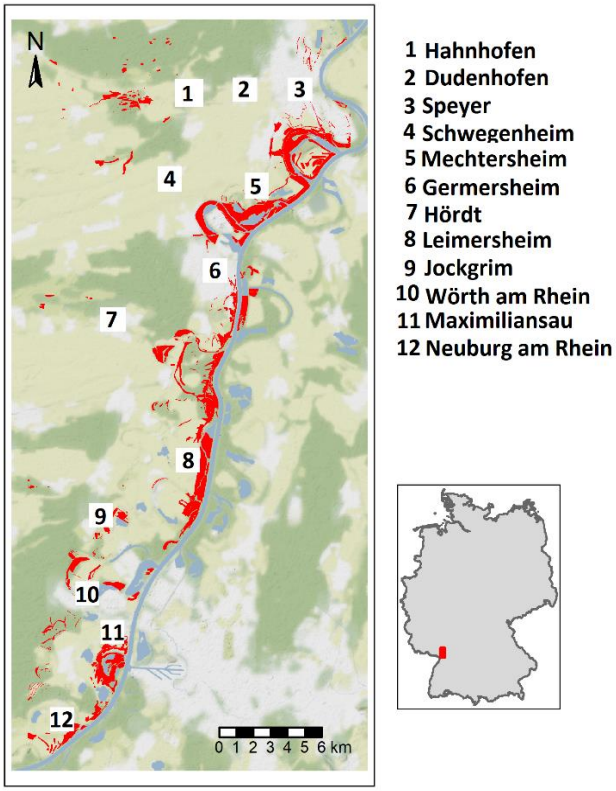

Figure 1: Study area. Numbers indicate areas surveyed; color coding: area treated with Bti (red), water areas (blue), forests (dark green), agricultural areas (light green), settlement areas (grey).

Due to the resulting nuisance, mosquito control has been implemented in the temporary wetlands of the Upper Rhine Valley for many years. Since 1976, control is carried out by the German Mosquito Control Association (Kommunale Aktionsgemeinschaft zur Bekämpfung der Schnakenplage e.V. - GMCA). The association is financed by the municipalities and counties in which control is carried out. It now has more than 100 regional member communities (Becker et al., 2018) with over three million people (Becker et al., 2010). Since 1981, control of floodwater mosquitoes has been conducted with formulations of Bacillus thuringiensis subsp. israelensis (Bti) (Becker et al., 2018). This involves the treatment of more than 400,000ha by helicopter and by hand (ground application) an average of five times per year, reducing the mosquito population by more than 90% (Becker et al., 2018). A large proportion of the treated areas (ca. 90%) are located in protected areas (Brühl et al., 2020).

5.1.2.1.1. Costs and benefits of mosquito control by Bti

Mosquito control has both benefits and costs for the public, which are shown in figure 2. On the one hand, the reduction of the mosquito population by more than 90% (Becker et al., 2018) potentially leads to a decrease in nuisance both within and outside of settlement areas. Consequently, a higher quality of life for people in their residence, for example, in the garden, outdoor seating or even in bedrooms is expected. They also benefit in recreational activities, such as walking, cycling, allotment gardening, or bathing and fishing, both within and outside settlement areas. In addition, the reduced nuisance can also have a positive effect on certain businesses, such as hospitality and agriculture. And likewise, the reduction in mosquitoes could lead to a further decline in the already very low probability of transmitted infections. The benefits of the described advantages result from the respective use as well as non-use values which people assign to these aspects. Thus, people who now find fewer mosquitoes in their bedrooms benefit (use value), but so do people who have never had a problem with mosquitoes in their bedrooms, but are happy that there are fewer mosquitoes because others used to suffer (non-use value).

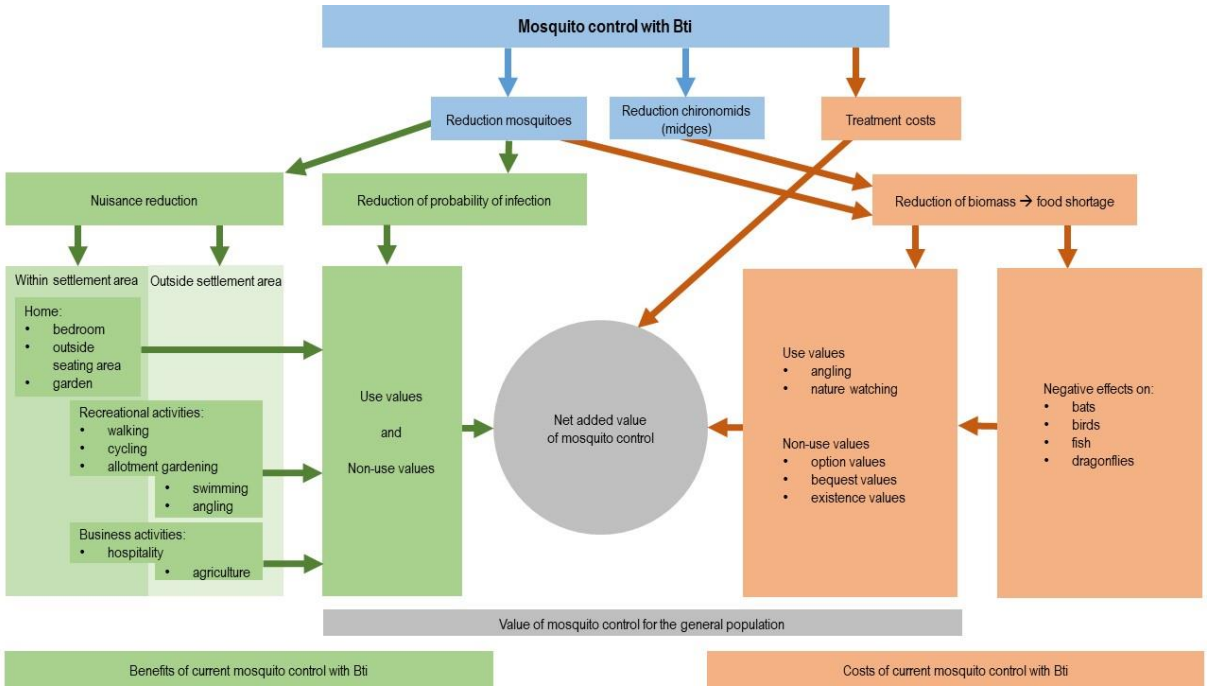

Figure 2: Costs and benefits of mosquito control with Bti. The figure shows the effects of the current mosquito control with Bti. The effects of Bti on mosquitoes and midges are shown in blue, the resulting benefits for the population in green and the costs in red. The net added value of mosquito control for the society is shown in gray. The examples given are only a selection of important effects and do not claim to be exhaustive.

At the same time, mosquito control is also associated with costs for households (figure 2). The work of GMCA is financed by its members. This amounts to about €3.5 million per year (KABS, 2016). On the other hand, the reduction of mosquitoes leads to a decrease in biomass, which is available as food for other species. In addition, current control with Bti also reduces the abundance of chironomid larvae, which are then also missing as a food source. The impact on the food web is of particular importance because Bti is applied to a large extent in protected areas (Brühl et al., 2020). For the local population, there will be fewer animals to observe and hunt, as their direct or indirect food source is reduced. On

the other hand, it has also the consequence that something is lost to the people, who attach a value to these animals, but also to mosquitoes and midges, without using them directly. One reason may be that they are happy that these animals exist (existence value), another that they are happy that their children may experience these animals in the future (bequest value) or because they still have the possibility to see these animals themselves in the future, to catch them or to use them in another way (option value).

The effects shown in figure 2 are not exhaustive. It is conceivable, for example, that affected animals can no longer fulfill other functions in the ecosystem, leading to further consequences for the ecosystem and the population.

5.1.2.1.2. The trade-off between nuisance reduction and nature protection

Previous cost-benefit analyses of mosquito control with Bti did not take into account the formerly unknown negative effects on midges and thus underestimated the full costs incurred by mosquito control. A reduction in these costs, however, would inevitably generate other costs. This is because only a reduction in treatment with Bti will lead to a better protection of midges; however, a reduction would simultaneously result in more mosquitoes, which would increase public nuisance. This represents a trade-off decision for households (figure 2). On the one hand, people benefit from a reduction of mosquitoes (figure 2, green), on the other hand, they benefit from an intact nature (figure 2, red). The key question is whether the lower costs associated with more nature-friendly mosquito control compensates for the lost benefits.

It is also important to consider that costs and benefits are perceived differently depending on the location. Nuisance is likely to be more strongly perceived within settlement areas than outside. And protection of midges is most useful in ecologically valuable areas. Thus, for the public's cost-benefit trade-off, it is crucial to know where midges will be protected and what the resulting nuisance is.

5.1.2.2. The contingent valuation study

This study aims at determining people’s preferences for a hypothetical more nature-friendly mosquito control scenario using the contingent valuation method (CVM). The CVM is a standardized procedure for determining the value of environmental goods, which can also be used to estimate non-use values (Johnston et al., 2017). The idea of the method is to offer a certain environmental good on a hypothetical market to households for purchase and to determine the value of the environmental good on the basis of the households' purchase decisions. The method has been continuously improved due to ongoing criticism (Venkatachalam, 2004) and is used in countless studies (Belay, Ketema, & Hasen, 2020; Bishop et al., 2017; Carson et al., 2003; Carson, 2011; McGurk, Hynes, Manton, Thorne, & Clifford, 2019; Sun, Ouyang, & Meng, 2019). For an overview of the method see (Alberini & Kahn, 2009; Bateman & Willis, 2006; Carson & Hanemann, 2005; Frör, 2018; Johnston et al., 2017).

The good evaluated in this study is a more environmentally friendly treatment scenario that does not abandon mosquito control by Bti in general, but treatment in ecologically valuable areas. With this scenario, we are following official efforts to reduce biocide use in ecologically valuable areas (BMU, 2019). The reduction in the use of Bti, however, would lead to increased nuisance within and outside settlement areas. In order to maintain the protection of the population within settlements, the scenario foresees the use of small-scale technical mosquito traps. Thus, the scenario ensures that the mosquito burden within settlements remains just as high as it is today, but increases outside of settlements. We do not claim that the scenario studied is the ideal and only solution to the problem at hand. It is only one potential option that we use to investigate the added value of a more nature-

friendly mosquito control. Further studies must show whether it is practically possible to protect settlements with the help of technical traps.

For the citizens of the respective settlements, the scenario would lead to a higher financial burden, as the technical traps need to be purchased and maintained, leading to one-off and regular costs. This is not vastly different to the current situation in which costs for mosquito control in the German Upper Rhine region are paid by all member municipalities of the GMCA via annual municipal contributions. The payment scenario presented to respondents requires households to finance the additional costs incurred to implement the adapted mosquito control in the form of higher municipal fees, bearing in mind that without financing the current mosquito control would remain in place. To determine the willingness to pay, a single bounded dichotomous choice (SBDC) format was chosen, in which the respondents are given the choice between the scenario presented, taking into account the associated costs, and the status quo at zero additional cost. The SBDC format was used as it is the only format that provides incentive compatibility and minimizes hypothetical bias (Carson & Groves, 2007). A total of five different cost levels (bids) were used (€10, €25, €50, €100, €200), which would have to be paid annually per household and were randomly assigned to the respondents in the sampling process. The bids were tested in advance and determined in the course of the preliminary survey.

5.1.2.2.1. Survey mode and strategy

The survey took place in the form of face-to-face interviews with households in 13 villages along the west bank of the Rhine between Speyer and Neuburg am Rhein (figure 1). A total of 318 individuals were interviewed in September 2017. A complete data set was available for 266 interviews, which were used for further statistical analysis. The interviews were conducted by trained students of the University of Koblenz-Landau.

Households were selected randomly on the basis of a defined procedure. In a first step, the planned number of interviews was distributed proportionally across the selected localities according to the number of inhabitants. Since the two cities of Speyer and Germersheim have by far the most inhabitants, these two cities were underweighted. In this way, more interviews were conducted in the smaller villages, which can be assumed to be more affected by mosquito control and therefore had a higher importance for the study. In order to controle for the influence of the underweighted cities we used an additional explanatory variable. In a second step, a random selection of streets was chosen for all localities and these in turn were assigned their share of the interviews in proportion to the number of inhabitants. In a final step, individual households were selected for an interview via random walk (Häder, 2019). An interview lasted an average of 20 minutes.

5.1.2.2.2. Questionnaire development and Pretest

The questionnaire and scenario were developed in several steps, as recommended by e.g. Johnston et al. (2017). Prior to the survey, two workshops on mosquito control and a first pre-survey were conducted. The first workshop was attended by 18 experts from science, authorities, environmental associations, GMCA, and representatives of affected communities. The second workshop had 38 participants from different authorities, nature conservation associations, science, representatives of KABS e.V. and the Federal Environment Agency, specialists for mosquitoes, amphibians and technical mosquito traps and a citizens' initiative from Bavaria that wanted to establish a mosquito control program. Both workshops included presentations and group discussions on the aspirations of inhabitants, the mosquito control program and the potential negative effects. Community representatives and mosquito control operators shared the opinion that inhabitants will not accept higher nuisance. The pre-survey concerning the population's concern about mosquitoes was

conducted in 2016 in front of supermarkets in several towns along the Rhine. A total of 293 interviews were carried out for this purpose.

Based on the results of the two workshops and the pre-survey, the main questionnaire and scenario was developed. The questionnaire was then tested again in a field pilot and revised several times. For this purpose, 37 interviews were conducted with randomly selected households in the Upper Rhine region.

5.1.2.2.3. Questionnaire and statistical analysis

The final questionnaire includes questions about (a) places where respondents spent time outdoors, (b) perceptions of and attitudes toward components of nature, (c) attitudes, knowledge about and satisfaction with current mosquito control, (d) perceived nuisance and protection measures personally taken, (e) the valuation scenario and the WTP question, (f) attitudinal questions about treatment with Bti and the scenario presented, and (g) demographic information of respondents. To prepare respondents to the specific project scenario, they were presented with background information on current mosquito control, current funding, treatment in conservation areas, and potential impacts on wildlife. This was followed by the specific project and payment scenario description (see section 2.2). The information given was illustrated by pictures and figures and after each block of information, questions were asked about the information given to ensure that the information had been absorbed.

For the statistical analysis, the function sbchoice from the package DCchoice (Aizaki, Nakatani, & Sato, 2015; Nakatani, Aizaki, & Sato, 2021) for the software R (version 1.2.5033) was used. The calculation of the WTP was performed using the standard logistic regression procedure (Alberini & Kahn, 2009; Carson & Hanemann, 2005; Haab & McConnell, 2002).

A logistic regression model was chosen for the estimation of the WTP function, as it can be assumed that the scenario could also lead to a negative willingness to pay for some respondents, due to the increased exposure to mosquitoes outside the settlements. The associated confidence intervals are calculated using the Krinsky & Robb procedure (1986).

A total of three regression models were calculated, which are built sequentially and differ in the number of variables included (table 2). The aim of the three models was to test the relevance of the different types of variables. Furthermore, it should be checked which effects turn out to be constant and which effects are possibly superimposed by other variables. For the discussion, the model with the best pseudo R2 was selected (Hensher, Rose, & Greene, 2010). The models were constructed as follows: the first model includes only socio-demographic variables, the second model includes environmental attitude variables and mosquito variables, and the third model includes additional variables on the respondents' recreational activities. An overview of the variables used can be found in table 4 (appendix).

The socio-demographic variables used are gender (MALE), age (AGE), school education (EDUCATION), place of residence (CITY), duration of residence (DURATION) and income (INCOME and NO_INCOME). The variable EDUCATION describes the highest school-leaving qualification acquired. A distinction is made between (1): no school-leaving qualification or still going to school, (2): lower secondary school leaving certificate (German Hauptschulabschluss), (3): secondary school leaving certificate (German Realschulabschluss) and (4): upper secondary school leaving certificate (German Fachhochschulabschluss or Hochschulreife). The income variable (INCOME) was determined in the questionnaire using a set of income intervals (in €100), with the mean values of these intervals used for the analysis. In order to include the INCOME variable in the regression analysis, the missing values of 102 respondents were replaced by the mean of the sample (35). To account for this procedure, an

additional dummy variable (NO_INCOME) was added to indicate whether or not a respondent reported his or her income.

The variables used for respondents' attitudes towards the environment include a variable that captures respondents' desire to protect components of nature (PROTECT). This is a dummy variable that indicates whether respondents felt that any of the following components of nature should be more protected: bees, insects in general, birds, frogs and toads, streams and ponds, and riparian landscapes of rivers. Furthermore, the respondents' opinion that there is a need to reconsider and further develop the current practice of Bti use in view of the possible negative effects for nature is taken into account (RECONSIDER). Another variable that links environmental and mosquito attitudes is the question of whether respondents would be willing to accept more mosquitoes outside of urban areas in exchange for not treating areas of high natural value with Bti (TOLERATE). Among the variables that tend to describe attitudes toward mosquitoes is one that captures the sum of all measures taken for personal protection against mosquitoes (MEASURES). The measures surveyed are: fly screens and mosquito nets, sprays and ointments, vaporizers, incense, protective clothing, avoiding being outside at dusk, and avoiding the forest or the Rhine river floodplains. Other variables capture the average perceived nuisance in the region over the last 3-4 years (NUISANCE) and the satisfaction with the current mosquito control (SATISFACTION). Regarding recreational behavior, the following activities are considered: Walking (WALKING), cycling (CYCLING), allotment gardening (GARDENING), and picnicking or barbecuing in nature (PICNIC). Since a main factor analysis had shown that the activities camping and swimming and the activities fishing and paddling were very strongly related, the mean values of these activities were combined in one variable each (CAMP_SWIM and FISH_PADD).

5.1.3. Results

The results of the survey show that the sample is largely representative for the population of the surveyed localities. However, there were a few differences. For example, the proportion of people between the ages of 20 and 34 in the sample was too low and the proportion of people between the ages of 65 and 79 was too high. In terms of gender, more women were interviewed, and in terms of education, more people with a higher degree were interviewed. An overview of the distribution of the various groups can be found in table 3 (appendix).

Furthermore, the results show that respondents do not rate the current nuisance as very high (2.23). But 84% of all respondents take measures to protect themselves from mosquitoes. On average, they take 2.23 measures, the most common being sprays and ointments (55%), followed by fly screens and mosquito nets (49%), and protective clothing (35%). In terms of recreational behavior, the results show that most respondents go walking (91%), followed by cycling (83%), camping and swimming (55%), picnicking and barbecuing in nature (35%), fishing and paddling (21%), and using an allotment garden (6%). Further, the results show that while only about 75% knew that their community is part of KABS, almost all respondents knew about mosquito control in their area. It also shows that currently 61% of the respondents are very satisfied with the mosquito control in their area. But, almost half of the respondents were not aware that mosquito control also takes place in areas intended for nature protection. However, 90% of respondents felt that parts of nature should be protected more and 36% of respondents fully agreed with the statement that they would accept more mosquitoes outside settlements if areas valuable for nature were no longer treated with Bti. Only 12% of respondents completely disagreed with this statement and only 18% of the respondents think that the current practice of Bti use should not be reconsidered and further developed. The mean values of the other variables used in the regression analysis can be found in appendix 2.

WTP for adapted mosquito control

Overall, 60.2% of respondents answered positively to the SBDC question presented. Among them, 82.7% agreed with a price of €10, 85.7% with a price of €25, 57.9% with a price of €50, 43.6% with a price of €100, and 34% with a price of €200. Of the respondents who rejected the price assigned to them, 41% fully agreed with the statement that there should be no increase in mosquito nuisance outside of localities. Likewise, 40% fully agreed with the statement that they do not believe that traps in towns will sufficiently reduce mosquito nuisance and 30% fully agreed with the statement that they do not see that the current practice of mosquito control with Bti could have negative impacts on nature and the environment.

The results of the regression analysis show that model 3 best describes the data, with a pseudo R2 of 0.33 (table 2). Furthermore, the results show that the model fit is clearly improved by the inclusion of the variables on the respondents' attitudes towards nature and mosquitoes (model 2). The variables describing the activities also contribute to an improved model fit, but only slightly (model 3).

Table 2: Results of the regression analysis

	Variables	Model 1	Model 2	Model 3
	Bid	-0,01 ***	-0,02 ***	-0,02 ***
	Intercept	0,59	-1,37	-1,22
Sociodemographics	MALE	0,60 **	0,74 **	0,74 **
	AGE	0,00	0,01	0,00
	INCOME	0,02 **	0,03 **	0,03 **
	NO_IMCOME	-0,74 **	-0,60 *	-0,69 **
	EDUCATION	0,11	-0,01	0,03
	DURATION	-0,01	-0,01	-0,01
	CITY	-0,08	-0,07	0,00
Attitudes	PROTECT		1,54 ***	1,40 **
	RECONSIDER		0,32	0,35
	TOLERATE		1,56 ***	1,60 ***
	MEASSURES		0,27 **	0,21 *
	NUISANCE		-0,27 *	-0,26 *
	SATISFACTION		-0,32	-0,49 *
Activities	WALKING			0,01
	CYCLING			0,27 *
	GARDENING			-0,54 *
	PICNIC			0,16
	CAMP_SWIM			-0,40
	FISH_PADD			0,41
	Pseudo R^2	0,17	0,30	0,33
	log-likelihood	-149	-124	-120
	Mean	134 (109-181)	121 (103-151)	124 (105-160)
	Median	117 (93-152)	112 (92-137)	114 (96 - 144)

*Mean statistical significance at 10%.

**Mean statistical significance at 5%

***Mean statistical significance at 1%

Regardless of the model fit, the results show that across all models the significant factors remain largely the same (table 2). As expected, the scenario was rejected more often if the associated costs were higher (BID). Regarding the socio-demographic variables, we find that male respondents have a higher WTP than females (MALE), and people with a high income have a higher WTP (INCOME). Respondents who refused to report their income have a lower WTP (NO_INCOME). Respondents' age (AGE), education (EDUCATION), duration of residence (DURATION), and place of residence (CITY) had no effect on WTP. Regarding the respondents' attitudes towards the environment, the results show that people who think that nature should be protected more, or who are willing to accept more mosquitoes outside the settlements in exchange for not treating areas of high value for nature with Bti, have a higher WTP (TOLERATE). On the other hand, the opinion of respondents that the current practice of Bti use should be reconsidered and further developed with regard to the possible negative effects on nature (RECONSIDER) showed no effect on WTP. Regarding respondents' attitudes towards mosquitoes, results show that WTP increases with the number of personal mosquito protection measures taken (MEASURES), but decreases with the level of perceived nuisance (NUISANCE) and satisfaction with the current mosquito control (SATISFACTION). Furthermore, with regard to recreational activities, people who frequently ride a bicycle have a higher WTP (CYCLING), while people who frequently use an allotment garden have a lower WTP (GARDENING). For the activities walking (WALKING), picnicking (PICNIC), camping and swimming (CAMP_SWIM), as well as fishing and paddling (FISH_PADD) no influence on WTP was observed.

Regarding the WTP of the studied population for an adapted more nature-friendly mosquito control, the results of model 3 show that mean WTP is €124 per household and year, and median WTP is €114, with respective confidence intervals ranging from €105 to €160 and €96 to €144 (table 2).

The total benefit for the studied scenario is obtained by aggregating the welfare estimates for the entire population of the region from which the sample was drawn. Taking into account the calculated mean WTP and the number of households in the study area (n = 61.789), this results in an added value of €7.661.836 per year. Using the lower and upper limits of the WTP confidence intervals (table 2), the total estimated benefits range from €6.487.845 to €9.886.240. When considering the whole area of the Upper Rhine where mosquito control is applied by KABS, the added value would be much higher. For the 1.138.000 households living in this area (von Hirsch & Becker, 2009), the added value would amount to about €141.112.000 per year. Taking into account the lower and upper bounds of the WTP confidence intervals, the added value would range from €119.490.000 to €182.080.000.

5.1.4. Discussion

5.1.4.1. The WTP for an adapted mosquito control and the added value for the population

The results of this contingent valuation study show that the majority of the surveyed population in the surveyed region of the Upper Rhine valley of Germany highly values an adapted mosquito control that better protects nature (table 2) and respects the current nature protection areas. Thereby, a majority of respondents accept a higher level of nuisance outside localities, but expect protection to be maintained within localities.

The willingness of people to pay for the scenario presented is determined by weighing the individual costs and benefits (figure 2). In this respect, the results show that the benefits of the scenario, namely a better protection of chironomid midges and the animals that depend on them, clearly exceed the costs, namely an increased mosquito burden outside the localities. The surplus benefits as measured by WTP still leave room to cover any yet unknown additional monetary costs due to more efforts for an adapted control. Since respondents' WTP takes into account both the benefits and costs resulting

from the use and non-use values shown in figure 2, and it is known that people place a high value on nuisance reduction (Dickinson & Paskewitz, 2012; Halasa et al., 2014), it can be deduced that the value people place on nature protection obtained from the presented scenario exceeds the calculated mean WTP of €124 (net added value). Furthermore, our results suggest that the value of nature for the population is primarily composed of the existence value, bequest value and option value of the respondents, since not so many people fish or actively observe nature in such areas and a direct use would also be negatively affected by the increased mosquito burden. This in turn shows that especially non-use values have a very high importance for the population compared to use values.

With regard to the added value of mosquito control, von Hirsch & Becker (2009) have already shown that the population in the Upper Rhine region attaches a high value to it and that this value exceeds the associated costs by a factor of 1.8. The results of this study now indicate that the added value for the population could even be significantly increased by applying a more nature-friendly mosquito control. However, since in our scenario costs are both monetary (more effort using the traps) and non-monetary (more nuisance outside of settlements), an outright benefit-cost ratio cannot be computed. Further, the monetary costs for such a more nature-friendly mosquito control remain unknown since up to now it has not been proven that a technical trap-scenario as presented here is functional in practice. This scenario is used here as a template for any other more nature-friendly mosquito control technique either existing or to be developed in the future.

5.1.4.2. Determinants influencing the WTP

As expected, respondents' WTP is determined by certain socio-demographic factors as well as the attitudes towards the environment and mosquitoes. As for sociodemographic variables, it is surprising to find that men have a higher WTP than women, as Halasa et al. (2014) found exactly the opposite effect. The lower WTP of women in this study could be explained by the distrust in traps; women were three times more likely to fully agree with the statement that they did not believe that the traps in the localities would sufficiently reduce mosquito nuisance. The effect shown is also important for the WTP, as women are overrepresented in the sample. The actual WTP of the population could therefore be even higher. Further, the results of the study show that similar to Dickinson et al. (2016), Farmer et al. (1989), John et al. (1987), John et al. (1992), and Mwebaze et al. (2017), higher income has a positive effect on WTP. This is typically due to the environment often being a luxury good whose perceived value increases with income, also it reflects an increasing ability to pay due to less budget restrictions. More interestingly, the variable NO_INCOME, which indicates whether the requested information on income was refused, has a negative effect on WTP. One explanation for this effect may be that the topic of mosquito control is a very controversial and polarizing issue in the region studied, and for this reason more people with a high interest in current control refused to report sensitive data like their personal household income. Furthermore, as already shown by Halasa et al. (2014), John et al. (1992), and Reiling et al. (1989), our results confirm that the place of residence has no influence on the WTP. This shows that the underweighting of the cities of Speyer and Germersheim in the sampling should not have biased the results. But not all expected effects could be confirmed. For example, neither an effect of education (Dickinson et al., 2016; Farmer et al., 1989; John et al., 1987), age (Dickinson et al., 2016; Farmer et al., 1989; Mwebaze et al., 2017; von Hirsch & Becker, 2009), nor length of residence (Farmer et al., 1989; von Hirsch & Becker, 2009) could be detected in this study. One explanation for this could be the fact that the variables integrated in this study on attitudes toward the environment and mosquitoes pick up the crucial influences already that in other studies are captured by education, age and the length of residence.

This study analyzes which attitudes towards the environment and mosquitos (nuisance) determine WTP for more nature-friendly control. Specifically, it is the desire to improve protection of sensitive

habitats and wildlife that leads to higher WTP statements, which is in line with the findings of Dickinson et al. (2016), Ingabire et al. (2017), and John et al. (1987). But WTP for a more nature-friendly mosquito control is also determined by the degree of acceptance of more mosquito nuisance outside of settlements if nature is protected in sensitive areas. This demonstrates that respondents truly evaluate the trade-off between the desirable nature protection and mosquito nuisance which is an indicator for the validity of our survey data.

However, the hypothesis that people who think that current control practices should be reconsidered and further developed will have an impact on WTP could not be confirmed. One reason for this is probably that it was relatively easy to agree with this statement since at the specific point in the interview when the questions was asked the consequences of any alternative were not clearly stated. Accordingly, although most respondents (67%) felt that current control should be reconsidered and further developed due to the described negative impacts on the environment, this attitude did not result in a significantly higher WTP. That these respondents nevertheless have a real change in mind shows that 75% of them would also accept a higher mosquito nuisance outside the localities.

Furthermore, it can be shown that, as already demonstrated by John et al. (1987), Reiling et al. (1989), and von Hirsch & Becker (2009), whether a respondent takes personal mosquito protection measures has an influence on WTP. One explanation for this may be based on people's experience. People who already take multiple measures to protect themselves from mosquitoes may have less of a problem with higher levels of nuisance outside of localities and may also be more positive about the use of technological traps. The fact that almost 50% of respondents have already installed fly screens or mosquito nets shows how well many people in the region have adapted to the constant nuisance of mosquitoes. Also, the perceived nuisance seems to have a negative influence on the level of WTP for mosquito control as already shown by Dickinson et al. (2016) and von Hirsch & Becker (2009). This effect is not surprising, since people who perceive themselves to be more disturbed automatically associate higher (emotional) costs with an increase in nuisance outside of localities. Like Farmer et al. (1989) and von Hirsch & Becker (2009), our study finds a significant negative effect of respondents' satisfaction with the current mosquito control and WTP for an alternative indicating the tendency to keep the status quo the more it suits them. This is also indicated by the fact that all respondents stating to fully agree that the current practice of mosquito control with Bti could not have a negative impact on nature and the environment were largely or very satisfied with it.

As expected, outdoor recreational activities also have an influence on the level of WTP. In general, we expect that more mosquito nuisance outside of settlements reduces utility of outdoor activities there and, therefore, results in a lower WTP. We find this plausible effect only in some activities like e.g. allotment gardening. No effects, however, were found for most other outdoor activities like walking, picnicking, camping and swimming as well as fishing and paddling. We presume that this may be the result of two counteracting effects: people who engage more in these activities may experience a higher nuisance when performing those activities but those people may be the ones with higher environmental attitudes so that no clear relationship to WTP can be observed. For cycling we even find a positive relationship which indicates that the effect of positive environmental attitudes of cyclists is rather strong. Although our models consider environmental attitudes as variables, we cannot rule out that we omitted decisive factors of such attitudes in our variables, leading to the described effects.

5.1.4.3. Reasons for negative response to the WTP question

Properly designed CVM studies using the dichotomous choice elicitation question format invariably lead to a large fraction of respondents answering "no" to the offered bid amount. The rejection rate typically increases with the bid offered as at higher bid amounts more respondents evaluate the benefits of the scenario to be smaller than the price to be paid, i.e. the bid. In this CVM study ca. 40%

of respondents answered “no” to the binary WTP question. Rejection may be due to various reasons. In this survey 41% of respondents who answered “no” to the WTP question at the offered bid agreed to the statement that there should be no increase in mosquito nuisance outside of the settlements. Likewise, 27.5% stated that they could not see any negative impacts from the current Bti treatment. Both statements represent expressions of the benefits respondents perceive to receive or not from the presented scenario and can, thus, be considered valid value expressions. However, also 40% of the respondents who answered “no” to the WTP question stated that they do not trust the technical traps and consequently fear a higher nuisance within the settlements while the scenario description says otherwise. This statement shows that not all respondents trusted the scenario presented. It remains open whether the aforementioned reasons also led to the respondents to see no benefit at all in the scenario presented and, accordingly, to have a WTP of zero. But the statements indicate that the calculated WTP is valid only on the premise that protection from mosquitoes is guaranteed within settlements and that people's WTP could have been even higher if all respondents had been given appropriate confidence in the traps. It is important to note once again that the scenario presented is currently purely fictional and was used in this study only to determine the value of more nature-friendly mosquito control. Whether technical traps could be used to protect settlements must first be further investigated. However, the reasons for rejecting the scenario also highlight the potential to increase the benefits of adapted mosquito control to society through awareness raising. In this way, people who recognize the now proven negative environmental effects of Bti treatment and trust alternative solutions may also be motivated to accept an increased nuisance outside settlements.

5.1.5. Conclusion

In summary, the results of the study show that the surveyed population attaches a considerable value to a more nature-friendly mosquito control as compared to the current costs of the Bti treatment and large parts of the population would apparently even accept a higher nuisance level outside the settlements. However, it is more than questionable whether the respondents would have accepted a higher nuisance within the localities. The results of the study further show that WTP for the presented scenario depends on gender, income, respondents' support that parts of nature should be more protected, willingness to accept more mosquitoes outside settlements, the number of personal mosquito protection measures currently taken, perceived nuisance, satisfaction with current mosquito control, and frequency of cycling and allotment gardening activities.

The results of this study indicate that such an environmentally friendly control strategy could generate a high added value for society. Whether such a scenario should involve the use of technical traps or other solutions is yet to be studied. What is clear, as demonstrated in our study, is that the majority of respondents (67%) want the current Bti application to be reconsidered and mosquito control further developed to be more nature friendly. This wish is in line with the call of numerous researchers for the adaptation of mosquito control to the latest scientific findings (Boisvert & Boisvert 2000, Brühl et al., 2020, Poulin et al., 2010). Further, recently the German federal law for the protection of nature was updated to counteract the continuing severe decline in insect biomass in German nature conservation areas (Hallmann et al., 2017). The law now explicitly states that large scale biocide applications (and Bti is such a biocide) are prohibited in nature conservation areas (NSG), national parks and other smaller conservation area types. Due to a lack of practical alternatives to the current treatment, state governments are issuing exemptions from this ban on the grounds of adverse health effects. But our study shows that people in the affected regions are both willing to accept higher mosquito nuisance outside of settlements and are willing to pay a considerably higher price for a more nature-friendly mosquito control. Consequently, now is the time to work on and promote practical and more nature-friendly alternatives to the current large-scale mosquito control with Bti, even if they come at some higher cost. As shown in our study, this would benefit both nature as well as people.

5.1.6. References

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5.1.7. Appendix

Table 3: Representativeness of the sample

Categories	Groups	Sample (%)	Study area (%)
Gender	female	58,4	50,6
	male	41,6	49,4
Age	16 to 19 years	3,4	4,6
	20 to 34 years	12,4	20,4
	35 to 49 years	19,2	21,9
	50 to 64 years	29,3	27,7
	65 to 79 years	27,4	17,3
	80 years and older	8,3	8,1
Education	without a school leaving certificate	1,9	7,6
	lower secondary school leaving certificate (german Hauptschulabschluss)	25,6	33,1
	secondary school leaving certificate (german Realschulabschluss)	25,9	23,9
	upper secondary school leaving certificate (german Fachhochschule or Hochschulreife)	46,6	35,4

Table 4: Description of the covariates of the regression model

Variable	Explanation	Measurement	Mean	Min.	Max.
MALE	Respondent is male	1 = male, 0 = female	42%	0	1
AGE	Respondent's age	years	55,71	16	93
INCOME	Houshold income	8 Level: 5, 15, 25, 35, 45, 55, 67, 80 (in €100)	35	5	80
NO_INCOME	Respondent did not state income	1 = yes, 0 = no	0,38	0	1
EDUCATION	Level of the respondent's school-leaving certificate	4 Levels: 1 = lowest degree, 4 = highest degree	3,17	1	4
DURATION	Duration of residence	years	32,8	1	85
CITY	Respondent is living in one of the two cities Germersheim or Speyer	1 = yes, 0 = no	0,33	0	1
PROTECT	Respondents desire that individual components of nature should be more protected	1 = yes, 0 = no	0,9	0	1
RECONSIDER	Respondent considers it necessary to reconsider and develop the current practice of Bti use in view of the possible negative impact on nature?	0 = no, 1 = not sure, 2 = yes	1,48	0	2
TOLERATE	Respondent would accept more mosquitoes outside the settlements if areas valuable for nature were no longer treated with Bti	0 = does not apply at all, 1 = does rather not apply, 2 = Partially applicable, 3 = fully applicable	0,67	0	1
MEASURES	Sum of personal measures against mosquitoes	sum of measures	2,23	0	7
NUISANCE	Average perceived nuisance of respondents in the region over the past three to four years.	6-point Likert scale; 0 = not at all, 5 = very high	2,23	0	5
SATISFACTION	Respondent's satisfaction with current mosquito control in their surroundings	0 = very dissatisfied, 1 = rather dissatisfied, 2 = generally satisfied, 3 = very satisfied	2,56	0	3
WALKING	How often do you go for a walk?	0 = never, 1 = seldom, 2 = from time to time, 3 = often	2,08	0	3
CYCLING	How often do you ride your bike?	0 = never, 1 = seldom, 2 = from time to time, 3 = often	2	0	3
GARDENING	How often do you use an allotment garden?	0 = never, 1 = seldom, 2 = from time to time, 3 = often	0,14	0	3
PICNIC	How often do you go for picnics or barbecues in nature?	0 = never, 1 = seldom, 2 = from time to time, 3 = often	0,57	0	3
CAMP_SWIM	How often do you go camping or swimming?	0 = never, 1 = seldom, 2 = from time to time, 3 = often	0,67	0	3
FISH_PADD	How often do you go paddling or fishing?	0 = never, 1 = seldom, 2 = from time to time, 3 = often	0,18	0	3
BID	Amount municipal fees	5 Levels: €10, €25, €50, €100, €200			

5.2. Inner city river restoration projects: the role of project components for acceptance

5.2.1. Introduction

Rivers fulfill a wide range of functions in cultural landscapes and are thus of great importance to people worldwide (Everard & Moggridge, 2012; Millennium Ecosystem Assessment, 2005; United Nations, 2021). However, many rivers are in poor condition. In Europe, only 41% of them have a good status; in Germany this applies to only 7% of rivers (European environmental agency, 2018). Progress in improving the quality of water bodies, especially in urban areas, has been rather slow to date (Palmer, Hondula, & Koch, 2014) and urban rivers are often much more degraded than in rural areas (Gurnell, Lee, & Souch, 2007; Klein, 1979; Paul & Meyer, 2001). Since 2000, the European Water Framework Directive (WFD) has obliged EU Member States to restore all water bodies to a good ecological status by 2027 at the latest (European Parliament, 2014). Billions are invested annually into the restoration of water bodies (Bernhardt et al., 2005), yet it is still not clear when the EU's targets will be achieved.

Though it might be easier for planners to focus on the natural functions of water bodies when designing restoration projects, such projects can only be successful with the support of the wider population (Eden & Tunstall, 2006; Reichert et al., 2007). While acceptance of restoration projects seems relatively high, this can vary by project (Åberg & Tapsell, 2013; Buijs, 2009; Eden & Tunstall, 2006; Marttila, Kyllönen, & Karjalainen, 2016). Nonetheless, a high level of acceptance is not necessarily sufficient, as even smaller groups can cause project failure or delays (Kondolf & Yang, 2008; Schively, 2007). A wide acceptance of restoration projects is thus critically important and should be considered during planning and implementation (Deffner & Haase, 2018; Miller & Hobbs, 2007).

To this end, several authors call for ecological measures to be complemented by social ones (Asakawa, Yoshida, & Yabe, 2004; Palmer et al., 2005). Social measures can be, for example, a playground or other infrastructural improvements, which are expected to increase the value of the project. The social component of river restoration is of particular interest in urban areas (Deason, Dickey, Kinnell, & Shabman, 2010; Kondolf & Pinto, 2017). This is partly because the ecological potential of urban water bodies is often rather low due to their severe degradation (Kondolf & Yang, 2008), but also because of the many different uses of water bodies for the urban population (Kondolf & Pinto, 2017). Accordingly, social measures can maximize the added value of restoration projects, especially within cities. However, it is obvious that complementary social measures are not welcomed by everybody and can, in fact, have a negative impact on the overall acceptance of projects. For future restoration projects it is therefore important to understand how the different components of a project contribute to the acceptance of the overall project.

Wüstenhagen, Wolsink, & Bürer (2007) define three dimensions of acceptance: socio-political, market, and community acceptance. Since river restoration projects are mostly small-scale projects where the acceptance of the local population is crucial, we focus on community acceptance. According to Becker, Klagge, & Naumann (2021), community acceptance is a function of (1) the perceived costs and benefits of a project, (2) perceived procedural and distributional justice and trust, (3) landscape change, place attachment and identity, (4) ownership structure, and (5) other contextual factors. These five factors are also relevant for river restoration projects and the associated ecological and social measures and are the focus of the subsequent paragraphs.

While the focus of river restoration projects is usually on the benefits of restored natural functions, ecological but more so social measures can lead to non-environmental benefits in the areas of recreation, aesthetics, education and urban development (Åberg & Tapsell, 2013; Eden & Tunstall, 2006; Findlay & Taylor, 2006; Millennium Ecosystem Assessment, 2005). Especially these benefits often have a particularly high value for the population (Bae, 2011; Findlay & Taylor, 2006; Marttila,

Kyllönen, & Karjalainen., 2016). On the other hand, river restoration projects may also be associated with costs or risks for the population. Several studies have highlighted the diversity of public concerns relating to restoration projects (Buijs, 2009; Deffner & Haase, 2018; Eden & Tunstall, 2006; Fox, Magilligan, & Sneddon, 2016; Seidl & Stauffacher, 2013; Weber & Ringold, 2015). Such concerns range from a potential danger to small children and negative impacts on agriculture to concerns about flood protection impacts and costs (Deffner & Haase, 2018; Eden & Tunstall, 2006). Consequently, the design and implementation of a river restoration project and its associated costs and benefits can also determine whether the project is perceived as just by the population and whether people trust decision-makers. Research suggests that public participation can have a positive effect on the appreciation of a project (Åberg & Tapsell, 2013; Deffner & Haase, 2018). In this sense, it is positive that the WFD already requires the public's active involvement in all measures affecting water bodies (European Parliament, 2014). However, it is evident that the different perceptions of planners on the one hand and the general public on the other still represent one of the greatest challenges in the implementation of such measures (Eden & Tunstall, 2006). One reason for this is that the level of public participation is still rather low (Jager et al., 2016; Szałkiewicz, Jusik, & Grygoruk, 2018).

River restoration projects can transform the landscape and the identity of a place, especially within cities. Many rivers in urban areas currently flow underground and have thus become invisible to the public. Restoration of these areas would lead to a significant increase in the presence and importance of rivers in inner-city areas, thereby also challenging the attachment that people have with these areas. As Åberg & Tapsell (2013) have already shown, large changes resulting from river restoration are often perceived negatively by the population. Another factor influencing acceptance is the ownership of the land needed for restoration. Since many of the required areas are privately owned, the implementation of the restoration measures can be difficult. Finally, the acceptance of river restoration also depends on the socio-economic, political and geographical conditions of the site. Since the factor of ownership of the needed land relates primarily to the acceptance by individuals, the acceptance by the general population depends primarily on the other four factors. It is therefore plausible that in situations where ecological and social measures are combined, these acceptance factors for river restoration projects are particularly diverse. Understanding acceptance as a function of these five factors highlights the urgent need for a comprehension of their interrelations in order to develop accepted and efficient restoration projects and project components.

To our knowledge, there are few studies that analyze this relationship quantitatively. While many studies identify preferences for different components of restoration projects (Brouwer et al., 2016; Che, Li, Shang, Liu, & Yang, 2014; Chen, Liekens, & Broekx, 2017; Logar, Brouwer, & Paillex, 2019), very few compare acceptability of the single project components. We were only able to find a quantitative comparison between measures in de Groot & de Groot (2009), who assessed the acceptance of various flood control measures in the Netherlands and attempted to explain it in terms of attachment, contextual factors, and other variables. However, there are a few examples of studies that examine the effects on individual river restoration projects. Buijs (2009) explored, among other things, how perceived costs and attachment to a place are related to project rejection; Åberg & Tapsell (2013) investigated the positive and negative effects of aesthetic aspects on the appreciation of a project. Although these studies provide information about the importance of individual acceptance factors, their relevance in relation to the various and diverse components of a restoration project is rather low.

In this study, we address this knowledge gap by analyzing the acceptance of different ecological and social components of a river restoration project in the city of Bad Bergzabern (Germany). We do so by building on Becker's (2021) acceptance factors by focusing on the four acceptance factors that were identified to be relevant for the general population. Thereby, the study pursues two objectives: (1) to

investigate the acceptability of a project and its components and (2) to explore interrelations between factors that explain acceptance of project components.

The analysis is based on a face-to-face household survey on a final plan of a river restoration project in Bad Bergzabern that includes both ecological and social measures. Regression analysis is used to examine the influence of the surveyed factors on the acceptance of the individual project components. The results of the analysis can be used to derive recommendations for urban planners and decision-makers on how to reduce acceptance problems in river restoration projects in the future and thus support a more efficient implementation of the urgent objects of the WFD.

5.2.2. Materials and Methods

Based on the factors of acceptance identified by Becker, Klagge, & Naumann (2021) we derive a simple conceptual framework of the causal relationship of project acceptance (see fig. 3). We expect that the overall project acceptance results from the acceptance of its components (i.e. the ecological and social measures), and, in turn, that acceptance of those components results from the factors identified by Becker, Klagge, & Naumann (2021). The four factors considered are: perceived *costs and benefits* (concerns) of the components, *communication and participation* that took place, *attachment* of the population to the site that is affected, and *socio-demographic* factors. In this study the *costs and benefits* factor represents the *concerns* that exist about the project, as these are of particular relevance in the run-up to the implementation of projects. We hypothesize that overall project acceptance can be increased by complementary social measures and that the factors explaining acceptance of the project components will differ between the components of the project.

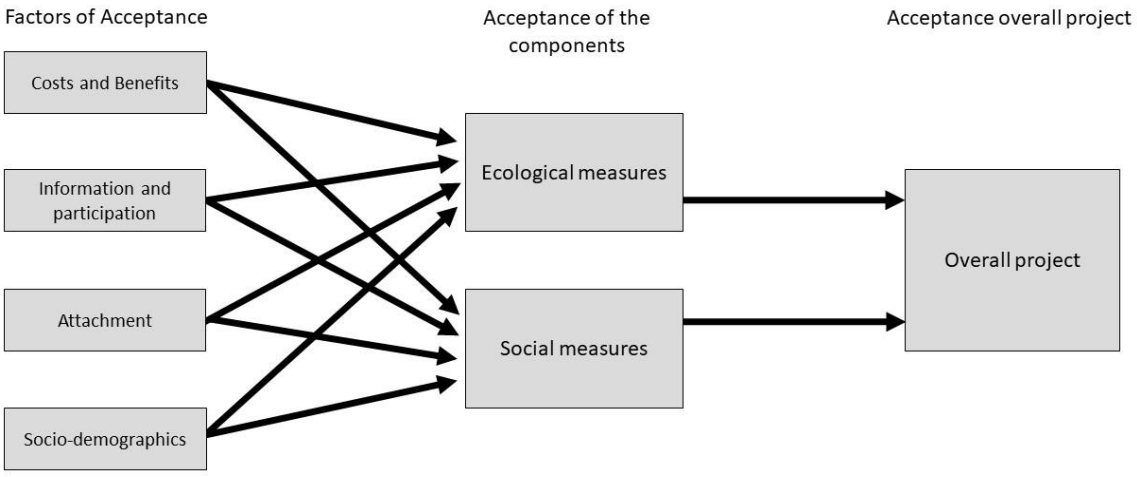


Figure 3: The causal model of the research, building on Becker, Klagge, & Naumann, (2021)

5.2.2.1. The restoration project

The research objectives of this study will be investigated in a case study based on the reopening and restoration of the river Erlenbach in Bad Bergzabern. Bad Bergzabern is located at the western edge of the Upper Rhine Plain in Rhineland-Palatinate, Germany, and has about 8000 inhabitants; the municipality of Bad Bergzabern has a total of 24.000 inhabitants (Figure 4). The river Erlenbach has its source in the Palatinate Forest and runs through Bad Bergzabern in an easterly direction, mostly in an underground tunnel. In the western part of the city, which extends into the Erlenbach valley in the Palatinate Forest, the ecological condition of the stream is now to be improved. To this end, the stream is to be reopened over the stretch of about 800 meters and restored according to the type of current use of the area. The area can be divided into four sections (see Figure 5). From east to west, the reopening is to take place in the town's spa park (a), in an adjacent parking lot (b), on the site of a hotel (c), and on a currently derelict area (d). The reopening in the spa park is the central part of the restoration project. The hotel area was not considered further in this research project, as it is not a public area. The measures in the spa park and parking lot need to respect the current use and are, therefore, subordinate to it. Due to the predominant use as a parking lot, the ecological potential of the resulting watercourse in the respective area is therefore moderate. The ecological improvements in the spa park will be significantly larger. A very natural stream with good ecological potential can be created on the currently unused land. In addition to the ecological measures, the project also includes two social measures: (1) the construction of a playground and (2) the redesign and renewal of the parking lot.

For the analysis of acceptance, we will subsequently distinguish between four components, two ecological ones and two social ones (see figure 5). The two ecological components are: (a) reopening and restoration of the Erlenbach in the spa park (*reopening in the spa park*) and (d) reopening and restoration of the Erlenbach on a brown-field site (*natural stream section*). The two social components are: (b) reopening of the Erlenbach in the parking lot and the associated redesign (*reopening with redesign of parking lot*) and (e) construction of a playground in the spa park (*playground*) (e).

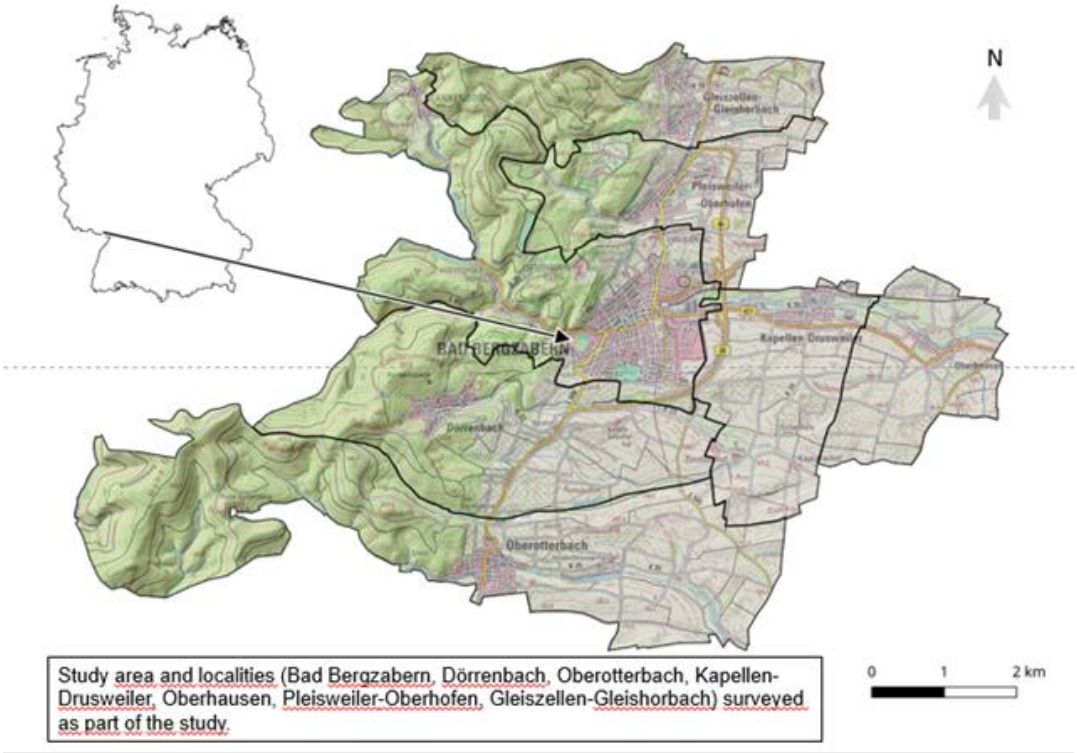
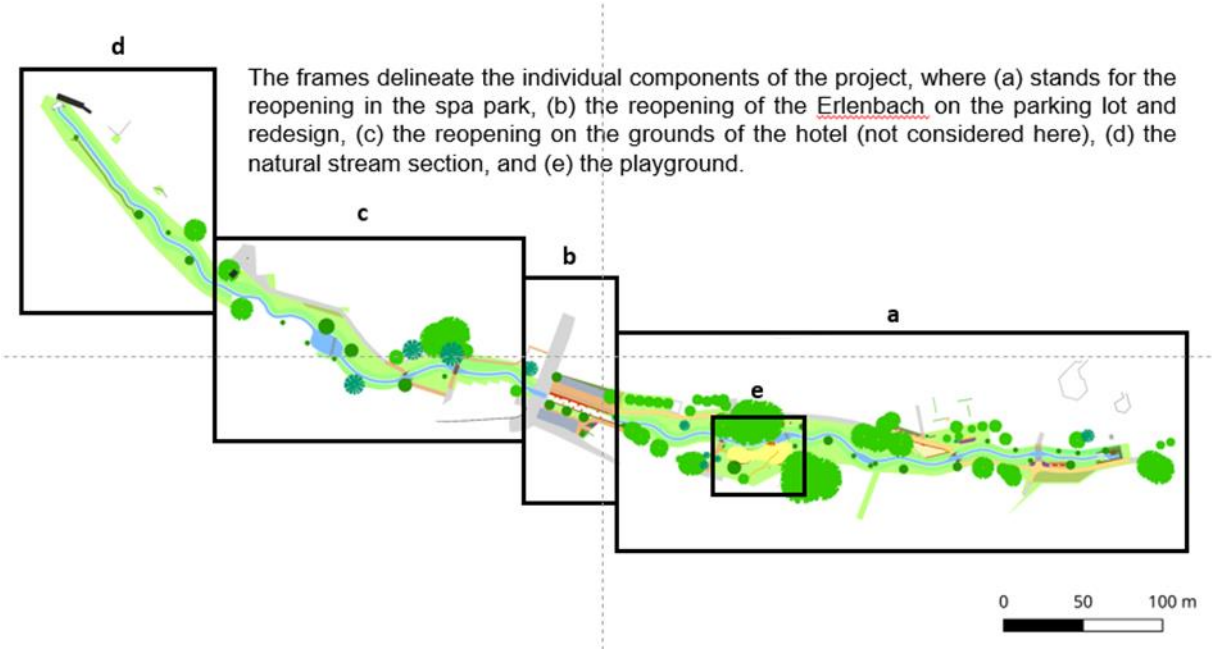


Figure 4: Study area



The frames delineate the individual components of the project, where (a) stands for the reopening in the spa park, (b) the reopening of the Erlenbach on the parking lot and redesign, (c) the reopening on the grounds of the hotel (not considered here), (d) the natural stream section, and (e) the playground.

Figure 5: Restoration project

5.2.2.2. Sample and data collection

For this study, 321 people in the municipality of Bad Bergzabern were interviewed in person in June 2018 using a standardized questionnaire. In addition to the city of Bad Bergzabern, all villages of the municipality close to the city were surveyed (Figure 4). On average, 2.4% of the population of each village were interviewed. The survey was part of a comprehensive study on the restoration project in Bad Bergzabern.

The sample was selected in three steps. First, the planned number of interviews was distributed proportionally among the villages. These interviews were then assigned to the individual streets of the localities in proportion to the number of inhabitants of each street. Finally, individual households were selected using the "random walk" method (Häder, 2019). Interviews were conducted by trained students and lasted an average of 28 minutes. The participation rate was approximately 36%. Of the 321 people interviewed, only 275 provided complete information on the acceptance of all four components. In the following, we consider this subsample of 275 as the full sample.

5.2.2.3. Data analysis

The statistical analysis of the data was performed using IBM SPSS Statistics software (version 25.0.0.1) and comprises three parts. In order to keep the dataset as large as possible, different sub-samples were used for the different analyses. The specific sub-sample size was determined by the number of questionnaires with complete data for the variables used.

The first analysis examined the acceptance of the four components (table 7). For this purpose, we identified groups of equal preference present in the surveyed population on the basis of the acceptance of the components. This analysis is based on the full sample of 275 interviews; these contain complete responses for all four components.

The second analysis explores the identified groups with respect to the level of acceptance of the overall project (table 7). This comparison is based on a subsample of 188 interviews out of the 275; these

respondents were aware of the project from the beginning of the interview and were asked the question about overall acceptance (subsample 1).

The third analysis examines how the acceptance of the different measures can be explained (table 8). This analysis is based on a subsample of 209 interviews from the full dataset of 275 interviews, as the analysis required complete answers for all explanatory variables. In a first step, a backward stepwise binary logistic regression was run for all four components to identify the variables that are best suited to explain the acceptance of the respective components (dependent variable in the corresponding model). In a second step, a binary logistic regression model was run for each component, including the previously identified influential variables (subsample 2). The binary logistic regression was chosen, due to the nominal/ordinal scale of the variables.

5.2.2.4. The variables

The first two analyses are based on four variables on the acceptance of the single components of the project and one variable on the acceptance of the overall project. The third analysis is based on the four variables for the acceptance of the project components and, additionally, explanatory variables on the acceptance factors presented earlier.

The survey differentiated between participants who had already been aware of the project and those that encountered the project during the survey for the first time. Only those respondents who stated to be aware of the project were asked about their acceptance of it as a whole. The single components were then presented in detail to all respondents to survey their acceptance of these components. This sequence was intended to ensure an evaluation of the overall project that was as unbiased as possible. This meant that respondents who were not familiar with the project were not asked about their acceptance of the project as a whole, which reduced the sample suitable for the second analysis.

In order to determine acceptance of the overall project, respondents were asked about their position towards the project. The response categories were very good, quite okay, don't care, and reject. It was defined that the project is acceptable if the respondents find it very good, quite okay or don't care, and the project is not acceptable if the respondents reject the project.

Acceptance of the four components — *reopening in the spa park, natural stream section*, *reopening with redesign of parking lo*t and *playground* — was assessed by asking respondents how useful they considered each component. They could rate the component as useful, somewhat useful, somewhat useless or useless. Subsequently, a component is understood to be accepted if it is considered useful or somewhat useful and not accepted if it is classified as somewhat useless or useless.

A total of 16 explanatory variables were collected related to four acceptance factors: perceived concerns (perceived *costs and benefits*), *information and participation* (perceived procedural and distributional justice), *attachment* (landscape change, place attachment and identity), and *socio-demographics* (contextual factors). An overview of the questions can be found in table 5.

Since restoration measures are associated with many concerns (Buijs, 2009; Deffner & Haase, 2018; Eden & Tunstall, 2006; Fox et al., 2016; Seidl & Stauffacher, 2013; Weber & Ringold, 2015), we evaluated the relevance of ten concerns that were raised in the lead-up to the survey at informational meetings held by the city about the proposed project. The corresponding question was: "Some citizens have expressed the following concerns. Do you personally think they are justified?" With regard to information and participation of the population, three variables were considered: awareness of the project, participation, and communication about the project. The influence of people's attachment to the area was considered in terms of the question of whether the spa park should remain as it is. Additionally, two socio-demographic variables, age and gender, were surveyed.

Table 5: Explanatory variables

No	Variable	question	Scale
Concerns (costs and benefits)			
1	*Construction noise*	The measure is causing construction noise.	yes / no
2	*Restriction due to construction*	Due to the construction site, the use of the spa park is temporarily restricted.	yes / no
3	*Noise of playground*	The children's playground leads to more noise.	yes / no
4	*Littering*	The remodeling of the spa park leads to an increase in littering.	yes / no
5	*Flood risk*	The opening of the Erlenbach leads to an increased danger of flooding.	yes / no
6	*Conflicts of use*	The project causes conflicts between new and existing user groups.	yes / no
7	*Running costs*	The redesigned spa park is associated with ongoing costs for the city.	yes / no
8	*Insufficient water*	The Erlenbach could dry up due to insufficient water in summer.	yes / no
9	*Restriction of use*	There will be restrictions on existing events in the spa park.	yes / no
10	*High cost*	The costs of the transformation of the spa park are too high for the city.	yes / no
Information and Participation			
11	*Project known*	Prior to this survey, had you heard that the Erlenbach in the area of the spa park was to be reopened and restored?	yes / no
12	*Citizen participation*	Would you have liked to have seen extensive citizen participation as part of this project to generate ideas?	yes / no
13	*Communication*	Overall, how satisfied are you with the way this project was communicated by the city?	very satisfied / somewhat satisfied / somewhat dissatisfied / very dissatisfied
Attachment			
14	*Status Quo*	How accurate do you think the following statement is? "The spa park should remain as it is."	fully applicable / partially applicable / does not apply
Socio-demographic variables			
15	*Age*	Please tell me your year of birth.	year
16	*Gender*	Gender	male / female

5.2.3. Results

The sample is largely representative regarding gender of the respondents (sample = 48.4% men; municipality = 47.6% men), while older persons are slightly overrepresented. The average age of the sample is 57.2 years, which is just above the average age of 52 years in the municipality of Bad Bergzabern.

For the full sample, the survey shows a high level of acceptance of the components examined. The *natural stream section* received the highest acceptance with 92%, followed by the *reopening in the spa park* with 83%, the *playground* with 76% and the *reopening with redesign of parking lot* with 72% (table 6). The acceptance of the project components in sub-sample 2 differs only slightly. The overall project was accepted by 75% of the respondents (sub-sample 1). Furthermore, it can be seen that almost all of the concerns raised during the cities informational meetings were considered justified by the majority of respondents. Concerns due to running costs were most widespread (83%) whereas concerns due to the restriction of use (29%) and flood risk (17%) were less so. 80% of respondents were aware of the project (project known), 30% would have liked to see public participation (citizen participation), 52% were somewhat or very dissatisfied with the communication that took place (communication), and 23% fully agreed with the statement that the spa park should remain as it is (status quo).

5.2.3.1. Acceptance of the restoration project and its components

The combination of four individual components and two possible positions (acceptance and rejection) results in 16 feasible combinations (clusters) that participants could fall into on the basis of their assessments. 14 clusters are found in the surveyed population. 58% of the respondents accept all components (cluster 1), 25% reject one component (clusters 2–4, 10), and only 3% reject all components (cluster 6).

A comparison of the acceptance of the preference clusters with the acceptance of the overall project shows that participants of only four clusters (6, 7, 12, 13) unanimously rejected the overall project initially (i.e. acceptance of overall project is 0.0%); apart from cluster 14, participants of all other clusters rejected the project at least partially. Furthermore, it is evident that most respondents who rejected the project (74% – the respective percentage points can be found in the last column of table 3) rejected the reopening in the spa park (clusters 4, 6–9, 11, 12), while the majority accepted the other measures. Thus, of the people who originally rejected the project, the *reopening with redesign of the parking lot* is accepted by 53% (clusters 1, 3, 4, 7, 10, 12), the *playground* by 53% (clusters 1, 2, 4, 8, 10–13), and the *natural stream section* by 72% (clusters 1–5, 7–9).

Table 6: Descriptive statistics of all variables used[1].

Variables number	Variables group	Variable	Response category	% Full sample (N=275)	% Sub-sample 2 (N=209)
A1	Acceptance components	Reopening in the spa park	useful	63,3	61,7
			rather useful	19,6	20,1
			rather not useful	8,4	9,6
			not useful	8,7	8,6
A2		Natural stream section	useful	78,5	76,6
			rather useful	13,5	14,8
			rather not useful	4,0	5,3
			not useful	4,0	3,3
A3		Reopening with redesign of parking lot	useful	52,4	48,8
			rather useful	23,6	23,45
			rather not useful	15,3	17,7
			not useful	8,7	10,05
A4		Playground	useful	71,6	71,8
			rather useful	8,4	7,65
			rather not useful	9,1	8,6
			not useful	10,9	12,05
1	Concerns (Costs and Benefits)	Construction noise	yes		63
2		Restriction due to construction	yes		67
3		Noise of playground	yes		48
4		Littering	yes		48
5		Flood risk	yes		17
6		Conflicts of use	yes		54
7		Running costs	yes		83
8		Insufficient water	yes		56
9		Restriction of use	yes		29
10		High cost	yes		69
11	Information and Participation	Project known	yes		80
12		Citizen participation	yes		30
13		Communication	very satisfied		6,7
			rather satisfied		41,7
			rather dissatisfied		38,4
			very dissatisfied		13,4
14	Attachment	Status Quo	fully applicable		23
			partially applicable		42
			does not apply		35
15	Socio-demographic variables	Age	years		57,1
16		Gender	male		48,4
			female		51,6

[1]The full sample has a complete set of data needed for the group analysis of the acceptability of the project components. Subsample 2 includes a complete set of data for all variables used for regression analysis. All variables that contain four levels in the survey were dummy coded for analysis, with the two positive and two negative levels combined. The overall project, which was evaluated by only 188 people (subsample 1), was rejected by 25% of respondents, while 10% did not care about it, 31% thought it quite okay and 34% thought the project was very good.

Table 7: Acceptance of the components and the overall project

	Components[1]						Overall project[2]		
Cluster	Sample (N / %)	Reopening in the spa park	Natural stream section	Reopening with redesign of parking lot	Playground		Number of respondents who also evaluated the overall project (N)	Acceptance overall project per cluster (%)	Proportion of rejections of the cluster to rejections of the overall project (%)
1	159 / 57,8						93	94,6	10,6
2	29 / 10,5						23	95,7	2,1
3	21 / 7,6						16	87,5	4,3
4	14 / 5,1						11	78,6	17,0
5	12 / 4,4						10	80,0	4,3
6	9 / 3,3						7	0,0	14,9
7	8 / 2,9						8	0,0	17,0
8	6 / 2,2						6	16,7	10,6
9	4 / 1,5						4	15,0	6,4
10	4 / 1,5						3	66,7	2,1
11	4 / 1,5						4	25,0	6,4
12	2 / 0,7						1	0,0	2,1
13	2 / 0,7						1	0,0	2,1
14	1 / 0,4						1	100	0,0
Total (%)		83	92	76	80			75,0	100
N	**275**						**188**		

	acceptance
	rejection

[1]Grouping of acceptance for the individual components (full sample).

[2]Acceptance for the overall project and proportion of rejections of the clusters in relation to the rejections of the overall project (subsample 1).

5.2.3.2. Factors explaining acceptance for project components

The descriptive results of the explanatory variables of subsample 2 (n=209) show that most concerns identified in the city's meetings prior to the survey were considered justified by the majority of respondents (table 6). Among these, concerns due to *running costs* received the highest support, while *restrictions of use* and *flood risk* concerns were shared by only a minority. In terms of socio-demographic variables, the sub-sample contains a slightly higher proportion of males and a slightly higher average age than the full sample (n=275). Results for the other variables can be found in table 6. A logistic regression model was constructed and estimated to explain the acceptability of each of the four components. The results of the four regression models can be found in table 8. The dependent variable in each of these models is the dummy-coded acceptance of the corresponding component.

The stepwise variable selection revealed that seven of the 16 variables investigated best explain acceptance of the planned *reopening in the spa park*. The final model (see table 8) was statistically significant ($\chi^2(5)=66.571$, $p<.001$), resulting in a medium degree of explained variance (Backhaus, 2003), as shown by Nagelkerke's $R^2=.445$. Of the seven variables entered into the regression model, six contributed significantly to predicting acceptance: *flood risk* (p=.02), *high cost* (p=.02), *project known* (p=.014), *communication* (p=.006), the second level of *status quo* (p<.000), and for *age* (p=.054). In addition to the agreement with the two concerns, knowledge about the project, dissatisfaction with communication, the desire for no change, and higher age also led to rejecting the component. Variables from all four acceptance factors, thus, had a significant effect on acceptance.

Acceptance of the *natural stream section* is best explained by five of the 16 variables investigated. The final binary logistic regression model was statistically significant ($\chi^2(5)=42.292$, $p<.001$), resulting in a

medium degree of explained variance (Backhaus, 2003), as shown by Nagelkerke's R^2=.413. Of the five variables entered into the regression model, one contributed significantly to predicting acceptance: "flood risk" (p<.000). The expectation of increased *flood risk* led to rejecting the component. This shows that only the acceptance factor *cost and benefits* had a significant influence on acceptance.

Acceptance of the *reopening with redesign of parking* lot is best explained by two of the 16 variables investigated. The final binary logistic regression model was statistically significant ($\chi^2(5)=15.785$, p<.01), resulting in a small amount of explained variance (Backhaus, 2003), as shown by Nagelkerke's R^2=.105. Of the two variables entered into the regression model, only *noise of playground* (p=.009) and the second level of *status quo* (p<.059) contributed significantly to predicting acceptance. Both the expectation of increased noise and the desire for no change led to rejecting the component. Thus, only variables from the two acceptance factors *cost and benefits* and *attachment* showed a significant influence on acceptance.

Acceptance of the planned *playground* is best explained by five of the 16 variables investigated. The final binary logistic regression model was statistically significant ($\chi^2(5)=82.559$, p<.001), resulting in a large amount of explained variance (Backhaus, 2003), as shown by Nagelkerke's R^2=.511. Of the five variables entered into the regression model, four contributed significantly to predicting acceptance: *noise of playground* (p<.000), *littering* (p=.001), *age* (p=.001), and *high cost* (p=.052). Both the expectation of increased noise and littering, higher cost, and an older age made respondents more likely to reject the component. Consequently, only variables from the acceptance factors *cost and benefits* and *socio-demographics* had a significant influence on acceptance.

Table 8: Results of the four final binary logistic regression models for the four components examined[1].

			Reopening in the spa park		Natural stream section		Reopening with redesign of parking lot		Playground	
Category	**Explanatory variables**		**Sig**	**OR**	**Sig**	**OR**	**Sig**	**OR**	**Sig**	**OR**
Concerns (Costs and Benefits)	Construction noise									
	Restriction due to construction									
	Noise of playground						0,009	2,34	0,000	16,33
	Littering								0,001	4,85
	Flood risk		0,020	3,33	0,000	13,43				
	Conflicts of use									
	Running costs									
	Insufficient water									
	Restriction of use									
	High cost		0,020	6,58	0,997	/			0,052	3,93
Information and Participation	Project known		0,014	8,45						
	Citizen participation				0,074	/				
	Communication		0,006	3,83	0,065	/				
Status Quo	Status Quo	"partially true"	0,932	/	0,244	/	0,224	/	0,078	/
		"fully true"	0,000	10,00	0,216	/	0,059	2,13	0,418	/
Socio-demographics	Age		0,054	1,029					0,001	1,06
	Gender		0,091	/						
Nagelkerke's R-squared			0,445		0,413		0,105		0,511	

[1]For each model, only those explanatory variables were considered that were previously identified as most suitable to explain the acceptance of the respective component. For the explanatory variables, both the significance (Sig) and the odds ratio (OR) are given. Nagelkerke's R-squared indicates the effect size for each model (Nagelkerke, 1991). According to Backhaus (2003), a value of >.2 is considered a small effect, >.4 as medium and >.5 as a large effect.

5.2.4. Discussion

5.2.4.1. Acceptance of the overall project and its components

The results of the household survey show that all four components examined received a high level of acceptance but that there were clear differences between individual components. For example, the *natural stream section* experienced by far the highest acceptance, while acceptance levels for the other three components are very similar at a lower level. Comparing the results with other studies (Buijs, 2009; Eden & Tunstall, 2006; Marttila et al., 2016), it is noticeable that acceptance is comparatively high for all the components examined. However, the share of people that accepts every single project component is notably lower than the share that accepts the overall project (table 7). This might be because preferences in the surveyed population are very heterogeneous, which is reflected by the representation of almost all conceivable preference patterns. Looking at the project components individually showed that, actually, more people have issues with at least one part of the project. Without the two complementary social components (reopening with redesign of parking lot and playground), for example, the percentage of people who accept all components would be significantly higher (80%). These findings highlight the potential risks of adding such components. However, as shown below, it would be too short-sighted to deduce that the inclusion of the complementary social components led to a rejection of the overall project.

As already mentioned, acceptance of the overall project is significantly higher (75%) than the proportion of people who accept all components (58%) (table 7). Due to the design of the survey, it is unfortunately not possible to draw direct conclusions on the importance of individual components for the acceptance of the overall project. It is possible that the assessment of the overall project is based on potentially incomplete or even incorrect assumptions about it. For example, those who stated to be familiar with the project, may have only been familiar with the key component (reopening in the spa park), but not with the additional components. Nevertheless, the comparison of the acceptance of the different project components with the acceptance of the project reveals interesting correlations. For example, most of the respondents who knew about the project and rejected it expressed negative opinions about the *reopening in the spa park* (74%); interestingly, the majority were in favor of the other three components. Even if it is not clear which components the respondents were aware of, these results show that additional components may have a positive effect and that this could be used by planners and local governments to sway people's perceptions of the overall project.

5.2.4.2. The importance of acceptance factors

The results of the regression analysis show that the factors examined can effectively explain the acceptance of the components *reopening in the spa park*, *natural stream section* and *playground*, but not the component *reopening with redesign of parking lot*. Therefore, in the following discussion, the variables examined will only be discussed for the first set of components.

The acceptance factor *costs and benefits* plays an important role with regard to the acceptance of the components. It can be seen that the concerns expressed in the run-up to the survey at information events held by the city about the planned project are not a niche phenomenon, but are shared by the majority of the population surveyed. This is of particular relevance because information and participation events are often criticized for only being attended by a minority and therefore not reflecting a representative opinion of the population (Vortkamp, 2013). The results of this study suggest that these concerns are unfounded as almost all of the concerns queried were considered justified by the majority of respondents. However, as this study only included concerns raised during the participation process, further concerns cannot be ruled out.

Interestingly, only some of the concerns (four out of ten) have an impact on the acceptance of components. The most significant concerns, *high cost*, *littering*, increased *flood risk* and *noise of playground*, are in line with other studies. Several authors have already shown that costs affect acceptance (Deffner & Haase, 2018). Costs for the project in Bad Bergzabern are very high at around €4,7 million for a restoration project of approximately 800m in length. Littering has also already been identified by other authors as a problem with river restoration projects (Asakawa et al., 2004). The importance of flood risk for acceptance has been documented by several studies (Buijs, 2009; de Groot & de Groot, 2009; Deffner & Haase, 2018; Seidl & Stauffacher, 2013). We did not find problems identified in other studies, such as use conflicts or temporary low water levels that could result in a rejection of such a project (Fox et al., 2016). One reason for this could be that the consequences associated with insufficient water levels are not really present in the population and that the conflicts of use between the previously rather old and the potentially younger population in the future are acknowledged but are not seen as a real problem, especially by younger respondents. Another reason could be that this study asked about the individual concerns in a closed-ended way but these would not have been mentioned actively (open-ended way) and are accordingly not equally relevant for all respondents.

One central result of this study is that concerns are largely component-specific. For example, concerns about excessive costs affect the acceptability of the *reopening in the spa park* and the *playground*, a feared increased risk of flooding affects the *reopening in the spa park* and the *natural stream section*, and an increase in noise and littering affects the acceptability of the *playground*. It is interesting to note that not all concerns are relevant for the acceptance of the components responsible for the respective concerns. Costs are mainly caused by the restoration measure. However, on the basis of costs, only the *reopening in the spa park* and the *playground* are rejected, but not the *natural stream section*. One explanation for this could be that the costs are incorrectly estimated because the respondents were not aware of them for the individual measures, or that the *natural stream section* is seen as more valuable because it makes a more important contribution to nature than the other components. Numerous authors (de Groot & de Groot, 2009; Fox et al., 2016; Seidl & Stauffacher, 2013) have already shown that projects that have a positive impact on nature are preferred. Which concerns are relevant thus seems to be measure-specific – the wider applicability needs to be tested in further studies.

In addition to the acceptance factor *costs and benefits*, the other three factors, *information and participation*, *attachment*, and *socio-demographics*, also affect acceptance of the components. While the high level of acceptance for the *natural stream section* can be explained exclusively by the concern of higher flood risk, other factors also play a role in explaining the acceptance of the *reopening in the spa park* and the *playground*. For example, acceptance of the *reopening in the spa park* depends not only on the concerns raised but also on the communication that has taken place, the desire to maintain the current state of the spa park and the age of the respondents. Age, in turn, also has an influence on the acceptance of the *playground*.

Several other studies have already shown the importance of communication for acceptance (Åberg & Tapsell, 2013; Deffner & Haase, 2018; Marttila et al., 2016). That people dissatisfied with how the project was communicated by the city tended to reject the *reopening of the spa park* is therefore not surprising. The fact that respondents who were not previously aware of the project were more likely to accept the *reopening in the spa park* makes the problem all the more apparent. This suggests potential issues with information dissemination in the run-up to the project. Indeed, the planning of the restoration project dragged on for several years and even the planning office had to be changed once due to escalating costs. This knowledge gap is also evident in concerns around flood risks and costs that are unfounded. Calculations have shown that the flood risk would be reduced by the

measures and costs would have been incurred regardless of the overall project, as the outdated piping of the Erlenbach urgently needed replacing. In fact, reopening the river made this necessary measure eligible for funding; the state of Rhineland-Palatinate covered up to 90% of costs. Neither of these benefits appears to have been sufficiently communicated to the survey participants – though information events had been offered. This draws attention to the crucial role of citizen participation in the acceptance of river restoration projects. However, our regression results show that while the desire for citizen participation was relatively high, this factor does not explain acceptance of the components. Dissatisfaction with communication, on the other hand, does have a (negative) influence on acceptance. In our study, satisfactory information and communication seem to be much more important for acceptance than public participation in planning.

It is also not surprising that people who think that the spa park should remain as it is reject the *reopening in the spa park*. The spa park in Bad Bergzabern is emblematic of a past time of success as a spa town. Many citizens are likely still familiar with this, even if only from stories. This historical significance may have created a special bond and thus a critical position towards reopening the Erlenbach. Several studies (Buijs, 2009; Fox et al., 2016) have shown that the attachment people have to a place has an important effect on the acceptance of actions planned there. It is interesting to note that the condition of the spa park worthy of preservation is not equally diminished by the *playground*. Up to now, the park was especially designed for older people and even playing on the meadows was forbidden. Accordingly, a *playground* would bring a big change. It is conceivable that the respondents were aware of the currently poor facilities for children in Bad Bergzabern and therefore attached greater importance to this component.

With regard to socio-demographic variables, the acceptance of the components studied does not depend on the gender, but does depend on age. It is not particularly surprising that older people tend to reject the *reopening in the spa park* and the *playground*.

5.2.4.3. Differences between components

Comparing the acceptance of the different components and the reasons that explain them, shows that high acceptance and few costs for the component go hand in hand. While concerns about the *natural stream section* are only raised due to a feared higher flood risk, acceptance of the *reopening in the spa park* and the *playground* simultaneously depends on several factors. One reason for these differences may lie in the current use of the areas: while the *natural stream section* is to be created on a brownfield site, the other measures are to be implemented on a partly intensively used site. The number of relevant factors, thus, seems to be directly related to location. Whether complementary components to a project contribute new costs, such as noise and littering, or are seen as an enrichment, thus, also depends on location and whether they are in competition with the former use of the site.

Another difference between the components studied is the degree of naturalness desired. Only the *natural stream section* explicitly pursues the WFD objective of good ecological status, while the reopening in the spa park is oriented more towards the needs of people. While the importance of closeness to nature was not investigated in detail, other studies suggest that it helps to explain the differences in acceptance, due to a high value for the population (de Groot & de Groot, 2009; Fox et al., 2016; Seidl & Stauffacher, 2013).

5.2.5. Conclusion

This study investigated the acceptance of an overall project and its components and explored what factors explain people's acceptance of specific components. Our assumption was that the acceptance of a project results from the acceptance of the individual components, whereby the acceptance of the

components is based on the four factors *costs and benefits, information and participation*, *attachment* and *socio-demographics*, as identified by Becker, Klagge, & Naumann (2021). We assumed that the acceptance of the overall project could be increased by complementary social measures and that the factors explaining the acceptance of the individual project components differ depending on the component. We applied this framework in an exploratory study of acceptance of river restoration in the German city of Bad Bergzabern.

The consideration of project components and their role for overall acceptance drew attention to the importance of this level. The results of the study show that while acceptance for the components was high, some of the components were viewed critically. As a result, the combination of several components leads to a significant increase in the proportion of people who are critical towards the project as a whole. At the same time, this does not necessarily lead to the overall project being rejected, as the proportion of people who reject all the components is very low, and the results indicate that it is precisely the supplementary components that tend to have a positive effect on the acceptance of people who view the overall project critically.

Furthermore, the results of the study show that all four factors investigated have an influence on acceptance, whereby the influence differs substantially with regard to the components. While the acceptance problems for the *natural stream section* can be explained exclusively by the factor *costs and benefits*, namely by a feared higher risk in flooding, the acceptance of the *reopening in the spa park* depends on all four factors. Thereby, the acceptance of the *reopening in the spa park* depends on feared higher risk in flooding, the perception of high costs, the dissatisfaction with the communication, the desire to maintain the current state of the spa park, but also on the age of the respondents. The acceptance of the *playground* depends again on the factor *costs and benefits* and *socio-demographics*, whereby it can be explained by high costs, a feared increase in noise and littering and a higher age of the respondents. The factor *costs and benefits* therefore appears to be important for all the measures studied, while the factors of *information and participation* as well as *attachment* are very specific to the measures. Furthermore, it is remarkable that with regard to the factor *costs and benefits*, almost all concerns raised in advance at information events are considered relevant by large parts of the population, yet only a few had an influence on acceptance.

Future studies should address some of the shortcomings of this work. Although this study indicates that complementary measures can increase the acceptance of the overarching project, future studies need to clarify which type of components and associated factors specifically contribute to overarching acceptance. Furthermore, with regard to the acceptance factor *costs and benefits*, future studies should take into account the benefits of a project in addition to the costs. Also, the degree of awareness of all components of the restoration project needs to be surveyed.

In addition, we understand that the reasons for lower levels of acceptance differ between restoration projects. With the aim of identifying general relationships and the most significant measures and associated concerns, future studies should attempt to cover the diversity of circumstances. One focus could be on projects that are planned within towns, as these offer particularly complex implementation opportunities due to their close proximity and resulting public needs. Additional studies would have the advantage of clarifying which measures have a particularly positive impact and which may even have a negative impact on the acceptance of the overall project. This would enable more targeted planning.

Several recommendations for future restoration projects can be derived from the results of the study. For example, the concerns raised at information or participation events in our case reflect the opinion of the general population and should therefore be taken seriously. However, since not all concerns are equally relevant to acceptance, it is important to differentiate between the concerns that arise and

actively address the most relevant ones depending on the action taken. The cost of the project and the issue of flood protection, but also the attachment of the population to a place, seem to play an important role in this respect and should therefore be carefully communicated in future projects.

5.2.6. References

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5.3. What determines preferences for semi-natural habitats in agrarian landscapes? A choice-modelling approach across two countries using attributes characterising vegetation

5.3.1. Introduction

The second pillar of the EU-Common Agricultural Policy (CAP) introduced agri-environmental schemes to support the development of rural areas and to protect biodiversity and ecosystem functions (EU, 2013, 2014). Since 2015, greening measures, including the implementation of ecological focus areas (EFAs), have been introduced as a precondition for farmers to obtain direct payments as part of the cross-compliance system. EFAs encompass a series of specifically defined types of green infrastructures and semi-natural habitats (SNH). According to Holland (2017), within CAP SNH are defined as "any habitat within or outside of the crop containing a community of non-crop plant species" (Holland et al., 2017). Grassy and woody SNH in our study comprise hedgerows and low-input grassland.

Studies in Europe including Switzerland showed the different agri-environmental measures have a positive influence on biodiversity though considerable variation in the botanical quality of semi-natural grassland is recorded (Batáry et al., 2010; Ó hUallacháin, Finn, Keogh, Fritch, & Sheridan, 2016). While there is some knowledge about the impact of SNH on biodiversity, less is known about the effectiveness of such measures in promoting multiple ecosystem services. Indeed, existing studies focus on the importance of SNH, predominantly grassy and woody elements, for providing regulating ecosystem services such as pollination and pest control (Gurr, Wratten, Landis, & You, 2017; Holland et al., 2017; Holland et al., 2016). Yet there is growing interest in investigating, mapping and quantifying other services in agrarian landscapes (Felipe-Lucia & Comín, 2015; van Zanten, Verburg, Koetse, & van Beukering, 2014). Cultural services like human well-being, aesthetic and spiritual benefits were already highlighted in the Millennium Ecosystem Assessment in 2005 (MEA, 2005).

Regarding the aesthetic preferences for typical SNH elements in the landscape only a few studies exist. In the United States, research based on a photo survey showed that landscape scenarios with grassy and woody buffer strips are preferred to landscape scenarios without such elements (Klein et al., 2015; Sullivan, Anderson, & Lovell, 2004). Two experimental studies in Germany and Switzerland, similarly, reveal respondents' preferences for species rich, flowering and colourful meadows (Lindemann-Matthies & Bose, 2007; Lindemann-Matthies, Junge, & Matthies, 2010).

The existing studies about the public's preferences for SNH suggest people show a preference for characteristics like a tidy, dense and green vegetation and landscapes with flowers and various colours (Junge, Schüpbach, Walter, Schmid, & Lindemann-Matthies, 2015). However, the definition of these characteristics remains unclear. Besides local conditions and management, seasons turned out to have an important impact on the visual aspect of the agrarian landscape (Stobbelaar, Hendriks, & Stortelder, 2004).

In this paper, we analysed the complex relationship between characteristics of vegetation as e.g. flowers, type and structure on the one hand and preferences of people for the visual quality of these characteristics on the other hand. Using choice experiments, we pursued the overarching aim to better understand the reasons for people's preferences for landscapes containing elements like certain typical crops as well as grassy and woody SNH. We do this by taking into account, in addition to the landscape elements like crops as well as grassy and woody SNH, their underlying characteristics that might even vary in the course of the seasons. We think that this study is an important contribution to better understand why respondents like the visual aspect of combinations of crops with grassy and

woody SNH. Knowledge about this may help policy makers or practitioners to increase the aesthetic value of the agricultural landscape for the population in the future.

Compared to studies based on multivariate models using preference rating of landscape pictures, choice experiment models have three advantages: first, they force the evaluators (i.e. respondents of a survey) to make trade-offs, by requiring them to choose the preferred landscape from a given set of pictures. Second, they provide a framework for a rigorous quantitative analysis of the factors determining the observed choices. Third, they allow considering preference heterogeneity between people evaluating the aesthetic aspects of the landscape pictures.
Choice experiments are often used for an assessment of the economic value of ecosystem services (Bernues, Rodriguez-Ortega, Ripoll-Bosch, & Alfnes, 2014; Campbell, 2006; Graves, Pearson, & Turner, 2017; Rewitzer, Huber, Grêt-Regamey, & Barkmann, 2017; van Berkel & Verburg, 2014). In these studies, money is typically used as a measuring rod for preferences.

In our study, however, we aim at finding out which characteristics of pictures best explain why a picture is considered aesthetic. Respondents should make trade-offs between landscape elements only whereas we opted deliberately for not including cost as an element for trade-off. Including cost would require constructing a credible payment scheme for SNH which is typically problematic and adds considerable sources of bias in respondent behaviour. We therefore applied a similar approach as Graves et al. (2017), in that we presented respondents pictures to choose from and used visual attributes as explanatory variables for the observed choices. Respondents were not given verbal explanations of attributes, i.e. they made their choices based only on the visual aspects of the pictures and, ideally, implicitly on the attributes. With this approach, we aimed for an unbiased evaluation by participants while also being able to include the attributes qualifying the vegetation in a choice model.

Applying these models, we aim at answering the following questions:
1. Are respondents' choices based on the SNH themselves or rather their underlying characteristics?
2. How do seasons influence the vegetation's characteristics of a restricted number of crop and grassy or woody SNH combinations and how does this impact preference statements in choice experiments?

Our research was part of the EU FP7 QuESSA project. The QuESSA project evaluated ecosystem services, i.e. pollination, biological pest control and soil conservation provided by semi-natural habitats in eight European countries (Holland et al., 2014). Covering the United Kingdom, France, Germany, Italy, Hungary, Estonia, the Netherlands and Switzerland, the project comprises a big range of climatic, geological and pedological settings as well as different social conditions. However, embedding our study in the research project QuESSA meant that our choice experiment was restricted to the combinations of a limited number of crops as well as grassy and woody SNH. For this study, we focus on the two countries Hungary and Switzerland.

5.3.2. Material and Methods

5.3.2.1. Choice modelling and landscape aesthetics

Choice experiments (CE) are used widely in marketing (James, Rickard, & Rossman, 2009; Vecchiato & Tempesta, 2015), transport (Masiero & Hensher, 2010; Willigers & van Wee, 2011) and environmental economics (Bernues et al., 2014; Campbell, Scarpa, & Hutchinson, 2008) to analyse preferences for alternatives, based on estimated monetary values of the different characteristics of a good or service. There are also numerous studies using CE to assess different options of landscape management or

landscape preference in a broad sense (Arnberger & Eder, 2011; Graves et al., 2017; Rewitzer et al., 2017; van Berkel & Verburg, 2014).

Choice experiments are firmly rooted in consumer theory (Lancaster, 1966) and make use of the random utility model (McFadden, 1974) as analytical framework. The basic idea behind CE is that from a set of various alternatives, rational individuals choose the alternative whose specific combination of characteristic attributes provide them with the greatest utility. By varying the set of attributes of the available alternatives across a series of choice occasions and recording responses, the relative strength of preferences for the different attributes can be assessed. The random utility model assumes that from the perspective of a researcher utility is composed of a systematic part, which is observable, and a random part, which is not observable. This can be described as follows:

$$U_{ni} = V_{ni} + \varepsilon_{ni} \quad (1)$$

where U_{ni} represents the utility of alternative i for the individual n, Vni the observable component of utility that the individual n associates with alternative i and εni denotes the error term of the model and, therefore, the unobservable or random part. The observable part V_{ni} can further be specified by

$$V_{ni} = x'_{ni}\beta \quad (2)$$

where x_{ni} is the vector of the specific attribute levels of the alternative i and β is the respective parameter vector. Assuming that the error term follows a Type I Extreme Value distribution and that the individual indicates their most preferred alternative, the probability of this alternative being selected is

$$P_{ni} = \frac{\exp(x'_{ni}\beta)}{\sum_{j=1}^{J}\exp(x'_{nj}\beta)} \quad (3)$$

The main shortcoming of this multinomial logit (MNL) model is the assumption of a representative utility function for all individuals as expressed in the fact that only a sample average of the preference weights vector, beta, can be estimated. However, in reality one can expect preference heterogeneity, i.e. the β-vector differs among individuals. The mixed logit model (MLM) assumes the elements of β to follow a continuous distribution. Different distributional forms for the elements of the β-vector are possible, with the normal and lognormal distribution most commonly used (Train, 2009). Parameters to the MLM can be estimated using simulated maximum likelihood. As an alternative, the latent class model (LCM), a special variant of mixed logit, assumes a discrete distribution of the preference weights. As a result, the LCM produces a limited number of systematic clustering of individuals into classes with sufficiently similar β-vectors. In this case, the probability that individual n belonging to class q chooses alternative i in a given choice set is specified by:

$$P_{ni}|(class = q) = \frac{\exp(x'_{nit}\beta_q)}{\sum_{j=1}^{J} exp\left(x'_{njt}\beta_q\right)} \quad (4)$$

Note that this probability is conditional on membership in class q. Class membership of individuals is probabilistic and determined within the model based on the choice observations. Using a standard Maximum Likelihood procedure, the parameters of both the class selection model as well as the choice probability model can be estimated (Pacifico & Yoo, 2013; Sarrias & Daziano, 2017).
The probability of class membership of an individual n is modelled similarly based on an individual's characteristics z_n and the class-conditional parameter vector γ_q.

$$H_{nq} = \frac{\exp(\mathbf{z}_n'\gamma_q)}{\sum_{q=1}^{Q}\exp(\mathbf{z}_n'\gamma_q)} \tag{5}$$

Joining the class membership probabilities with the choice model probabilities yields the aggregate log-likelihood function for individual n

$$S_n = \sum_{n=1}^{N} \ln\left\{\sum_{q=1}^{Q} H_{nq}\prod_{t=1}^{T}\prod_{j=1}^{J}\left[\frac{\exp(\mathbf{x}_{njt}'\beta_q)}{\sum_{j=1}^{J}\exp(\mathbf{x}_{njt}'\beta_q)}\right]^{y_{njt}}\right\} \tag{6}$$

where Q is the number of classes, T is the number of choice sets an individual is presented and J is the number of choices within each choice set. γ_{njt} equals 1 if individual n chose the j-th alternative in the t-th choice set and 0 otherwise.
In this study, we chose to model our choice data using the latent class model for a number of reasons. While the MNL model rests on rather strict assumptions like the Independence of Irrelevant Alternatives (IIA) property and the inability to account for unobserved preference heterogeneity, this is not the case for the MLM and LCM. Further, the analysis showed that LCM had a better model fit as assessed by the criteria Bayesian Information Criterion (BIC) than any of the other model types (see appendix table 14 for a comparison of model performance). In addition, among the two methods MLM and LCM, which both consider preference heterogeneity among individuals, the LCM appears to be more suitable for policy makers since such models deliver, as output, more or less homogeneous classes with similar preferences. This makes it easy for policy makers to assess which groups in society are in favour of a particular alternative.
In our analysis, we estimate the model shown in equation (6), which yields as results the respective classes q, the estimates of choice parameter vectors β_q for each class as well as the class sorting vectors γ_q.

5.3.2.2. The QuESSA project as the experimental framework

The QuESSA project evaluates pollination and predation services provided by hedgerows or woodlots (woody SNH) and grassy elements, such as low input meadows or pastures (grassy SNH) (Holland et al., 2014).

In order to analyse the respective services, QuESSA experiments applied the following design:
(1) A core crop was combined with three different adjacent elements: (a) an adjacent crop, (b) a grassy or (c) a woody SNH. (2) The core crop in each country was fixed; in Hungary the core crop was sunflower, in Switzerland it was rapeseed. As an additional service, our study evaluated the effect of woody and grassy SNH on the visual landscape quality in order to include aesthetic values in overarching analyses about ecosystem services of SNHs. The need for visual preference values for experimental fields requires a picture-based survey among the QuESSA partner countries that visualise the examined combinations.

5.3.2.3. Data collection

5.3.2.3.1. Definition of attributes characterising the pictures

In order to better explain the preferences behind the superordinate attributes crop, grassy and woody, we used the existing literature (Junge et al., 2015; Lindemann-Matthies & Bose, 2007; Lindemann-Matthies et al., 2010) to determine additional attributes that describe these aspects. The attributes are related to vegetation density, vegetation structure and neatness, but also colour quality. These

attributes were defined in parallel to the creation of the pictures, but they were not mentioned in the choice set. Respondents made their choices only on the basis of the pictures. To ensure that the assignment of additional attributes was as precise and as free from subjective assessment as possible, objective criteria were defined for all attributes, which were used to classify the attribute levels (see table 9).

Thereafter, three of the authors and a student assistant applied the criteria to the pictures of Switzerland. The assessments of the four persons were compared and discussed until there was consensus on the classification for each attribute and each picture. Initially, a large number of attributes were considered. In a next step, we analysed the correlation among the SNH as well as the full set of attributes to select the relevant attributes and reduce multicollinearity. To this end, a factor analysis using the varimax rotation procedure was conducted to determine those attributes that obtain the highest loadings on independent factors. This resulted in four central and uncorrelated attributes to be used in our analysis: (1) ordered structure in the depicted combination ('Ordered'); (2) the amount of bare soil, gravel or rocks in the depicted combination ('NoVeg'); (3) the amount of green vegetation in the picture ('Green'); (4) the availability of yellow, white, or purple features in the landscape, which usually originate from flowers ('ColAvail)', For all attributes except 'ColAvail' three levels (including 0) were defined (this was implemented by separating the respective attribute into two dummy variables). Together with the two superordinate attributes 'Grassy' and 'Woody' indicating the two SNH, these additional attributes were included in our models (see section 5.3.2.4). In table 9, all attributes with their respective levels are listed. The additional attributes together with the superordinate attributes formed the basis of the choice experiment.

Table 9: Definition of the attributes characterising the combination.

Variable	Level	Description
Ordered	0	No clearly defined borders. Surfaces not homogeneous and no clear pattern like rows visible; Patchy, scrubby vegetation.
	1	One more or less clearly defined border, one surface either with a homogeneous structure or with a clear pattern like rows, or several homogeneous patches.
	2	Only clearly defined borders and all surfaces have a homogeneous structure or a clear pattern like rows.
NoVeg	0	All surfaces in the picture are covered with dense vegetation. Bare soil is not visible.
	1	Several spots of bare soil or one land-use type with sparse (dry) vegetation, or one field with bare soil in the background
	2	One land-use type is dominated by bare soil; only a few small plants.
Green	0	No green vegetation
	1	Some green vegetation; the occurrence of green vegetation does not stand out.
	2	Green surfaces clearly visible
ColAvail	0	No or only isolated colours like yellow, white or pink in the picture.
	1	Yellow, white or red-orange patches (e.g. sunflowers or flowering SNH) in foreground. At least one colour
Woody SNH	0	Combination without woody element
	1	Combination with woody element
Grassy SNH	0	Combination without grassy element
	1	Combination with grassy element

5.3.2.3.2. Study material and photo editing

Following the design of QuESSA, all sites where pollination and predication experiments were conducted were photographed. In Hungary, the sites were located in eastern Hungary in the Jászság region. The landscape in this region is monotonously flat and dominated by crop production. The annual precipitation amounts to 570mm (www.met.hu/eghajlat/magyarorszag_eghajlata/varosok_jellemzoi/Szolnok). The sites in Switzerland are located in the north-eastern part of Switzerland, in the Canton of Aargau (see maps (a), (b) and (c) in appendix A). The landscape is characterised by rolling hills, a mixture of grassland and crops (Sutter, Albrecht, Jeanneret, & Diekötter, 2018). The annual precipitation amounts to 1000mm (Meteo Schweiz, 2014).

Photos were taken on three (Switzerland), respectively four (Hungary) different occasions in 2014 in order to depict the relevant stages in the vegetation period of the included crops (see Tables 10 and 11). Photos were taken as to always show the same section of the landscape, with the same focal length and from the same side of the field in a defined angle. The position of the focal crop field in the picture was also determined. The pictures were provided by the project partner of the respective country.

In order to maximize variation, we selected two pictures for each combination and season. The attributes characterising the combination as defined in section 3.2.1 (i.e. ordered structure, bare soil, green vegetation and colour) were used as criteria to select two samples of each combination in each season and country. Photo editing was used to standardise the pictures by transferring the same neutral but seasonally adapted background to all pictures. As a result, we created the following four pictures for both countries and for each available season:

Crop – crop (cc, control): A combination of the focal crop field (Hungary Sunflower, Switzerland oilseed rape) and an adjacent other crop field.

Crop – grassy (cg): A combination of the focal crop field and an adjacent grassy SNH.

Crop - woody (cw): A combination of the focal crop field and an adjacent woody SNH.

Crop - grassy – woody (cgw): This combination was not provided by the original QuESSA design. We therefore used the crop-grassy pictures described above and copied for each country a woody element which was identic for both replicats of each country but varied with season into the background of the already existing crop - grassy combinations. We created this combination to achieve an orthogonal factorial design (Montgomery, 2001) with respect to the two SNH types grassy and woodyl.

Table 10: Seasonal stages of sunflower and grassy SNH represented in the different choice tasks in the questionnaire for Hungary.

	Season 1	Season 2	Season 3	Season 4
Date	April	May	July	September
Crop status	Freshly sown	Young plants	Flowering	Dry, brown Flowers and plants
SNH grassy status	Green, a few tufts of dry grass	Green, a few tufts of dry grass	One domina-ted by dry grass, the other green, with tufts of dry grass	One green, a few tufts of dry grass the other with a grass species of brown colour

Table 11: Seasonal stages of rapeseed and grassy SNH represented in the different choice tasks in the questionnaire for Switzerland.

	Season 1	Season 2	Season 3	Season4
Date	Mid-April	June	End of July	NA
Crop status	Flowering	Ripe	Harvested	NA
SNH grassy status	Brown, patchy with bare soil	Green with a few flowers	Green with flowers	NA

5.3.2.3.3. Questionnaire

The survey was developed by a group of scientists involved in the QuESSA project. The questionnaire was designed in English and compiled as an online questionnaire in UniPark (QuestBack, 1999-2012) in order to enable pilot testing in a preliminary design by different researchers of the University of Landau (Germany) as well as by further researchers involved in the QuESSA project in other European countries. The aim of the pilot test was to receive feedback on the quality of the pictures, the length of the questionnaire, the clarity of the questions and the tasks. Once a satisfying version of the questionnaire was achieved, it was translated into Hungarian, German and French. The German and French versions were used in Switzerland. These versions were pilot tested again using a convenience sample of about 10 persons in the respective country to verify the quality of the translation.

A next version of the questionnaire was then pre-tested using 50 participants of a panel provided by Respondi ® (www.respondi.com). In Switzerland, this was done between June 1 and June 6, in Hungary between June 30 and July 13. The main aim of the pre-test was to see, if all quota were correctly set and if they were functioning as expected. Furthermore, some descriptive statistical analyses were performed to see whether the answers were plausible.

In accordance with the choice experiment approach described in 2.1, we presented choice cards with four pictures each, depicting a crop – crop, crop – grassy, crop – woody and a crop – grassy – woody combination from the same season (see an example for Hungary and Switzerland in Appendix B). As described in section 2.3.2, each combination in each season (and country) was represented by two different pictures to reduce a potential bias due to picture selection (for details see section 2.3.2). This resulted in two choice cards for each season and country. Participants from Hungary therefore evaluated eight choice cards, participants from Switzerland 6 choice cards.

From each choice card participants had to select the picture they liked best. Furthermore, we collected information on gender, age and education, and participants were asked how familiar they were with pictures of landscapes similar to the pictures in the choice cards.

5.3.2.3.4. Data collection and respondents

Respondents for both countries were recruited from a panel of Respondi ® (www.respondi.com). In both countries the sample is representative of the population with regard to gender and education and in Hungary also for age. In Switzerland, it was additionally representative with regard to the two dominating languages German and French.

The survey was conducted between June 12 and June 22, 2015 in Switzerland and between July 22 and August 8, 2015 in Hungary. In both countries we sought for a sample of 350 participants.

In Switzerland altogether 380 respondents completed the questionnaire; in Hungary there were 408 participants. The answers of the respondents of both countries were subjected to a quality check on the base of which the final selection of the participants used was determined. This check was based on the quality index provided by Unipark. It calculates a rate from the time a participant needs to fill in one page compared with the time needed to fill in all pages available in the questionnaire.

Furthermore, several questions that were answered with "I don't know", while no particular knowledge was necessary to answer this question, were used as an additional information about the validity of the answers. In Hungary, additionally participants who used less than 5 minutes to fill in the questionnaire were excluded. Furthermore, the balance of the different quota (gender age and education) was considered. After quality control, the sample size for each country was 352 respondents. In Switzerland, we had to exclude 11 participants while performing the choice models, as they did not answer all the choice cards. The final number of respondents for each social group in each country can be found in Table 12.

5.3.2.4. Data analysis

In order to answer the two research questions, we estimated a model based on the structure described in section 2.1 with the superordinate attributes 'Grassy' and 'Woody' as well as the additional attributes. The socio-demographic variables enter via the classes indirectly into the estimation. The model was estimated separately for the two countries. To determine the number of classes in latent class models, the information criterion was used. We have considered the Bayesian Information Criterion (BIC) since this is the most common for latent class models (Heckman & Singer, 1984). Another decision criterion was the requirement that all classes must differ significantly from each other. In our analyses we found that above a certain number of classes, one or more classes no longer differed significantly from class 1. Such models were not considered but are reported in appendix C. Other decision criteria, such as the size of the estimates of class probabilities or the stability of the structural parameters did not play a role in our case. All models were performed in R (R Core Team, 2008).

5.3.3. Results

5.3.3.1. Description of the classes

Considering BIC and the fact that all classes must differ significantly from class 1, the calculations of the Latent Class Models showed that for our model containing the superordinate as well as the additional attributes in Hungary a three-class model and in Switzerland a two-class model explained the data best. The largest group (class 1) in Hungary included 65% of respondents and the second largest 20% (class 2). In Switzerland, 65% of respondents belonged to class 1 (Table 12).

In Hungary, men, older participants and participants with a primary or secondary education belonged to class 1 significantly more often. Younger participants and participants with a higher education significantly more often belonged to class 2 or class 3. Women belonged significantly more often to class 2 than to class 1 or class 3 (Table 12). Overall, participants of classes 2 and 3 selected substantially more combinations containing SNH. The choices of participants of class 3 were dominated by crop – woody combinations (Figure 6).

In Switzerland, men and participants with a primary or a secondary education significantly more often belonged to class 1 (Table 12), while women and more educated participants significantly more often belonged to class 2. Furthermore, participants of class 2 tended to be older than those of class 1. Similar to Hungary, participants of class 2 overall selected more frequently combinations containing SNH (Figure 7).

Table 12: Proportions of gender, age and education in the different classes for Hungary and Switzerland

Variables	Hungary All [352][1]	Class 1 [65%][2]	Class 2 [20%][2]	Class 3 [15] [2]	Switzerland All [341][1]	Class 1 [35%][2]	Class 2 [65%][2]
Gender							
Male	49 [49][3]	49.1	38.2	60	49.5 [50] [3]	51.1	46.6
Female	51 [51] [3]	50.9	61.8	40	50.5[50] [3]	48.9	53.4
Education							
Primary	10 [10] [3]	12.8	4.2	8.7	12 [12] [3]	12.6	11.8
Secondary	59 [59] [3]	60.8	59.4	51.4	40 [39] [3]	41.6	36.7
Higher education	31 [31] [3]	26.4	36.4	39.9	48 [49] [3]	45.8	51.5
Age							
19-39	46 [47] [3]	47.1	47.	44.5	47 [34] [3]	48.9	45.8
40-59[4]	43 [43] [3]	38.6	60.8	44.2	38 [45] [3]	38.3	38.7
60 -64[4]	11 [10] [3]	14.2	2.2	11.3	13 [21] [3]	12.8	15.5

[1]Number of participants included in the analysis
[2]Proportion of participants belonging to the respective class calculated on the basis of posterior membership probability (Sarrias & Daziano, 2017)
[3]Proportion of social group in the whole society in Hungary and Switzerland respectively
[4]In Switzerland 19- 39, 40-65 and >65

5.3.3.2. Vegetation characteristics

The results of the model (Table 13) showed that 'Woody' had a significant positive influence on the selection probability of the pictures both in Hungary and in Switzerland. However, in Switzerland this was true only for class 2. 'Grassy', on the other hand, had a significant negative influence on preferences in class 1 and 3, yet only in Hungary. Also, the first level of 'Ordered' (Ordered_1) had an influence on the selection probability only in Hungary (class 2 and 3), but in this case a positive one. In contrast, a higher degree of ordered structures (Ordered_2) had a positive influence on selection in both countries, in Hungary in class 2 and in Switzerland in class 1. A low percentage of green vegetation (Green_1) only had a positive effect on class 1 in Hungary, whereas a high proportion (Green_2) had a positive effect on classes 1 and 3 in Hungary and class 1 in Switzerland. The availability of colour had a positive effect in Hungary in classes 1 and 3 and in both classes in Switzerland. The proportion of surface area without vegetation (only considered for Switzerland) had a negative influence on the selection probability for both classes in the first level and in the higher level for class 1. Non-significant coefficient estimates are not relevant for participants in the respective class and the associated attributes do therefore not influence their choices.

Table 13: Coefficients of the latent class models for Hungary and Switzerland

	Hungary			Switzerland	
Attributes	Class 1 [1][65%]	Class 2 [1][20%]	Class 3 [1][15%]	Class 1[1][65.2%]	Class 2 [1][34.8%]]
Woody	0.179*	0.459**	2.932***	0.173	3.362***
Grassy	-0.358***	0.664	-1.969***	-0.433	1.088
Ordered_1	0.146	2.168***	0.677**	0.335	0.301
Ordered_2	0.514***	1.097**	0.47	1.683***	4.508
Green_1	0.357**	10.463	0.935	-0.068	-0.531
Green_2	1.006***	10.895	1.924*	0.549**	1.636
ColAvail	2.663***	12.494	4.625***	1.928***	3.576**
NoVeg_1	Excluded	Excluded	Excluded	-1.809***	-1.919***
NoVeg_2	Excluded	Excluded	Excluded	-0.770**	2.061
Class 2		2.588***			-0.334*
Class 3			0.761***		NA

* < 0.05, ** < 0.01, *** < 0.001

[1]Proportion of participants belonging to the respective class, calculated on the base of posterior membership probability (Sarrias & Daziano, 2017)

5.3.3.3. Seasons

Figure 6 shows the choices for the three Hungarian classes by season. The comparison of the classes shows that the respondents of classes 1 and 2 chose a mixture of all combinations, while the respondents of class 3 mainly chose crop-woody combinations. In terms of the season, it is apparent that in all classes the proportion of selected crop-crop combinations is by far highest in the first season (spring), while the proportion of crop-grassy-woody combinations is highest in season 4 (autumn, see also Table 10). In addition, the combination crop-woody is on the whole most prominent in all three classes in season 2 and 3. Further, it is also apparent that the combination crop-grassy was hardly ever chosen in class 3.

Figure 7 shows the choices for the two classes in Switzerland by season. The comparison of the classes indicates that the proportion of crop-grassy-woody combinations was much higher in class 2 than in class 1. This is especially true in early and late summer where crop – grassy - woody combinations dominated the selections in class 2. In class 1, however, the proportion of crop-crop combinations was much higher. Furthermore, it can be seen that in class 2 the combination crop-crop and crop-grassy were hardly ever chosen. Moreover, both in classes 1 and 2, in season 1 the proportion of crop-woody is considerably higher than in the other seasons. Furthermore, in class 1 the proportions of crop – grassy and crop-grassy-woody also increased in early and late summer (season 2 and 3) compared to spring.

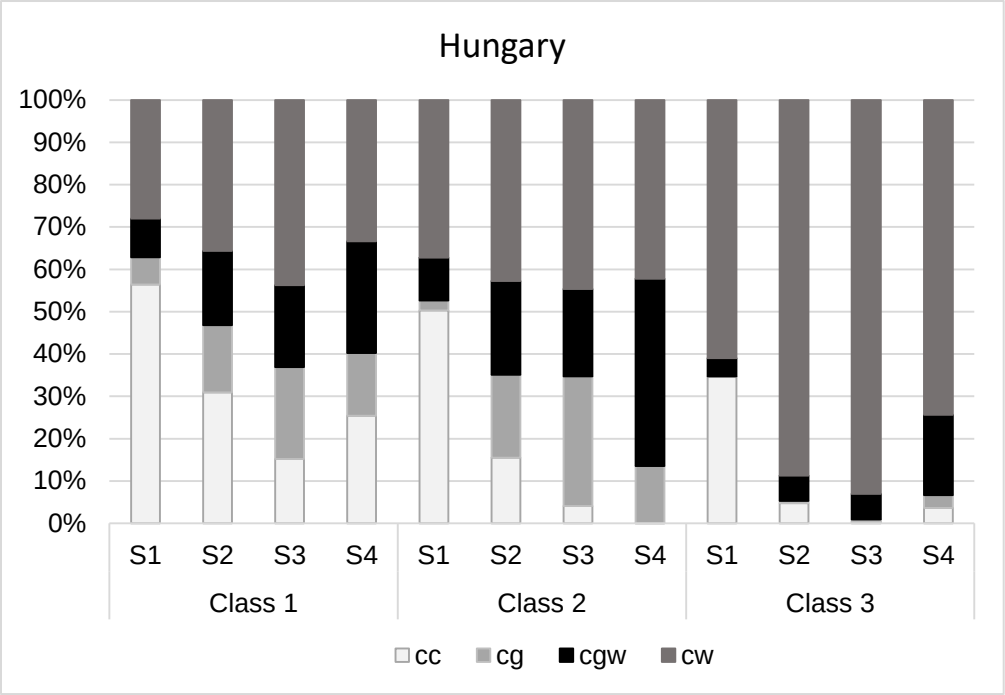

Figure 6: Preference for combinations by class and season in Hungary
cc: crop – crop; cg: crop – grassy; cgw: crop – grassy – woody; cw: crop – woody.

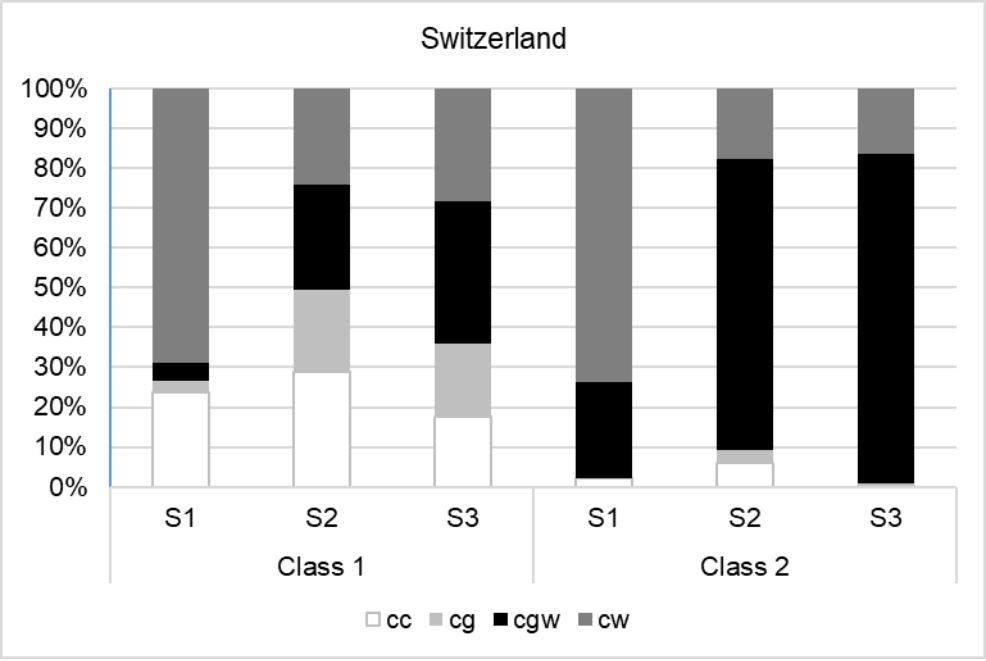

Figure 7: Preference for combinations by class and season in Switzerland
cc: crop – crop; cg: crop – grassy; cgw: crop – grassy – woody; cw: crop – woody.

5.3.4. Discussion

5.3.4.1. Which characteristics explain preferences?

The clear preference of respondents for landscape pictures containing SNH (see figures 6 and 7) is in line with the existing literature (Hasund, Kataria, & Lagerkvist, 2011; Junge et al., 2015; Klein et al., 2015; Schaak & Musshoff, 2020; Sullivan et al., 2004).

The results of our models containing both the superordinate as well as the additional attributes reveal that 1) the additional attributes contain explanatory power in addition to the superordinate attributes grassy and woody SNH. This follows from the results that the additional attributes are significant and that the model fit as measured by BIC of the model with additional attributes is significantly better than the fit of the model containing only the superordinate attributes (BIC changes from 7272 to 6204 in Hungary and from 5035 to 4328 in Switzerland, see Appendix table 17). 2) The superordinate attributes still contain explanatory power in the case of 'Woody' in both countries and 'Grassy' in Hungary, however, not in the case of 'Grassy' in Switzerland. From this, it follows that in the case of grassy SNH in Switzerland we were able to comprehensively capture the aesthetic characteristics people associate with those SNH, so that 'Grassy' loses its significance as an explanatory attribute in itself. In the other cases the superordinate attributes may be explanatory in themselves or still contain some characteristics that we failed to capture by our chosen additional attributes. For example, respondents may like woody SNH simply because they are woody or because they break the horizon and represent a structural element in the foreground. This is subject to further research.

Considering the different attributes (table 13), 'ColAvail' turned out to be the attribute preferred by most respondents in both countries. 'ColAvail' denotes the presence of colourful flowers as yellow, white or red-orange patches. The importance of colourful flowers for landscape preference is already known (Akbar, Hale, & Headley, 2003; Graves et al., 2017; Junge et al., 2015). While in Hungary blooming rapeseed and sunflower fields were the source of colour, it was rapeseed fields and blooming meadows in Switzerland. Pictures of crops and meadows were consequently preferred because they contained colours from flowers.

The attribute 'Green' applied to all areas of the picture containing green vegetation (level 1) or that were uniformly green (level 2). The results showed that green vegetation was highly valued in Hungary, whereas it was less important in Switzerland. The considerably dryer climate in Hungary may explain the higher appreciation for the green colour there, since during the dry summer months, green vegetation is rare. Indeed, the Jászság region receives about half the precipitation of Switzerland (MeteoSchweiz, 2014) (www.met.hu/eghajlat/magyarorszag_eghajlata/varosok_jellemzoi/Szolnok). With respect to the research question, we conclude that one of the main reasons for respondents' preference for meadows as well as hedgerows is that they are green for a large part of the year.

The attribute 'Order' was defined by the proportion of clearly delineated homogeneous areas or areas with clearly visible seed rows. Our results showed that, overall, a high degree of ordered structure was appreciated in both countries. Previous studies (Junge et al., 2015; Stilma et al., 2009) have already demonstrated that a lack of ordered structure leads to a lower appreciation. According to Nassauer (2011) 'stewardship' and 'care' are important aspects in landscape preference; "Care means protecting or maintaining what we pay attention to…". Furthermore, Sevenant and Antrop (2010), have shown that care and naturalness have the largest positive effects on landscape aesthetic preference. An ordered structure, however, is not the main quality of woody and grassy SNH. Especially low input meadows, as shown in Switzerland, can have a rather messy character. Woody plants may also appear rather patchy due to their composition; this can be aggravated in certain vegetation periods. However, woody plants in straight lines can also add clear patterns and homogeneous areas to the landscape.

The acceptance of grassy and woody SNH in terms of the preference for an ordered structure thus clearly depends on their composition, but also on the respective season.

In our study, the attribute 'NoVeg' described the proportion of bare soil or sparse (dry) vegetation. While this attribute could not be tested in Hungary, it was found to be very important in Switzerland. Respondents significantly rejected pictures with 'NoVeg1' and 'NoVeg2' attributes more often than pictures without such elements. Junge et al. (2015) showed that dry or sparse vegetation is valued low. However, our study finds that 'NoVeg' has a more diverse dimension: In Hungary, it was associated either with freshly sown plants in straight lines in spring or harvested fields with dry organic remain in autumn. While the first situation was related with an ordered structure, the second reflected a messy aspect. In Switzerland, 'NoVeg' also occurred in patchy meadows in spring.

We can summarise, that all additional attributes were relevant to the population in our study. Attributes were crucial to explain SNH choices, as the elements crop, grassy and woody SNH that define our combinations changed their visual appearance over time. Depending on their visual appearance characterized by the mentioned additional attributes, combinations were or were not selected. However, the superordinate attributes may still contain explanatory power, depending on the specific case.

5.3.4.2. The role of seasons for explaining preferences

The results presented above largely depend on the seasonal differences of the combinations shown in the questionnaire. This is true for all of the attributes studied. The influence of the season on the attribute colour is certainly the most obvious, since plants naturally bloom during a limited time of the year and, therefore, this attribute may or may not be present. The same applies to the attribute 'Green'. On the one hand, intensity and shade vary throughout the year, on the other hand some plants wilt during the year and thus lose their colour altogether. In addition, the area covered by green vegetation increases during the year due to plant growth. The degree of ordered structure of the landscape is also subject to seasonal changes. While in spring plants sown in rows provide such ordered structure, this can be lost over the course of the year as plants grow; this is even more the case once crops are harvested. For meadows and woody plants, the effect is somewhat different, but here too, a seasonal effect on an ordered structure of the landscape can be expected: both types of vegetation experience an increase in biomass over the course of the year while parts of the vegetation die off, thus creating a change in structure. The fact that surfaces are not covered with vegetation is, of course, also related to seasonal effects and, in particular, the agricultural cycle of sowing and harvesting.

These findings can also be illustrated by studying the pictures that were selected by participants. In Hungary for example, spring pictures of pure agricultural combinations (crop-crop) were chosen more often. Crop - woody and crop - grassy combinations, on the other hand, are increasingly preferred in early and late summer pictures, while crop – grassy- woody combinations were more likely to be preferred in autumn pictures.
The decisions were based on the characteristics available at the respective time of year. If, for example, colour was only available in the crop-crop combination (spring), this picture was preferred. If colour was not available in any combination (early summer) or in every combination (late summer), then the choices were based on the other characteristics, green vegetation, ordered structure and bare soil, depending on their availability in the pictures.

Our results clearly show that preferences for a landscape element cannot really be determined without taking seasonal effects into account. Until now, the literature has mostly examined mere snapshots (Brassley, 1998) and has left out the seasonal variability in vegetation. Our results demonstrate the need to include all relevant stages (seasons) during the vegetation period in order to obtain an

accurate picture of preferences for agrarian landscape elements or agrarian landscapes in general in survey studies based on landscape pictures.

5.3.4.3. Implications for the management of grassy and woody SNH

In this section we discuss how to optimise the management of grassy and woody SNH with regard to the visual landscape and to what extent visual landscape quality and biodiversity may be in conflict with each other. Measures for the management of grassy and woody SNH are particularly effective when they foster the most important characteristics. Our results show that all the attributes studied had a significant impact on the choice of pictures in both countries for at least one of the classes (table 5). However, the size of the coefficients of the attributes allows no clear statement about the most important attribute since the units of the attributes are not comparable (see table 1).

Nevertheless, we know the proportion of participants for which a certain attribute is relevant, and we know that the coefficient estimates of all relevant attributes never had conflicting signs within one country (table 5). We therefore consider those attributes to be robust in representing people's preferences within each country.
In Hungary all additional attributes turned out to be relevant for at least 80% of participants, while the attribute for 'bare soil' could not be included in the Hungarian model (see also sections 3.2 and 4.2). In Switzerland the additional attributes 'NoVeg' (bare soil) and 'ColAvail' (colours) were relevant for all participants, 'Order' (ordered structure) and 'Green' (green vegetation) were still relevant for 65% of Swiss participants.

In the following we discuss how the evaluated characteristics could be enhanced in woody or grassy SNH in order to increase the quality of the visual landscape for people.
The original reason to introduce SNH in the agrarian landscape in Europe and EFAs in Switzerland was to enhance biodiversity. Our results show that in general the characteristics of SNH are also appreciated by respondents from an aesthetic perspective, but also some conflicts between aesthetic aspects and biodiversity become apparent and need to be taken into account by decision makers.

Regarding woody SNH it was found that people in both countries appreciate woody elements like hedgerows simply because they are woody. In addition, woody SNH can contribute to the fulfilment of people's aesthetic preferences for green vegetation (throughout the year, except in winter), colourful flowers (in spring) as well as providing an ordered structure in an agricultural landscape. A potential conflict with biodiversity targets may arise because respondents preferred those pictures that contained relatively ordered and homogeneous elements, but patchy hedges are typically more valuable for biodiversity (Graham, Gaulton, Gerard, & Staley, 2018).

While the effects of measures regarding hedgerows are similar in Hungary and Switzerland, they clearly differ regarding grassy SNH as their visual aspects are fundamentally different between the two countries. The depicted grassy SNH of Hungary have a predominantly green aspect in most seasons and have a rather ordered character. These characteristics meet the aesthetic preferences of respondents in this respect. What is missing, however, in grassy SNH in Hungary are colourful flowers. In Switzerland, in contrast, the shown grassy SNH have a messy aspect with open soil in spring but flowers in addition to the green colour later in the year. While these meadows do not always satisfy the need for ordered structure and only little open soil, they serve respondents' needs for colour in a later period. In Switzerland, existing agri-environmental programs foster the presence of colourful flowers. For example, the program for 'botanical quality' rewards farmers if their EFA-meadows harbour a certain number and composition of (flowering) plant species. EFA meadows not fulfilling these criteria receive lower payments (SR 910.13, 2013). Improvements to the existing regulations could be to make the 'botanical quality' program mandatory to fulfil cross compliance. Furthermore,

species composition of these meadows should be developed towards mixtures providing flowering plants and therefore colours throughout the whole vegetation period. This would also be favourable for pollinators. Nevertheless, we identify a potential conflict between aesthetic preferences and biodiversity regarding the aspect of open soil as well as ordered structure. Open soil as well as structural diversity are further positive aspects for (insect) biodiversity (Holland et al., 2016; Jeanneret et al., 2016)

On the EU level, however, no such rules for species richness and composition exist. As Hungary has no country-specific regulation for this aspect there is currently no incentive to promote flowering plant species in grassy SNH. Moreover, in Hungary and also in the Jászság region, low-input grassland in general is subject to be converted to cropland (Bozsik & Koncz, 2018). In this situation the EU regulation to not convert permanent grassland into cropland (EU, 2013, 2014) may be helpful to preserve unmanaged grassy SNH and preserve at least in late summer and autumn green colour in a rather dry landscape. In addition, programs to foster flowering plant species providing colourful flowers during the whole vegetation period are recommended.

5.3.4.4. Limitations of the approach

The discussion until now showed that including seasons in our study was indispensable to understand participants' choices. This, however, required showing pictures of real combinations of crops and SNH following a seasonal sequence and caused several limitations of our study. Firstly, the number of possible combinations of vegetation elements was restricted, consequently, precluding a full orthogonal or factorial design with regard to the vegetation characteristics. As a result, variations within the pictures regarding our attributes may necessarily have been low, in some cases. This, secondly, also limited the number of additional attributes used. Future studies should consider additional attributes, such as the presence of dry vegetation, to determine what other characteristics are hidden behind the preferences for SNH. Thirdly, our study is based only on two countries. It will be necessary to test the performance of our empirical model in other contexts like the remaining QuESSA countries.

Finally, the sample sizes were rather small. The number of 350 participants in each country was a trade-off between financial resources and recommendations for a minimum sample size we found in the literature (Graves et al., 2017; Rewitzer et al., 2017; van Berkel & Verburg, 2014). A higher sample would probably have resulted in a further differentiation of classes in the models. However, we expect that even with a larger sample size the core result that all attributes are relevant for most respondents does not change.

5.3.5. Conclusions

In this study, we used choice experiments with standardised landscape pictures to investigate how to best explain the aesthetic preferences of the general population for woody and grassy SNH in combination with typical crops. The results of the study show that the superordinate attributes for SNH are not sufficient to explain the aesthetic preferences of the population adequately, while the used attributes for colour, green vegetation, ordered structure and bare soil contribute significantly to the explanation of these preferences. Colours and ordered structure were particularly important for most participants. The preference for colourful flowers is in line with the needs of biodiversity. The preference for ordered structure and homogeneity, however, conflicts with these needs. Furthermore, our approach allows for a better consideration of the seasonal effects on visual landscape quality. By differentiating the relevant seasons in the choice experiment and thus relating the seasons to our additional attributes, we can identify the different characteristics that are preferred.

One of the limitations of our study results from the inclusion of seasons, which forced us to show seasonally realistic combinations of landscape elements and led to a reduced variation and a suboptimal choice design. Further, the sample sizes of 350 respondents in each country was still rather small due to limited financial resources. Future studies should use larger sample sizes and increase variation of the characteristics in the pictures in order to be able to test more potential aesthetic attributes.

In order to increase the aesthetic value of SNH for the population, various measures could be taken and recommendations made following our results. Firstly, more hedges, ideally with visible flowering species should be included in the agricultural landscape since they provide structure, a fresh green aspect and, at least in some seasons, colour through flowering. Second, measures should be taken to increase colourful flowering ideally throughout the year. For this purpose the existing 'botanic quality program' in Switzerland, could be made mandatory to fulfil cross-compliance. In Hungary, it is recommended to establish a similar program at all. In a first step, we recommend protecting the existing meadows and prevent the on-going land conversion.

However, we identified also potential conflicts with biodiversity targets regarding SNH. In general, people preferred an ordered and well-structured landscape with rather homogeneous elements. Also, patches of open soil in spring are not appreciated. But a more patchy, unstructured landscape with heterogeneous elements is typically beneficial to sustain biodiversity in agricultural landscapes. Decision makers should be aware of these potential conflicts and carefully take into account society's preferences both regarding biodiversity as well as landscape aesthetics.

5.3.6. References

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5.3.7. Appendix

Appendix A

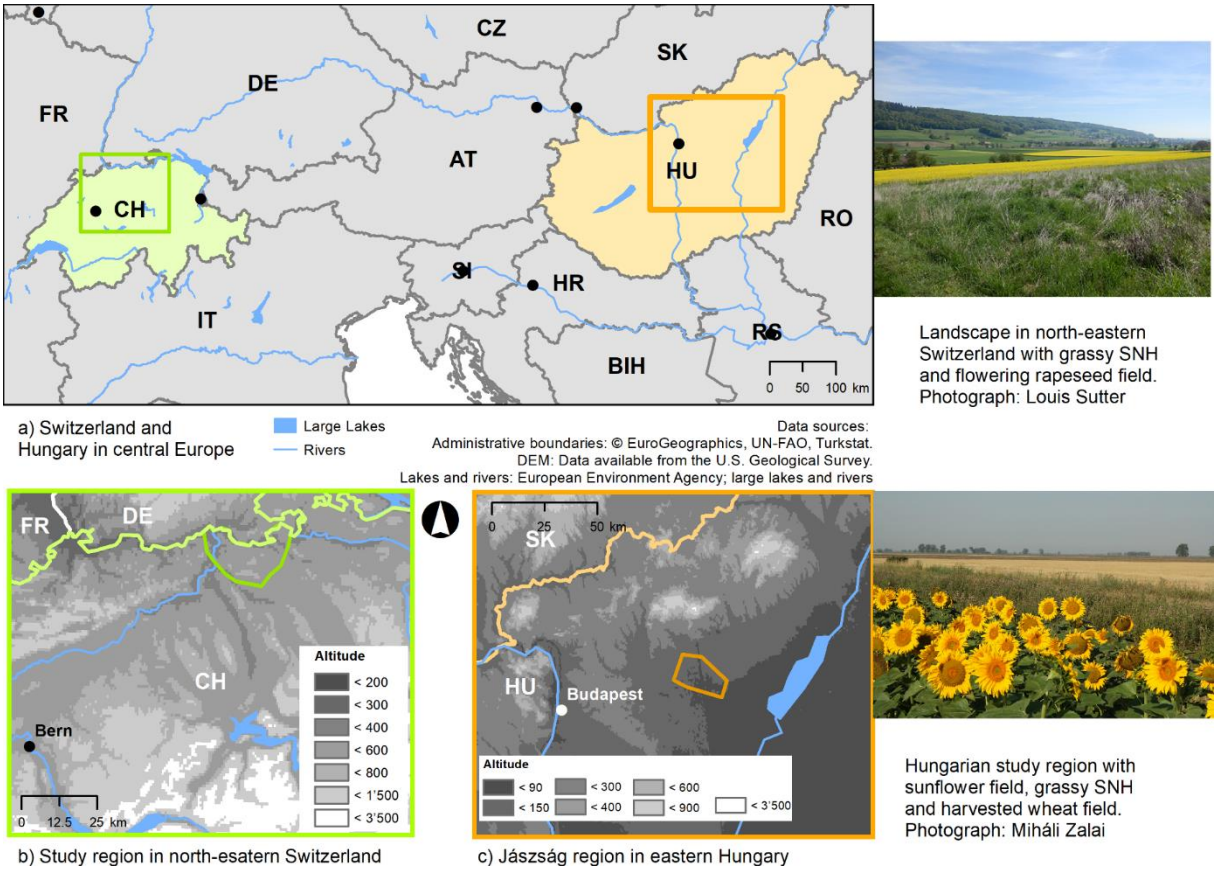

Figure 8: Map of the study regions

Appendix B

Figure 9: Example of a choice card of Hungary

Figure 10: Example of a choice card of Switzerland

Appendix C

Table 14: Model fit for multinomial-logit, mixed-logit and latent class models for Hungary and Switzerland

Model Input	BIC / AIC	Multinom. Logit model		Mixed logit model		Latent class model,	
		Hungary	Switzerland	Hungary	Switzerland	Hungary	Switzerland (2 classes)
Grassy + woody + gender + age + education	BIC	7192.072	5206.453	7120.689	5087.629	[2]7072.703	5035.349
	AIC	7120.755	5139.023	7037.486	5008.96	[2]7013.272	4979.156
Grassy + woody + green_1 + green_2 + Ordered_1 + Ordered_2 + [1]Noveg_1 + [1]Noveg_2 + ColAvail + gender + age + education	BIC	6546.159	4669.773	6396.712	4515.968	[3]6204.735	4286.632
	AIC	6249.005	4388.811	6069.843	4138.452	[3]6008.613	4151.77

[1]Not included in the Hungarian model

[2]Model with 2 classes

[3]Model with 3 classes

Table 15: BIC and AIC of latent class models for Hungary

Model input	Number of classes	BIC	AIC
Grassy + woody + gender + age + education	*2*	*7072.703*	*7013.272*
Grassy + woody + gender + age + education	3[1]	7107.428	7000.453
Grassy + woody + Ordered_1 + Ordered_2 + NoVeg_1 +NoVeg_2 + Green_1 + Green_2 + ColAvail + gender + age + education	2[1]	6197.2	6054.566
Grassy + woody + Ordered_1 + Ordered_2 + NoVeg_1 +NoVeg_2 + Green_1 + Green_2 + ColAvail + gender + age + education	3[1]	6177.607	5945.827
Grassy + woody + NoVeg_1 +NoVeg_2 + Green_1 + Green_2 + ColAvail + gender + age + education	2[1]	6254.367	6135.506
Grassy + woody + NoVeg_1 +NoVeg_2 + Green_1 + Green_2 + ColAvail + gender + age + education	3[1]	6293.749	6097.628
Grassy + woody + Ordered_1 + Ordered_2 + + Green_1 + Green_2 + ColAvail + gender + age + education	2	6204.054	6085.193
Grassy + woody + Ordered_1 + Ordered_2 + + Green_1 + Green_2 + ColAvail + gender + age + education	**3**	**6204.735**	**6008.613**

[1]One of the tow classes does not significantly differ from class 1

The model in italic letters was used to compare with the full model in bold letters; the model in bold letters is reported in Tables 4 and 5.

Table 16: BIC and AIC of latent class models for Switzerland

Model input	Number of classes	BIC	AIC
Grassy + woody + gender + age + education	*2*	*5035.349*	*4979.156*
Grassy + woody + gender + age + education	3[1]	5055.012	4953.865
Grassy + woody + Ordered_1 + Ordered_2 + NoVeg_1 +NoVeg_2 + Green_1 + Green_2 + ColAvail + gender + age + education	**2**	**4286.632**	**4151.77**
Grassy + woody + Ordered_1 + Ordered_2 + NoVeg_1 +NoVeg_2 + Green_1 + Green_2 + ColAvail + gender + age + education	3[1]	4328.887	4109.737

[1]One of the tow classes does not significantly differ from class 1

The model in italic letters was used to compare with the full model in bold letters; the model in bold letters is reported in Tables 12 and 13.

Table 17: Coefficients of the base model (latent class) for Hungary and Switzerland

Attribute	Hungary		Switzerland	
	Class 1 [75%]	Class 2 [25%]	Class 1 [65%]	Class 2 [35%]
Grassy	-0.605***	-1.841***	-0.4878***	0.2977*
Woody	0.249**	1.773***	0.478***	3.619***
Class 2		-0.648**		0.3252*

* < 0.05, ** < 0.01, *** < 0.001

6. Synthesis of results

All three empirical studies were aimed at achieving a better understanding of the interrelations described in subchapters 2.2 and 2.3 in order to further close the knowledge gap regarding the lack of information on the impacts of biodiversity protection efforts. In the following sections, all three studies are described in terms of their results as well as in terms of their contribution to the overall objective of finding the most efficient measures to protect biodiversity.

6.1. Synthesis of empirical study 1 on the added value of more nature-friendly mosquito control

The study "Assessing the trade-offs in more nature-friendly mosquito control in the Upper Rhine region" (Weiß, Allgeier, Brühl, & Frör, to be published) focuses on willingness to pay. The contingent valuation method found that the surveyed population has a mean willingness to pay of 124€ per household and year for the more nature-friendly mosquito control. The associated survey reveals that the extent to which people are affected by the two measures (the stop of Bti application in areas of particular value for nature and the use of technical mosquito traps against nuisance in settlements) plays an important role in terms of WTP. People who think that parts of nature should be protected more, but also those who would accept more mosquitoes outside of the villages in exchange for better nature protection, have a higher WTP. On the other hand, people who are sensitive to mosquito nuisance have a lower WTP. Furthermore, the results show that people who already protect themselves against mosquito nuisance have a higher WTP; people who are satisfied with the status quo of control have a lower WTP. With respect to socio-demographic factors, men and higher income groups have a higher WTP, while people who did not report their income have a lower WTP. Moreover, it can be seen that people's activities have an influence on WTP: allotment gardeners have a lower WTP and cyclists have a higher WTP.

A few limitations need to be noted. Due to the focus of the study on the top scale of the project, the individual preferences for most of the impacts associated with the project and potential links between the design of the project, its framing conditions and their concrete impacts remain largely unknown. Only the socio-demographic characteristics of the respondents as well as their attitude towards nature and their sensitivity towards mosquitoes allow transferring the results to other locations with similar framework conditions. Further studies need to focus on the other aspects to verify the transferability of the results of this study. With regard to preferences, the study indicates that most respondents derive a benefit from the protection of biodiversity and that the nuisance caused by mosquitoes is seen as a cost. In order to increase the cost-benefit ratio systematically, more precise information would be needed. It would be helpful, for example, to have information on people's preferences with regard to the specific impact on individual species, as well as a better understanding of the locations and intensity of perceived nuisance.

The results of this experiment have revealed a great deal of mistrust towards the proposed project and showed that many people doubt the effectiveness of the social measure (technical mosquito traps), but also the necessity of the ecological measure. As a result of these concerns, it can be assumed that such a project would have little, if any, added value at first. This might change once the project is implemented and reality disproves people's concerns. A low added value, especially at the beginning of a project, illustrates the importance of paying attention to the acceptance for such a project. The concerns identified by survey participants offer some important avenues for further exploration with regard to an efficient implementation and an optimization of the added value of more nature-friendly mosquito control projects.

Finally, the study shows that the surveyed population attaches a high value to the protection of nature and that the more nature-friendly mosquito control is appreciated despite its negative effects (i.e. increased nuisance). However, since our scenario involves both monetary costs (more effort in using the traps) and non-monetary costs (more nuisance outside the settlements), no statement can be made on the added value of the project. Furthermore, the monetary costs for such a more nature-friendly mosquito control are not known, as it has not yet been proven that a technical trap scenario like the one presented here works in practice. Instead, the study shows how costly the protection of settlements may be in order for such a project to have an added value for the population. In terms of optimizing the added value, this means that the more cost-effective the protection of settlements against mosquitoes, the higher the added value and, thus, the more efficient the corresponding project.

In summary, the study provides information on how high the value of nature in floodplains is for people. Further studies will have to explore what people's preferences are with regard to the specific impacts and how the design and the framework conditions affect them.

6.2. Synthesis of empirical study 2 on the impacts of different ecological and social components of a river restoration project

The study "Inner city river restoration projects: the role of project components for acceptance"(Weiß, Schilling, & Frör) focuses on river restoration. It shows a high acceptance of the overall restoration project (75%) as well as its ecological and social components (72% - 92%). Of the four components that make up the project, acceptance of the natural stream section is the highest. 58% of respondents accept all components, 25% reject a single component, and only 3% reject all components. Most respondents (74%) who reject the overall project also reject the central measure of the project, while complementary components are accepted by the majority. The analysis demonstrates that acceptance can be explained in terms of people's concerns, perception of communication about the project, people's attachment to the affected area, and socio-demographic factors; which factors are significant is not consistent across the different components. Rejection relating to the reopening in the spa garden was linked to concerns that the measure would lead to increased flood risk and that the cost was too high, as well as to knowledge about the project, dissatisfaction with communication, desire for no change, and a higher age. Only the expectation of increased flood risks led to a rejection of the natural stream section. Both the expectation of increased noise levels and the desire for no change led to a rejection of the reopening with redesign of parking lot, while the expectation of increased noise and trash, higher cost, and an older age made respondents more likely to reject the playground.

Not surprisingly, the results show that the number of relevant impacts increases with the number of components. What is interesting is the clear differences between the ecological and social components, as well as between the two ecological and social components studied. It appears like most of the relevant costs are associated with the central ecological measure. Complementary measures seem to be less controversial, and the results of the study thus support the expectation that they have a positive impact on the acceptance of the overall project (Linnenweber & Finsterbusch, 2015). Whether this is widely applicable, however, must be verified by further studies.

In addition to the significant costs, it can be assumed that the other concerns that respondents considered to be relevant also have an influence on the added value of a project. The finding that these concerns did not influence acceptance may be related to timing; some of them occur during the construction phase and may be considered irrelevant overall due to their temporary nature.

There are also differences between the components with regard to individual costs. For example, the acceptance of the reopening in the spa garden depends on people's attachment to the area. This is not

the case for the playground, even though both measures are planned at the same location. There are also differences in the degree of importance of individual costs. For example, the concern that flood protection will decrease has a much higher importance for the acceptance of the natural stream section than for the reopening in the spa garden. It must be noted that this is a fictitious cost, since the project actually improves flood protection. However, the study cannot answer why single impacts of measures are perceived differently. Further studies will need to examine the third scale of river restoration projects more closely in order to uncover these interrelationships.

The component-specific differences highlight how important it is for planners to take the individual parts of a project into account and to treat them individually, especially with regard to fictitious impacts. The identification of costs can be taken forward to future projects, whether through careful design of the project or through the active dissemination of information. The consideration of the socio-demographic characteristics of the respondents facilitates transferring the results to other scenarios with matching framework conditions.

The particular phase during which the project was examined provides a rare insight into the processes or framework conditions that take place in the background of the implementation of a project. The results indicate that the way in which information about a project is communicated is a decisive factor, while participation does not seem to be of great importance. The important role of communication is not surprising, as communication affects people's trust in decision-makers and the fairness associated with the project (Becker, Klagge, & Naumann, 2021). The importance of information, however, draws attention to the dependency of the added value of a project on this framework. A project can be of great benefit, but if the information about the project is poor, the perceived value of the project can still be negative. The insignificance of participation may not surprise, as, often, only few people participate in such events.

With respect to the concrete added value of the project, the explanatory power of the study is rather low. This is due to the focus of the study. However, since the factors that determine acceptance largely coincide with those that determine added value, one could infer the value of the project from its acceptance. This argument is based on the logic that people who accept a project also accept its costs and, therefore, have a willingness to pay that corresponds with the project costs. However, this would only describe people's minimum willingness to pay, as it is not known whether they would have accepted higher costs. Following this line of reasoning, the study not only provides information on several real and fictitious impacts of ecological and social components of a river restoration project that are perceived as costs, but also a concrete assessment of the value of the project.

Finally, the information on different impacts as well as the concrete differences regarding individual impacts can help to design future projects more efficiently. However, further research is needed to verify the effects shown, to investigate the perception of further impacts of river restoration projects and their interrelationships, and ultimately to quantify the added value of such projects.

6.3. Synthesis of empirical study 3 on aesthetic preferences of semi-natural habitats

The study “What determines preferences for semi-natural habitats in agrarian landscapes? A choice-modelling approach across two countries using attributes characterising vegetation” (Schüpbach, Weiß, Jeanneret, Zalai, Szalai, Frör & 2021) focuses on the aesthetics of different landscapes. It shows that semi-natural habitat in the form of hedges or meadows can have both positive and negative effects on the perceived aesthetics of the landscape; the effect ultimately depends on the design. Specifically, the results show that respondents' preferences for the aesthetics of a landscape depend on whether it contains colors, the amount of green vegetation, the degree of order in the landscape, the amount of areas without vegetation, and presence of woody and grassy elements. A high

proportion of green, as well as a high degree of order and the presence of woody elements have a positive effect on aesthetics. A high proportion of areas without vegetation and the presence of grassy elements have a negative effect. However, there are differences between the two countries studied. The presence of color, the order of the landscape, the proportion of green areas and the presence of woody elements have a positive effect on aesthetics in both Switzerland and Hungary. Whereas the presence of grassy elements only has a negative effect in Hungary, and a high proportion of areas without vegetation only in Switzerland, whereby this attribute was also only taken into account in Switzerland. Furthermore, the results show that the groups of similar preferences identified by the latent class models differ with respect to the socio-demographic variables.

Due to the focus of the study on perceived aesthetics, the results do not include any further impacts and also no statement on the added value of the semi-natural habitats. However, the results show that the details of the project are very important when it comes to identifying efficient biodiversity conservation projects. Semi-natural habitats do not, per se, have a benefit for the population simply because they are perceived to be aesthetic. Rather, a benefit depends on how natural habitats are designed and, therefore, depends on species, flowers, the amount of visible open soil, and the tidiness of the structures of a landscape.

There are also some trade-offs between aesthetic aspects and biodiversity that need to be taken into account by decision-makers. A potential conflict with biodiversity objectives could be due to people's preference for relatively ordered and homogeneous elements, while patchy hedges and structural diversity are generally more valuable for biodiversity (Graham, Gaulton, Gerard, & Staley, 2018). Another conflict is the preference for a small amount of open soil, as this is an important factor for (insect) biodiversity (Holland et al., 2016; Jeanneret et al., 2016).

This study is unique in that it covers a wide range of seasonal, climatic, geological, pedological, and social conditions and also takes into account the differences in aesthetics that result from these framework conditions. Whether and on the basis of which characteristics a landscape is perceived to be aesthetic can differ significantly between seasons. This is particularly relevant for plants that only flower for a limited period of time. Season, consequently, determines the presence of color from flowers in the pictures. The proportion of green areas also varies throughout the year. While for some plants, the intensity and shade of colors vary throughout the year, some plants wilt during the yearand lose their color altogether. In addition, the area covered by green vegetation increases during the year due to plant growth. Since the added value of a project in terms of aesthetics depends on the perception of its characteristics, it is therefore important to take these differences into account as well. The results also show that the preferences for the characteristics also depend on socio-demographic variables. The results of the study show differences both between groups of people with the same preferences in a country and between countries. The preference heterogeneity within the population of a country but also between countries should therefore also be taken into account in a later assessment of the added value of a project.

In contrast to the two other studies, it can be assumed that provision of information does not play a special role in the determination of preferences, since on the one hand respondents were not presented with a hypothetical project scenario or a concrete project in advance, but were only asked to judge different images in terms of their aesthetics. On the other hand, it can be assumed that individual aesthetic preferences are not shaped by direct information, but rather by previous experiences. It can therefore be assumed that the preferences determined in this study are transferable to other projects with regard to this framework condition.

6.4. Synthesis of methodological implications

The three studies demonstrate that it is, in principle, possible to collect information on several scales with individual studies. However, there is currently no known evaluation method available that can examine all scales at the same time. CVM and CE can determine the added value of a project, i.e. the top scale. CE is able to determine the preferences relating to different characteristics of a project and, thus, can identify the added value of different project variants, i.e. explore the middle scale. And finally, as this work shows, CE can even be used to examine the bottom scale of a project and thus the interrelationships between individual impacts and the project with its framework conditions.

However, study 3 has also demonstrated that the interrelationships that need to be considered with regard to the third scale are so complex that it is unlikely to identify a realistic payment scenario that would allow a simultaneous valuation of the added value. Whether a monetary valuation of the third scale of projects would be useful at all can generally be questioned, as such a valuation is always associated with methodological problems and can therefore falsify the results of people's preferences (Johnston et al., 2017). It is the hypothetical nature of CVM and CE, which is necessary for a monetary valuation, that limits these methods in terms of their ability to analyze the impacts and interrelationships of a project. A hypothetical evaluation scenario does not allow capturing the impact of real information provision or people's participation in a project. This is problematic because both have value due to their importance for perceived procedural and distributive justice, but also because they significantly influence the perception of all other impacts of a project.

Alternative approaches such as measuring the acceptance of a project and the associated factors, which do not focus on the monetary value of a project (as done in study 2), offer the possibility to analyze real projects in terms of their impact at different points in time. From this, one can gain valuable insights into real projects by capturing the impacts and correlations with regard to the information provided about and participation in a project. Further studies must clarify whether the preferences determined in this way correspond to the preferences assessed by CE.

A transferability of results between the measurement of acceptance and CE would open up new possibilities regarding the evaluation of existing projects and the consideration of different phases of a project, due to the great similarity of the factors. In terms of transferability, there are many questions that need to be clarified: If the added value of a project is positive for one person, is it automatically accepted by that person? Are the factors that have a significant influence on the acceptance of a project also the factors that are associated with the greatest utility changes for people? What is the role of the factors that do not have a significant influence on acceptance for the added value? What is the value of the factors that do not have a significant influence on the acceptance on the added value? In order to address these open questions, a combination of methodological approaches to one project appears essential. This would then simultaneously examine acceptance and added value while taking into account the same selection of factors.

7. Conclusion and Outlook

In order to identify the most efficient projects that protect biodiversity and assist a return towards a reality within our planetary boundaries, information is needed on the different scales of all subsections of biodiversity conservation. Such information is needed for the biodiversity protection of floodplains, rivers, and agriculture alike. The three studies presented in this thesis provide specific information that helps to optimize protection projects in the respective areas, but they also indicate that the results obtained represent only a small part of the necessary information.

The first study “Assessing the trade-offs in more nature-friendly mosquito control in the Upper Rhine region” (Weiß, Allgeier, Brühl, & Frör, to be published), for example, shows that a more nature-friendly mosquito control that stops the application of Bti in areas of particular value to nature, but maintains protection against nuisance within localities has a high value for the population. The study also points to how expensive individual components of the measures may be in order for such a project to have added value. As it can be assumed that a stop of Bti treatment does not cause any financial costs, the determined willingness to pay describes, above all, the maximum costs that the protection of settlements should cause. Further studies must clarify the preferences people have for specific impacts associated with nature-friendly mosquito control. Similarly, further studies need to explore how exactly individual impacts are related to the design or concrete solution for both, the protection of floodplain biodiversity, the protection of people from nuisance, and the different framework conditions.

The second study "Inner city river restoration projects: the role of project components for acceptance” (Weiß, Schilling, & Frör, to be published), in turn, demonstrates that the costs that people associate with a river restoration project do not necessarily have to be real and that perceived costs can differ significantly between different ecological and social project components. Furthermore, the results of the study stress the importance of information provision. Information determines which effects of a project are perceived at all. They themselves have an effect on the perceived justice and therefore also influence the added value and the acceptance of a project directly. The identified costs and differences between the components of the project allow for a more targeted planning and optimization of similar projects in the future. However, further analyses must explore what further costs but also, what benefits are associated with such a project. Likewise, further studies must examine how the preferences of the people with regard to specific impacts are linked to the design of the project and its framework conditions and, above all, whether such a project has an added value for the people at all.

The third study “What determines preferences for semi-natural habitats in agrarian landscapes? A choice-modelling approach across two countries using attributes characterizing vegetation“ (Schüpbach, Weiß, Jeanneret, Zalai, Szalai, & Frör 2021) reveals how people's aesthetic preferences are related to the design of a biodiversity protection project in the agricultural sector and to different framework conditions. The stated preferences of people show how measures have to be designed in order to be seen as aesthetic. On this basis future projects can be optimized with regard to their aesthetic value. The results expose preference heterogeneity with regard to the aesthetic perception of the characteristics of the biodiversity measures. They highlight that the preferences depend, above all, on seasonal variations. The value of the characteristics that determine the aesthetics of a landscape need to be addressed in further studies. Here, seasonal differences and preference heterogeneity, both within individual countries and between them, should also be taken into account. Likewise, with regard to the investigated semi-natural habitats, further characteristics that might explain remaining open questions regarding the aesthetic preferences for woody structures need to be examined. The relevance of the characteristics for other ecosystems, such as forests, also need to be investigated in

order to uncover general correlations with regard to people's aesthetic preferences. Finally, further studies need to examine additional impacts associated with such projects and the tradeoffs that need to be considered with respect to the added value.

In order to identify the most efficient biodiversity protection projects, numerous analyses of the different scales of a project are needed. Whether a specific project to protect biodiversity has more advantages than disadvantages for people can only be determined by analyzing its added value. Knowledge about the added value of a project helps to assess whether a project makes sense at all, but it is of little help when the goal is to identify the most efficient solution. Accordingly, it is necessary to understand the costs and benefits (impacts) associated with a project. Only knowledge about the interrelationships between the design of a project, its framework conditions, and impacts enables truly targeted planning and thus optimization.

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Hiermit erkläre ich, dass ich die eingereichte Dissertation selbstständig verfasst habe und alle von mir für die Arbeit benutzten Hilfsmittel und Quellen in der Arbeit angegeben sowie die Anteile etwaig beteiligter Mitarbeiterinnen oder Mitarbeiter sowie anderer Autorinnen oder Autoren klar gekennzeichnet sind. Bei der Erstellung der Arbeit wurde keine entgeltliche Hilfe von Vermittlungs- oder Beratungsdiensten (Promotionsberater oder andere Personen) in Anspruch genommen. Die Dissertation wurde nicht in gleicher oder ähnlicher Form als Prüfungsarbeit für eine staatliche oder andere wissenschaftliche Prüfung im In- oder Ausland eingereicht. Auch wurde die gleiche oder eine andere Abhandlung nicht in einem anderen Fachbereich oder einer anderen wissenschaftlichen Hochschule als Dissertation eingereicht. Mir ist bewusst, dass ein Verstoß gegen einen der vorgenannten Punkte den Entzug des Doktortitels bedeuten und ggf. auch weitere rechtliche Konsequenzen haben kann.

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