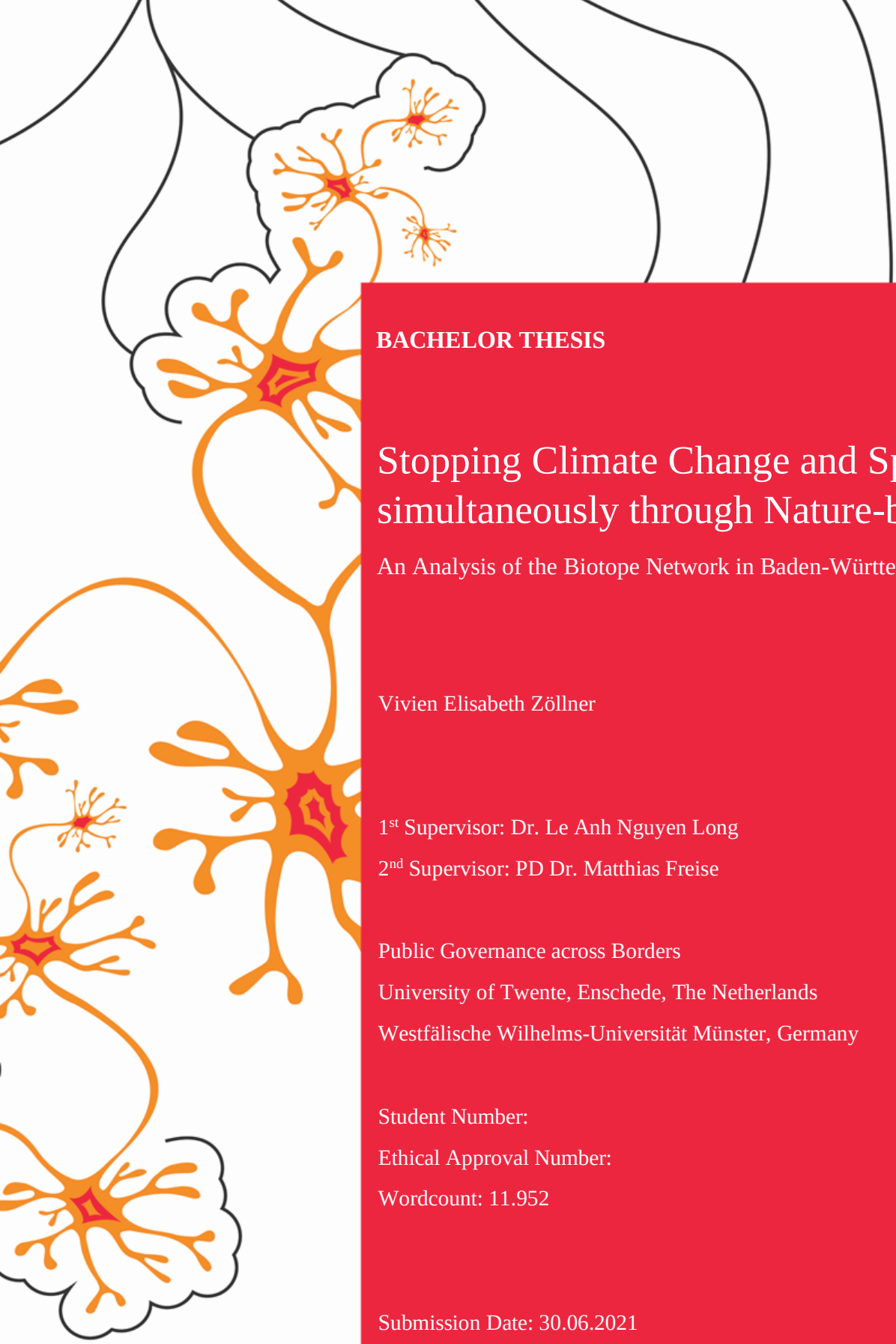

Westfälische Wilhelms-Universität Münster

BACHELOR THESIS

Stopping Climate Change and Species Extinction simultaneously through Nature-based Solutions

An Analysis of the Biotope Network in Baden-Württemberg

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Declaration of Academic Integrity

I hereby confirm that the presented thesis:

Stopping Climate Change and Species Extinction simultaneously through Nature-based Solutions - An Analysis of the Biotope Network in Baden-Württemberg

is the result of my own independent scholarly work, and that in all cases material from the work of others (in books, articles, essays, dissertations, and on the internet) is acknowledged, and quotations and paraphrases are clearly indicated. No material other than that listed has been used.

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Abstract

Nature-based solutions are a topic of increasing attention worldwide, as they are proposed to generate environmental, social, and economic benefits simultaneously. However, its actual capabilities have not yet been fully explored, as the idea of this policy instrument is still relatively new. Using the biotope network in Baden-Württemberg as a case study, this paper aims to determine whether nature-based solutions are effective. For this purpose, the thesis focuses on the following research question: "*To what extent does the Biotope Network in Baden-Württemberg generate environmental, social, and economic impacts?*" Findings derived from expert interviews and analysed documents suggest the successful functioning of the biotope network as a nature-based solution. The network provides environmental services such as CO_2 storage and biodiversity protection. By linking habitats, the biotope network creates a near-natural and resilient landscape that increases the recreational value for people. It also contributes to the quality of life and thus improves people' health. In addition, the network has an impact on the economy by creating new jobs through its expansion. In the long term, the biotope network maintains essential ecosystem services by preserving the water storage capacity of ecosystems and increasing pollination services. It was observed that the network primarily provides environmental benefits but further positively influences the economy. The biotope network has relatively lower social values compared to those mentioned before.

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List of Abbreviations

BfN	Bundesamt für Naturschutz
BUND	Bund für Umwelt und Naturschutz Deutschland
CO_2	Carbon Dioxide
EC	European Commission
EU	European Union
GI	Green Infrastructure
IPCC	Intergovernmental Panel on Climate Change
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
LUBW	Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg
NABU	Naturschutzbund Deutschland
NBS	Nature-based Solutions
NGO	Non-Governmental Organisation
RQ	Research Question
SDGs	Social Development Goals
SRQ	Sub-Research Question
UN	United Nations
UTC	Urban Transformative Capacity

1 Introduction

"*Climate change is the single greatest threat to a sustainable future but, at the same time, addressing the climate challenge presents a golden opportunity to promote prosperity, security and a brighter future for all*" (Ban Ki-Moon, 2014). At the 2014 United Nations Conference, Ban Ki-Moon, the former UN Secretary-General, urged all governments to address the challenges of climate change. He also pointed out that if humanity did not act now, the costs of climate change to society, the economy and the environment would rise to unbearable levels.

1.1 State of the Art

Humankind is currently facing one of its greatest challenges since its existence – climate change. It threatens both flora and fauna due to increasing biodiversity loss and shows a tendency to change our society permanently (European Commission, 2021). Scientists expect unpredictable weather swings, unstable weather forecasts, heatwaves, and droughts, as well as heavy rainfall – including in Central Europe. In addition, the growing population is causing cities to continue to grow, more land is being sealed every day, and important ecosystems are being destroyed (IPBES, 2019) Therefore, there is a need for innovative, new solutions that can cut across social, political, and economic boundaries to generate the behavioural and institutional changes necessary for averting a possible climate crisis.

In accordance with the world's leading climate scientists, the European Commission (EC) agrees that human activities are the leading cause of global warming (European Commission, 2021). To prevent or curb a further rise in global temperatures, many countries came together in 2015 at the Paris Climate Conference and ratified a key points plan – the Paris Agreement. It sets out a global framework for combating climate change: global warming is to be kept well below 2°C; the temperature rise is to be limited to 1.5°C by further measures. Since its ratification, numerous EU directives have been adopted, and legal texts have been adapted to encourage countries to implement appropriate measures (e.g., the Biodiversity Strategy) (European Commission, 2021).

One of these possible measures are ‘Nature-based Solutions’ (NBS). NBS are multifunctional and aim to address societal challenges, such as climate change, social integration, human health, or species extinction (Faivre et al., 2017). They can provide social, economic, and environmental benefits, including protecting biodiversity, increasing the resilience of cities and landscapes, and promote human well-being, quality of life and health (Marselle et al., 2019). There is growing recognition of the opportunities of implementing and using NBS because the advantages that can be achieved with them to address global and societal challenges have never been more relevant than today, as the European Commission

states (Wild et al., 2020). NBS are currently gaining increased attention because they can simultaneously address the climate crisis and species extinction. Intact ecosystems provide essential habitats for plants and animals as well as they can absorb and store CO_2. Additionally, the Secretary-General of the Climate Convention, Patricia Espinosa, announced that the upcoming climate summit in November 2021 would focus on nature-based solutions. NBS also feature prominently in the IPCC and the IPBES report released in June 2021. The report addresses the importance of the interplay between climate change, the destruction of nature and its social consequences (Krumenacker, 2021).

Another measure to address the Paris Agreement is the program 'Green Infrastructure'. Green Infrastructure (GI) is a strategically planned, spatially located network designed to link valuable natural and semi-natural areas with other landscape elements to provide a wide range of ecosystem services in both urban and rural areas. GI is based on the idea that maintaining and enhancing ecosystems and their services are essential for a country's development. It aims to secure and improve the environment for humans efficiently through a network of near-natural areas and conserve biodiversity simultaneously through the conservation and restoration of ecosystem services and thus the protection of natural capital. Those are goods and services of nature and landscape, i.e., of biological diversity, soil, water, climate, air, as well as their interactions (European Commission, 2014). In Germany, the project Federal Defragmentation Program (Bundesprogramm Wiedervernetzung), launched in 2012, is part of the GI framework. It aims to reconnect habitat corridors for flora and fauna to facilitate the rehabilitation of a national biotope network. There are already many positive examples that show that implementing a biotope network system for dry, wet and forest habitats in the area is possible in different ways within the framework of projects (European Commission, 2014).

One of these projects is the Biotope Network in Baden-Württemberg. In the context of this bachelor thesis, it is assumed that the biotope network is a nature-based solution. Therefore, its interest lies in **discovering the network's social, economic, and ecological advantages and disadvantages to determine to what extent the Biotope Network in Baden-Württemberg has the capacity to restore habitats and thus provide society and the economy with multiple benefits that are preserved sustainably**. This is scientifically and socially relevant because it could encourage other countries to expand their biotope networks and increasingly rely on ecosystem services. Furthermore, the benefits and costs of the biotope network as a nature-based solution can show which opportunities and challenges such solutions offer and to what extent science apply this approach to solve social and environmental issues.

1.2 Research Questions

For the thesis, expert interviews and document analysis were conducted to determine which costs and benefits the Biotope Network in Baden-Württemberg has and whether it meets the requirements of a nature-based solution. Therefore, this paper aims to answer the following research question (RQ):

> *To what extent does the Biotope Network in Baden-Württemberg generate environmental, social, and economic impacts?*

The RQ is empirical. Therefore, additional descriptive and explanatory sub-questions are necessary to answer the main question systematically. Thus, the thesis is divided into four sub-questions. The first sub-question shall develop an understanding of NBS and their contributions to different life sectors. It asks, (SRQ1) "*What are nature-based solutions and what are their costs and benefits for society, economy, and the environment?*". The second question will discuss the results of the expert interviews and the document analysis. It is based on this thesis' central findings and asks, (SRQ2) "*Can the Biotope Network provide environmental, social, and economic benefits?*". The third sub-question directly follows and completes the results: (SRQ3) "*Which of these benefits does the Biotope Network seem to provide more of?*". Answering this question is crucial because it leads to the fourth sub-question (SRQ4), namely "*Does the Biotope Network as a nature-based solution fail or does it succeed, and why?*". The answer to this question forms the heart of the thesis and, at the same time, contains social and scientific relevance. It consolidates the results of the first three sub-questions and leads back to the main question.

The sub-questions and their answers divide the paper into sections. The section that follows explains two leading theoretical concepts of nature-based solutions and biotope networks. In the context of the presentation of NBS, the first sub-question is answered. Furthermore, two central terms, resilience and ecosystem services, are defined. The third section introduces the research design and describes the Biotope Network in Baden-Württemberg. Moreover, it explains the case selection and shows how the data was conducted and coded for the analysis. In section four, the data analysis, the findings of the data are presented. Thereby, the biotope network is analysed, and its impacts on the environment, society, and economy are discussed, thus answering the second and third sub-questions. Section five places the analysis results within the theoretical framework of nature-based solutions, answering sub-question four. Furthermore, some limitations of the qualitative research are discussed. The conclusion forms the last section. First, the main research question is answered. Thereupon, possible future research is mentioned, and implications for policymakers are presented.

2 Theoretical Framework

The thesis' central research question is based upon two major theoretical concepts: ‘Nature-based Solutions’ and ‘Biotope Networks’. First, this section defines ecosystem services and resilience before describing biotope networks. Thirdly, it introduces the concept of NBS, their benefits for the environment, society, and the economy, and their costs to address the first Sub-Question, "*What are nature-based solutions, and what are their costs and benefits for society, economy, and the environment?*".

2.1 Definitions

2.1.1 Ecosystem Services

NBS leverage the idea of ecosystem services. They refer to contributions that ecosystems (combined with other inputs) make to human well-being (Faivre et al., 2017). Ecosystems can be essential to well-being, health, livelihood, and survival (Ruskule et al., 2018). In the face of looming climate events like floods and heatwaves, ecosystems have the potential to provide a range of services to reduce the impacts of natural hazards and natural disasters. Protected areas help stabilise soils, store water, prevent desertification and dust storms, and mitigate flood damage (Marselle et al., 2019). They also provide habitats for protected and endangered species, contributing to their conservation (Ruskule et al., 2018). Investing in the protection and restoration of natural habitats can, in some cases, not only reduce disaster risk in the long term but also be more cost-effective than hard or grey infrastructure (Marselle et al., 2019). Nature-Based Solutions bring the concept of ecosystem services into the real world (Faivre et al., 2017), where healthy and biodiverse ecosystems are at their core and key to succeed in delivering positive social, economic, and environmental impacts that enable improved resilience to climate change (Wild et al., 2020). NBS can help to strengthen local ecological and social sustainability and ensure long-term productivity (Maes & Jacobs, 2017).

2.1.2 Resilience

The concept of resilience is multidisciplinary. It has various definitions in environmental, social, and other sciences (Oliver et al., 2015). Walker et al. (2004) describe resilience as " the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks – in other words, stay in the same basin of attraction" (p. 2). In ecology, the concept of resilience is applied to ecosystems that can maintain their functions during significant stresses and unpredictable change. Particular attention is paid to their recovery and capacity to withstand environmental degradation and recover quickly through internal reorganisation, also called adaptive capacity. Resilience refers primarily to the stability of ecosystems and the constancy

of their ecosystem services (Oliver et al., 2015). As described below, one of the central goals of NBS is to generate resilient ecosystems.

2.2 Biotope Networks

Biotopes are habitats for plants and animals. A biotope network is thus the spatial exchange between habitats that are not necessarily close to each other. It allows plants and animal species to move between the individual sub-areas or biotopes so that biodiversity is maintained or promoted in the area under consideration (Jedicke, 1994). This includes both the preservation and development of core areas, such as large, protected areas and the development of suitable habitats as links between populations of individual species (BUND, 2018). Three different components of a biotope network system can be distinguished: (1) core areas as stable, permanent habitats, (2) connecting elements as areas that should "ensure or facilitate genetic exchange among the populations of animals and plants of the core areas, as well as migration, dispersal and re-colonisation processes" (BfN, 2021) (e.g., through steppingstones or corridors), and (3) the surrounding landscape matrix, which should become less hostile to organisms and thus more continuous (BfN, 2021).

The concept of biotope connectivity is not new to nature conservation. Behind this approach is the recognition, based on the island theory of the 1960s, that the conversion of near-natural areas and the associated fragmentation and urban sprawl of the natural regions is one of the leading causes of the decline in biodiversity (LUBW, 2017). Many valuable biotopes have been lost due to changes in land use, building development, and the fragmentation of the landscape by roads, railroads, or routes. The number of animals in fields and meadows is declining because fertilisers and chemicals against pests have increased in recent decades (LUBW, 2014). As settlements become denser and the road network expands, only a significantly reduced area remains where flora and fauna can live undisturbed. As a result, biotopes are broken down into isolated individual parts that are particularly exposed to disturbing influences from the environment due to their small size (BfN, 2021).

However, since most animals do not stay in one place for their entire lives as their food supply, mates and shelters are found in different areas, they must migrate. Animals encounter many hazards when moving from one biotope to another; sometimes roads hinder them, sometimes whole settlements, or fields of monocultures, like cornfields, are to be crossed, which can be a deadly trap. Therefore, such island biotopes are a threat to biodiversity (BUND, 2018). The resulting genetic impoverishment of fauna and flora threatens the long-term survival of communities and leads to a loss of biodiversity. To counter this development, habitats must be preserved, enlarged, and improved (LUBW, 2014). More wild-flowering herbs and perennials on fields, meadows, and unused fields, as well as the connection of habitats, can help to create a green net in the landscape – the biotope network (Figure 1). For interspecies

exchanges, especially between gene poles of a species, wide green margins along trails, forests, roads, and crossing opportunities for highways and railroads can be valuable solutions. It is also essential to create networks of rivers and lakes with surrounding green areas and forests. A crucial factor is to link biotopes and nature reserves (BUND, 2018).

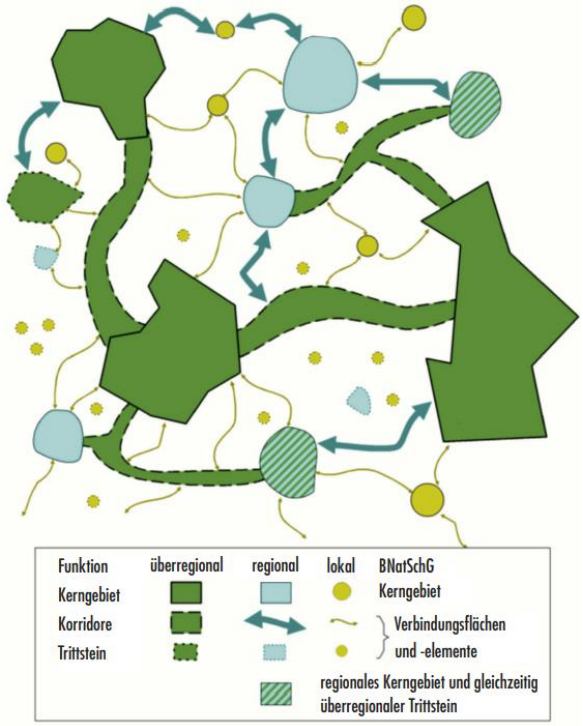

Figure 1: Schematic Representation of Complementary Biotope Network Systems at Different Spatial Scales (Riecken et al., 2004)

2.3 Nature-Based Solutions: A Brief Introduction

The term ‘Nature-based Solutions’ has different meanings in different parts of the world. This occurs because NBS are multifunctional (Frantzeskaki, 2019) and provide social, economic, and environmental benefits. In Appendix 6 (8.6), a brief distinction of NBS from other nature-using solutions can be found. For this thesis, I adopt the definition of NBS formulated by the European Commission, which describes it as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient and systemic interventions" (Wild et al., 2020, p. 3). More generally, NBS can be used to target societal challenges such as climate change, social inclusion, and human health (Faivre et al., 2017). It has been proposed that NBS can mitigate

biodiversity loss, increase the resilience of cities and landscapes, and promote human well-being, quality of life, and health (Marselle et al., 2019; Wild et al., 2020).

There is a growing recognition in the public sphere of the opportunities to implement and use nature-based solutions as alternatives to traditional 'grey' solutions. Publications on NBS have increased six-fold in the last five years. The EC has also recognised the value of these solutions, stating that "[t]he benefits and opportunities achievable using Nature-based Solutions (NBS) to address global and societal challenges have never been more relevant, important or urgently needed than now" (Wild et al., 2020, p. 3). NBS offer an excellent opportunity to solve existing and emerging societal challenges. They are considered durable and tangible opportunities that leverage and enhance the attributes and services of natural ecosystems (Marselle et al., 2019) "to deliver sustainable, cost-effective, multi-purpose and flexible alternatives to address societal challenges" (Wild et al., 2020, p. 5).

The Federal Government of Germany divides NBS into two categories with different complementary objectives: climate change mitigation on the one hand and adaptation to climate change on the other hand. Nature-based climate protection aims to use the services of ecosystems to reduce greenhouse gas emissions by conserving and expanding natural carbon sinks. Nature-based adaptation to climate change aims to make ecosystems more resilient to climate change. This will allow them to continue to provide essential services to society and mitigate the negative impacts of climate change on humans, such as more rainfall, more frequent floods, heatwaves, and droughts (EU, 2021). These goals are to be achieved by maintaining the functionality of ecosystems, ensuring their long-term usability, and increasing their resilience using various measures that contribute to the protection and renaturation of ecosystems and their sustainable use (Naumann & Kaphengst, 2015).

2.3.1 Benefits of Nature-based Solutions

Nature-based solutions are associated with various benefits ranging from increasing air quality, human well-being, and health via conserving biodiversity, mitigating, and adapting to climate change. Since I assume for the thesis that the Biotope Network in Baden-Württemberg represents an NBS, but it is unclear which of the mentioned effects the network has, it is crucial to describe the different benefits of nature-based solutions. This section will explain the impacts of NBS regarding ecological, social, and economic goals. I will use this explanation to explore SRQ 1 about the nature of NBS.

2.3.1.1 Ecological Benefits

The primary objective of nature-based solutions is the conservation and enhancement of biodiversity. Decades ago, the EU introduced the EU Birds and Habitats Directives in response to biodiversity loss. These directives form the legislative basis of European biodiversity and habitat protection and have

established an extensive network of protected areas, the Natura 2000 network. It is one of the core elements of the European Green Infrastructure and currently (as of 2020) covers 18% of the EU's terrestrial and 9% of its marine areas (Wild et al., 2020). “NBS can contribute to the connectivity of the network and support its management to better achieve conservation goals” (Wild et al., 2020, p. 37). It may be possible to halt species extinction through reforestation, restoration of wetlands, expansion of protection and renaturation zones, or reconnection (Faivre et al., 2017; Naumann & Kaphengst, 2015; Wild et al., 2020).

Reconnection means establishing connectivity between ecosystems, which can be achieved by creating green bridges over highways, fish migration aids along dammed river courses, or green corridors to biotopes further apart. Such measures are essential to enable climate change-induced range shifts and genetic exchange within species (Naumann & Kaphengst, 2015). To avoid being stopped by roads or settlements in the process, green corridors help creatures to migrate into more suitable areas. Green corridors are a nature-based solution that can also be created in urban areas (Faivre et al., 2017). Habitat reconnection also conditions the genetic exchange of many species. Due to the fragmentation of the landscape by, for example, the dense transport network in Europe, it is difficult for many species to penetrate areas where unknown conspecifics are native and to exchange their genes there. This results in the genetic impoverishment and islanding of many populations (BUND, 2018). NBS are intended to address this issue precisely. They aim to improve ecological conditions, halt biodiversity loss by increasingly protecting ecosystems and landscapes, and improve functional and structural connectivity by expanding the Natura 2000 network in urban and rural areas (Wild et al., 2020).

In addition, NBS offer the opportunity to “reduce CO2 emissions or remove CO2 from the atmosphere” (Wild et al., 2020, p. 17). Thus, reforestation and forest conservation are among the most effective solutions to mitigate climate change. For example, Pérez-Soba et al. (2016) found that existing forests in Europe can sequester carbon equivalent to up to 13% of total EU greenhouse gas emissions from fossil fuel combustion. Other ecosystems “with a high potential to sequester CO_2 [are] wetlands, grasslands, peatlands, and biodiverse forests” (Wild et al., 2020, p. 38). Therefore, these ecosystems play a role in carbon storage and sequestration and support the EU in achieving global climate targets (Wild et al., 2020).

2.3.1.2 Social Benefits

Nature-based solutions offer multiple benefits to society. Climate change results in rising temperatures that will be most felt in cities due to sealed floors, heating systems, traffic, and reduced turbulences. Extreme temperatures can lead to heat shocks, mainly affecting children and the elderly (Wild et al., 2020). Nature-based solutions in green spaces such as parks, allotments, urban forests, street trees, green roofs and facades, and blue infrastructures such as rivers and ponds mitigate high temperatures in

cities. They contribute to shading (through trees), evaporative cooling (through rivers) and can also reduce levels of air pollution and noise (Marselle et al., 2019; Wild et al., 2020). Parks and urban forests also positively impact water supply and reduce infections from contaminated drinking water (Wild et al., 2020). In addition, the World Health Organization estimates that up to a quarter of all deaths worldwide could be prevented through better management of environmental problems such as air pollution, water contamination, and dust reduction from drylands (Marselle et al., 2019).

More numerous and diverse green spaces have the potential to restore the connection between people and nature and manifest values such as connectedness with nature, community experiences, knowledge and awareness of our place on the planet, and meaningfulness in life. Nature-based solutions can connect green spaces in urban and suburban areas to create new space for pedestrians and cyclists. This could subsequently help to reduce car use and to reduce associated emissions. More diverse ecosystems can also boost tourism and, through intelligent outreach by municipalities, ensure that green cities and natural landscapes become tourist magnets (Wild et al., 2020) while providing habitats for various species and supporting conservation goals (Marselle et al., 2019). They can also improve quality of life, including "physical health, psychological state, personal beliefs, social relationships" (Wild et al., 2020, p. 168), and relationship with the environment. Experiences with nature can increase engagement and acceptance of conservation activities, thereby contributing significantly to protecting our livelihoods on Earth (Wild et al., 2020).

Lack of access to nature can cause "physical and mental health disorders including vitamin D deficiency, asthma, anxiety and depression" (Marselle et al., 2019, p. 365). Conversely, increased access to nature has been shown to reduce "stress, depression and negative emotions" and increase "positive emotions, mental well-being, cognitive abilities and increasing physical activity" (Marselle et al., 2019, p. 3). In addition, the COVID-19 crisis in 2020/21 points to the possibility that ecosystem destruction and exploitation of other species may contribute to infectious disease outbreaks. Committed biodiversity conservation at the global level can counteract this trend and help prevent new outbreaks (Wild et al., 2020).

2.3.1.3 Economic Benefits

Most nature-solutions are not primarily designed to deliver financial benefits. Nevertheless, NBS have been shown to have both direct and indirect, and especially long-term, impacts on the economy. Immediate benefits are mainly socio-economic impacts such as newly created jobs. As already mentioned in the social benefits section, NBS can be tourism magnets and enable new fields of employment, especially in tourism and gastronomy (Maes & Jacobs, 2017; Naumann & Kaphengst, 2015). In addition, new areas of work are created primarily through the planning, construction, and maintenance of

projects. The management and care of land outside cities are often taken over by farmers, providing them with an increasingly secure source of income (Naumann & Kaphengst, 2015; Wild et al., 2020).

The number of indirect, long-term benefits significantly exceeds the direct impacts. However, they are difficult to quantify. For example, "NBS are also essential to enable sustainable agriculture production systems" (Wild et al., 2020, p. 39). Such nature-based farming practices benefit both farmers – including "improved resource efficiency and resilience to climate impacts" (Wild et al., 2020, p. 39) – and nature – such as meeting climate change targets, protecting biodiversity, and managing soil and water. In the long term, such production systems make sense financially for farmers. However, short-term costs and risks must be overcome first (Wild et al., 2020).

NBS can be critical in finding ways to cool cities. For example, tree planting contributes to shading; green roofs and green facades contribute to transpiration. Incident solar radiation and heat energy emitted from surfaces are reduced, and water transpired by plants helps cool air temperatures. This contributes to significant energy savings and results in indirect CO_2 savings, which means economic savings and contributes to achieving climate targets (Wild et al., 2020). In addition, urban greenery also contributes to improving air quality, which can lead to financial savings in the health system (Marselle et al., 2019; Wild et al., 2020).

2.3.1.4 Assessing Nature-based Solutions

Solutions created for the environment or to mitigate climate change are often contrasted with the economy or people. It is often argued that standing up for the climate is too costly, and more impoverished people would suffer the most. Examples of this are the coal phase-out in Germany by 2038, which will cause many people to lose their jobs and impoverish whole regions because the only major employer will disappear (Döschner, 2021). Petrol prices are to be increased to make people drive less, to the detriment of commuters (Bartlitz, 2020). Organic products and meat substitutes are often more expensive than their non-sustainable counterparts (BR24, 2021).

Nature-based solutions, however, take a different approach. The reasoning and hope behind NBS are that they are supposed to create a trifecta of benefits, i.e., for people, the planet, and profit. As mentioned above, the services that NBS can deliver are numerous and splendid. However, since the idea behind nature-based solutions is still new and has been implemented rather selectively so far, their benefits have yet to be empirically substantiated. This gap is to be closed a little further with the help of this thesis. The aim here is to validate which services NBS can provide and look at a concrete case study to see which of the three pillars - society, environment, economy - was considered most dominantly in the implementation and for which the most benefits are actually provided.

2.3.2 Costs of Nature-based Solutions

NBS' ability to yield the benefits mentioned above is still unclear. NBS is a novel approach, and substantial study has yet to be done to substantiate current claims about the benefits of NBS. Therefore, SRQ1 not only asks about the benefits of NBS but also about their costs. To begin with, NBS are not without its challenges. The main ones are conflicting goals or land use, a lack of resources like knowledge and money, and the difficulty of measuring the effects of NBS.

Probably the biggest challenge is that the benefits of NBS usually only become apparent in the long term. In addition, monetary benefits often cannot be measured directly in numbers. Therefore, nature-based projects are frequently only evaluated qualitatively, leading to them being underestimated and not given sufficient consideration (Naumann & Kaphengst, 2015). One reason is the lack of sufficiently robust indicators that can assess and replicate the potential of NBS. They are often not predictable in the same way as 'grey' or 'hard' infrastructure, such as flood protection walls. In addition, NBS depend on local conditions such as weather and soil characteristics, which can change over time. The lack of appropriate assessment techniques and models is primarily due to knowledge gaps among key stakeholders and the costs associated with monitoring and evaluating projects. Detailed monitoring occurs only in the context of specific research and implementation projects, as both capacity and expertise are lacking at the local level (Wild et al., 2020).

Furthermore, NBS can trigger conflicting goals or conflicting uses during implementation, meaning that there may be conflicts between climate change mitigation and other purposes for which a compromise must be found. One such trade-off relates to forestry, as "increased management and use of wood product can negatively impact on the potential for forests to store and sequester carbon" (Wild et al., 2020, p. 30). Yet, reforestation and preservation of mixed forests are considered one of the main projects of nature-based solutions. A second trade-off can be found in the agricultural sector. Here, intensive production is opposed to nature conservation (Wild et al., 2020). On the one hand, the growing world population requires the production of more food. And, on the other hand, pesticide usage and monocultures endanger biodiversity and drive species extinction. For example, when farmers are asked to plant flower strips in their fields, this often leads to resistance or lack of acceptance because the area for the flower strips cannot generate income (Naumann & Kaphengst, 2015).

In addition, the development and maintenance of NBS rely on multiple stakeholders, leading to governance challenges. For example, problems can arise due to a lack of knowledge about the costs and benefits of NBS and conflicts over regulatory powers such as planning control and management. Collaborations between business and civil society or staff shortages in technical areas also pose challenges that require leadership capacity to enable and facilitate collective action (Wild et al., 2020).

3 Methodology

The third chapter aims to clarify and justify the methods used to answer the research questions. First, the research design will be explained. Then, the case under investigation in this study will be described, and the selection choice will be further elaborated. The chapter continues by explaining the selection of policy documents and interviewees. Last, it outlines how the selected data will be analysed using the theory-based coding scheme and the coding method by Mayring & Fenzl (2019).

3.1 Research Design

This Bachelor Thesis focuses on a single case – the Biotope Network in Baden-Württemberg – and, hence, uses the case study research design. A case study is an intense study of a specific case. It is a way of defining cases to generalise a single unit or case across a more extensive set of units. The objective is to gain practical, contextualised, in-depth knowledge about a particular real-world issue. It allows the researcher to explore the key features, meanings, and implications of the specific case (Gerring, 2004). Case studies often focus on qualitative data as it applies in the present thesis. In preparation, expert interviews were conducted, coded, and analysed together with policy documents for the analysis. Using those methods is to gain the most powerful possible understanding of the case and its context. The data was coded and systematically analysed for the characteristics of nature-based solutions using qualitative content analysis. NBS are divided into three categories for this thesis - ecological, social, and economic impacts - which are used to analyse the Biotope Network in Baden-Württemberg and discuss how it fits into the framework of the NBS-theory. Furthermore, the paper examines whether the biotope network can strengthen and maintain the region's resilience in the long term. The research design is deductive because the above theories are applied to the data to answer the research questions.

3.2 Case Selection

3.2.1 The Biotope Network in Baden-Württemberg

The Germany-wide biotope network has been anchored in the Federal Nature Conservation Act since 2002. In the latest amendment of July 2009, the corresponding regulation is found in §§ 20 and 21. It states that a biotope network system is to be developed on at least 10% of the country's surface area. It is also intended to improve the linkage of the European system of protected Natura 2000-areas. The concept of the biotope network is further supported by the EU Water Framework Directive, which aims to contribute to improving the status of water bodies, “including dependent terrestrial ecosystems, and their interconnection” (BfN, 2021).

In 2015, Baden-Württemberg incorporated the state-wide biotope network plan - a state-wide technical plan for such a biotope network - into the state's Nature Conservation Act (Section 22 NatSchG). As a result, municipalities must now consider the new law in all planning on an urgent basis. In addition, in 2019, as part of the "Save the Bees" referendum, the state government formulated a critical points paper, which attaches enormous importance to the biotope network to protect and safeguard native animal and plant species. As a result, the Nature Conservation Act was amended, and Baden-Württemberg committed to developing a total of 15 per cent of the state's open land as functional biotope network areas by 2030 (LUBW, 2021).

The goal of the Baden-Württemberg state-wide biotope network is the sustainable protection of native species, species communities and their habitats, and the preservation, restoration, and development of functional, ecological interrelationships in the landscape. The specialist plan for the state-wide biotope network relates mainly to the open countryside, with a particular focus on less mobile species such as insects and amphibians. For the interconnection of forest areas, the already completed specialist planning of the General Game Trail Plan (Generalwildwegeplan) was incorporated into the concept of the state-wide biotope network. The specialist plan for the open land biotope network is divided into three sub-areas (see Figure 3): open land of dry sites, open land of medium sites and open land of wet areas (LUBW, 2014).

The concept distinguishes between three levels for the spatial management of measures for the conservation and development of habitat corridors and the biotope network: the state-wide search areas including the core areas, large-scale interconnected axes in the open countryside, and the wildlife corridors of the General Game Trail Plan Baden-Württemberg (LUBW, 2014).

Figure 2: Example of a Wildlife Corridor (Picture made by Klaus Leidorf)

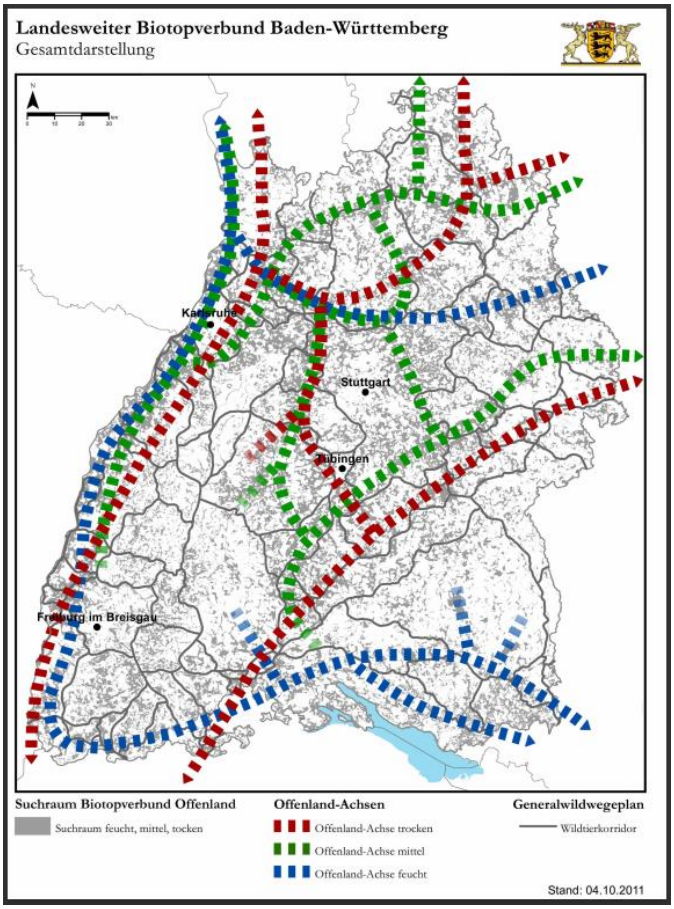

Figure 3: State-wide Biotope Network Baden-Württemberg with the Open Land Axes for Dry (red), Medium (green) and Wet (blue) Sites (LUBW, 2011a)

3.2.2 Case Selection Choice

There are both substantive arguments and practical arguments that justify why I selected the biotope network as a case for the presented Bachelor Thesis. First, the Biotope Network in Baden-Württemberg is a unique case that represents a significant project covering an entire federal state and can be extended across borders, provided that the expected results are achieved. Secondly, Baden-Württemberg has also funded several model projects to advance and study the implementation of the biotope network at various levels. Therefore, many publicly available documents form the core of the analysis. Thirdly, a practical argument is more accessibility to interview partners because I completed an internship at the Bund für Umwelt und Naturschutz (BUND) in Baden-Württemberg and was thus familiar with both the subject matter and the structures and actors of the state.

3.3 Data and Data Collection

3.3.1 Expert Interviews

To answer the question adequately, I conducted three expert interviews within the framework of the bachelor thesis. An expert is a person who has superior and encompassing knowledge or expertise in a well-defined field (Balduf et al., 2011).

I selected the interview partners according to whether they were involved in developing and implementing the biotope network or providing background knowledge that documents do not reflect. Three interviews were conducted. The first interview was conducted with two employees of the State Institute for the Environment of Baden-Württemberg (LUBW). The LUBW published the state-wide plan of the biotope network and other documents used in the analysis. A second interview was conducted with an employee of the state office of the BUND. The BUND has accompanied model municipalities in the implementation of the biotope network and evaluated the project. In addition, the interview with an NGO provides a balance to political authorities. A third interview was conducted with an employee of the Ministry of the Environment. The Ministry of the Environment is mainly involved in the financing and overall organisation of the project. An overview of the interview partners, the date and length of each interview can be found in Appendix 3 (8.3).

The purpose of the semi-structured interviews offers insight into inside opinions and views from the experts about the biotope network that are not available in documents. Each interview lasted between 35 minutes to 1 and a quarter-hour. The interviews were recorded with the consent of the interviewees and later stored on a secure server. I divided the interview questions into five blocks. The first section served to get to know each other. The interview partners could introduce themselves, their organization, and their position, and I could present my thesis. The following sections, two to four, contained questions about the impact of the biotope network on the environment, society, and the economy. The fifth part included questions about transformative capacity. Since it was beyond the scope of this bachelor thesis, I decided not to examine the biotope network for its transformative capacity. The used guideline with the interview questions can be found in Appendix 4 (8.4). I transcribed all interviews and removed word duplications, long pauses, and some filler words to improve the reading flow and facilitate the analysis. The interviews were coded and analysed using the software Atlas.ti. The transcripts can be found in a separate file.

3.3.2 Documents

In addition to conducting the interviews, a document analysis was used as a further method. Publicly available documents on the planning, design and implementation of the biotope network can be

found on the websites of the BUND, the NABU and the LUBW. Papers from a political institution and NGOs were selected to maintain a balance and use opinions from different perspectives, as was already the case with choosing the interview partners. An overview of the documents with title, publisher, date of publication and a link can be found in Appendix 2 (8.2). I also coded the papers for the analysis using Atlas.ti and provided the results in the form of a table in Appendix 1 (8.1).

3.4 Data Operationalization and Data Analysis

According to Mayring & Fenzl (2019), qualitative content analysis is used to analyse the documents and interviews. For this purpose, the data were coded following a coding guide. Both the method of deductive category derivation and inductive category formation are used. For deductive category derivation, a theory-based coding guide was first developed and applied to the documents. While the documents and interviews were coded, the inductive category formation took place. In this process, additional categories were introduced and incorporated into the guide. In addition, key terms were further expanded. Two-phase coding ensures that no keywords are overlooked but also that not too much is coded. The coding guide includes the superordinate category and subcategories provided with key terms, a coding rule, and a respective typical example taken from the data. The coding rules and keywords are used to operationalise the theory, especially the terms ‘environmental impacts’, ‘social impacts’, ‘economic impacts’, and ‘challenges’ of NBS (see Figure 4). The guide is created as a table, which is attached in Appendix 5 (8.5).

Using qualitative research methods, bias may occur. It is possible that I over- or underemphasised information, primarily as I have worked for the BUND. To reduce bias in my Bachelor Thesis, a peer cross-checked my paper. This will also increase the robustness and validity of my study. Furthermore, the peer coded parts of the interviews using my codebook. It appears that both of us coded 70% equally. I rate a two-thirds agreement on coding as good, as coding rules are often subjective, especially if only one coder has developed them. Nevertheless, there is still a lot of inaccuracy that the code development of several researchers could have resolved.

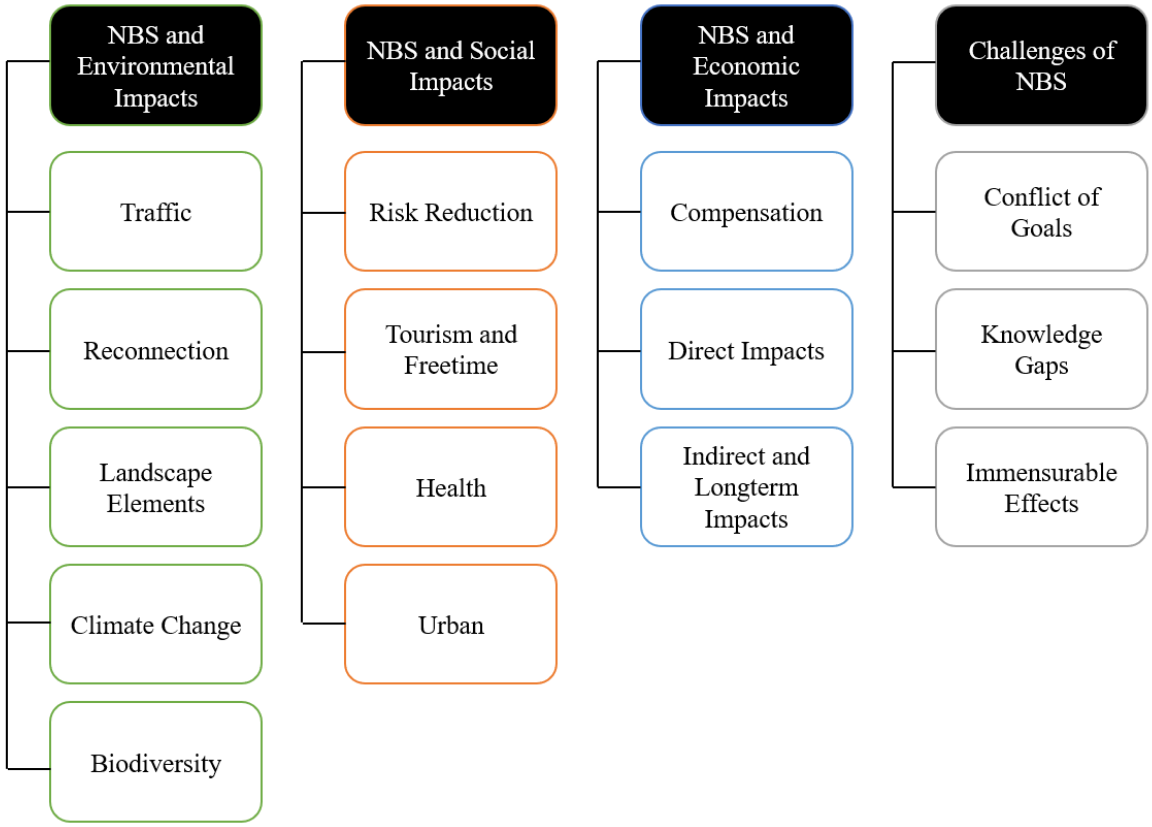

Figure 4: Coding Scheme

4 Data Analysis

The following chapter presents the results and findings from the expert interviews and documents. It is based on a case study analysis, where the case presented is the Biotope Network in Baden-Württemberg. The data analysis aims to determine if the biotope network impacts the environment and shows measurable effects for society and the economy. Thereby, the focus is on answering the second sub-question, "*Can the Biotope Network provide environmental, social, and economic benefits?*". The results are presented in three parts: ecological, social, and economic impacts. Furthermore, SRQ3 will be answered as well: "*Which of these benefits does the Biotope Network seem to provide more of?*". Therefore, a table is presented in Appendix 1 (8.1), listing how frequently codes were found in which interviews and documents.

4.1 Ecological Impacts of the Biotope Network

The following section presents the findings of the effects the biotope network in Baden-Württemberg has on the environment, biodiversity, and climate. The analysis of the data shows that the biotope network can (1) improve biodiversity, (2) help to regenerate habitats, (3) absorb CO_2 from the environment, and (4) helps species by adapting to climate change. However, it is not easy to gauge the actual impacts and successes of measures on biodiversity. There is no precise value for biodiversity and species extinction as there is for the 1.5-degree climate target or CO_2 emissions, so effects remain relatively imprecise (Interview 2).

The theory section explains that biotope networks are designed to link isolated biotopes with each other so that animals and plants are given the chance to spread and migrate despite roads and settlements. The biotope network in Baden-Württemberg was also developed with this aim in mind. An interview partner summarized again why such a network is necessary: "The technical background is that we live in a highly urbanised landscape in Germany and especially in Baden-Württemberg. This means that we have a high pressure of settlement and traffic, which leads to a strongly fragmenting landscape and thus [...] a migration and spreading of species is strongly restricted and this can, of course, lead to a genetic impoverishment and the extinction of species in the medium term" (Interview 1, l. 15 ff., own translation).

Habitat fragmentation and cutting are some of the main threats to animal species in Baden-Württemberg, as the state is one of the most fragmented regions in the world (BUND & NABU, 2012). Through the biotope network, an attempt is being made to **reshape the region** so that animals and plants can cope with the development. Special attention is paid to more minor mobile species, i.e., insects,

amphibians, and reptiles. These often have a dispersal range of no more than 1000 meters (Interview 3). In the model municipality of Nürtingen, flowering strips were planted along roadsides on fields and meadows to improve the connectivity situation for grasshoppers and butterflies (BUND, 2017). Flowering strips are an excellent measure to **stop insect mortality** (Interview 2). Furthermore, such flowering strips have not only positive effects on the insect population but also generate windfall effects for birds or bats. When prey such as insects or seed plants increase, the population of other species also increases (Interview 3). "[T]hrough selective efforts, the food web can already be improved, and many can benefit" (Interview 3, l. 101 ff., own translation).

What many species also benefit from is the **creation of resilience** in the landscape. Resilient ecosystems are threatened primarily by the severe fragmentation of the landscape by roads and fields. Linking multiple biotopes can cause a supposedly disrupted ecosystem to rebuild and remain intact. "And that is basically exactly what we mean by resilience: that ecosystems, despite impairment, despite changes, especially [...] with regard to climate change, [...] adapt and in principle regulate themselves again in their composition [...]" (Interview 2, l. 169 ff., own translation).

However, in general, it is difficult to measure and visualize the positive effects of the biotope network on the environment. Extensively used grasslands and wetlands such as peatlands serve as CO_2 reservoirs, "but that is of course very, very difficult to measure, so research projects are just now getting started." (Interview 1, l. 145 ff., own translation). On its official website, the German government states that intact peatlands cover only three per cent of the world's land area but store twice as much CO_2 as all the world's forests combined (Bundesministerium für Umwelt, 2020). The rewetting, preservation, and protection of peatlands impact the native and rare flora, fauna, and climate (Interview 3). In the context of the "Biotope Network Open Land Wet Sites", the protection of peatland areas is considered crucial. Therefore, it can be assumed that the expansion of the biotope network plays a role in carbon storage and sequestration.

The biotope network also plays a role in the **adaptation of species to climate change** (LUBW, 2014) as one interviewee clarified: “Species that now have deteriorated living conditions in their ancestral habitat, due to temperature increase or decrease in precipitation, [...] can then in principle also migrate further and spread and perhaps defeat more suitable newer habitats [...]" (Interview 1, l. 137 ff., own translation). Thus, biotope connectivity allows species to disperse when local climatic conditions change. They should then find similar conditions elsewhere to settle there (Interview 3).

4.2 Social Impacts of the Biotope Network

Positive effects of the biotope network on the population are mentioned both in the interviews and in the documents. These are (1) touristic use, (2) the increase of quality of life, health and well-being, and (3) the protection against natural disasters.

One document presents some model municipalities and their intention to implement the biotope network. For example, one community in the Swabian Alb was particularly interested in generating **liveable nature for recreationists and tourism** (Interview 1). In another municipality, hiking trails, mountain bike trails, and cross-country ski trail systems were also created to raise the community's popularity. Routes that pass through low-disturbance scenic areas have a unique appeal to recreationists (LUBW, 2017). Interviewees are ambivalent about tourism use of the biotope network, as it is not the goal of the network to increase recreational use (Interview 1). One interviewee notes that steppingstones and corridors would not look very nice, but on the other hand, protected natural areas are often tourist magnets (Interview 2). Another interviewee mentions the importance of a liveable environment and the ability to find recreation in nature in times of a pandemic: "In Corona times, we now have a clear example of how important it is to be able to experience nature in people's living environment" (Interview 1, l. 157 ff., own translation). A diverse and natural landscape is more valuable for people than a monotonous land use such as cornfields (Interview 1). It is of great importance for recreational use that nature is intact and can be experienced in various ways (Interview 2). Many municipalities make use of the biotope network to be able to shape the landscape in new and diverse ways. On the one hand, this strengthens biodiversity, and, on the other hand, people in the surrounding area benefit from a landscape that is close to nature.

However, Interviewee 3 also emphasizes that nature-friendly use should always be in the foreground. Therefore, most biotopes, steppingstones and corridors are only accessible within limits (Interview 1), as too many visitors can cause disturbances or trampling damage. Thus, no improvements for target species can occur (Interview 3). However, to enable people to enjoy nature, educational walking trails are created, for example, as in the model municipality of Nürtingen. As part of the project implementation, the Round Table decided to establish an educational trail on the topic of biotope connectivity to promote the transfer of knowledge about species and biotopes (BUND, 2017).

Through implementing the biotope network, it impacts society by **involving citizens in nature conservation**. Citizen participation is crucial for the acceptance and further expansion of the biotope network. "Society benefits from the fact that it also supports this task of biodiversity conservation and sees that something is happening. You can then also create awareness for the issue and be proud, so to speak, that you have contributed to it" (Interview 3, l. 133 ff., own translation). Interviewee 2 clarifies

that nature conservation has an excellent value for many people and can also increase their **quality of life** by consciously committing themselves to nature. The diversity of species and habitats also directly influences people's quality of life. Vibrant wildlife such as singing birds, flowering meadows, and buzzing insects in the immediate environment is closely linked to **mental health**. Furthermore, nature experiences promote the personality development of children and strengthen the formation of their environmental awareness (LUBW, 2017). One interview partner also discusses the **physical effects** of the biotope network. Climatic changes can also occur in certain areas, such as through shading, which reduces heatwaves and positively affects people's health (Interview 1).

The use of biotope connectivity to specifically **reduce natural disasters** was mentioned by only one interviewee. For example, measures in riparian landscapes could have an impact on reducing flood events. However, he emphasized that this only applies to specific individual elements of the biotope network and is not one of the actual goals (Interview 3).

The state-wide biotope network plan specifies that the biotope network should be implemented in the open country in undeveloped areas. It considers cities and settlements primarily as barriers for living organisms (Interview 2). Especially in metropolitan areas, it is difficult for species to overcome large distances or barriers such as building blocks and roads (Interview 3). One interviewee emphasizes that it would be desirable if municipalities were also made more nature-friendly to improve the networking function even within cities (Interview 1). A project not directly related to the biotope network is intended to ensure that urban areas are enhanced. The project is called "Natur nah dran." One interviewee says that the project could contribute to the biotope network, but no direct technical connection exists (Interview 3).

4.3 Economic Impacts of the Biotope Network

The data show that the biotope network has both direct and indirect economic effects. Such effects include (1) the ability to offset biotope connectivity measures, (2) the creation of new jobs, and (3) financial savings in various sectors. However, challenges such as land competition and the difficulty of measuring long-term effects were also mentioned.

In Baden-Württemberg, biotope network measures can be accounted for as **compensation measures**, and municipalities have the option of having biotope network planning credited as eco-account measures (LUBW, 2017). The eco-account offers municipalities the opportunity to implement measures to enhance biotopes, improve soil functions and water balance, or promote rare species to offset intervention projects as compensation measures later (LUBW, 2011b). For this purpose, land can be reallocated if, for example, new construction areas or rail networks are built elsewhere. The

interviewees were ambivalent about this possibility. One interviewee criticized that the focus of the municipalities is to generate eco-points and that the biotope network is only implemented so that a new construction area can be built elsewhere (Interview 1). They mentioned that there is too little control over whether areas that should actually be secured for the biotope network are built on, and the municipality compensates for this area elsewhere (Interview 2). The project sponsors are more interested in the construction of a road or a wind power plant, and the impact compensation is seen more as a legal requirement instead of a "possibility to enhance the (native) landscape" (LUBW, 2017, p. 67). Another interviewee looks at the criticism from a different perspective. He considers the compensation measures to be positive. They provide an incentive for municipalities to implement the biotope network, which might not happen to the same extent if the eco-account did not exist (Interview 3). Eco-account measures can result in a gain on both sides, as the municipalities benefit financially from the compensation measures, and at the same time, the biotope network is expanded (LUBW, 2017).

However, the expansion and compensation of the biotope network also raise new challenges, especially concerning the issue of conflicting land use between the development of the biotope network, construction planning and agricultural land. Baden-Württemberg is a very heavily built-up state. The use of infrastructures such as roads, parking lots, settlements and commerce take up a lot of space. In addition, intensive agricultural use leaves only a few valuable biotopes and makes it difficult to connect them (Interview 2). Since the willingness of farmers to re-allocate more land is very low, "not least triggered by the increasing competition for land for the cultivation of corn for the production of bioenergy" (LUBW, 2017, p. 71), incentives must be created so that municipalities decide to implement the biotope network (Interview 2). The most significant motivation is commercial because the implementation of the project requires investments first and foremost. Funds that are invested in the financing of the biotope network are lacking in other areas. One interviewee also mentioned the impact of the Corona pandemic on many municipalities, which is now confronting them with financial challenges: "If you think about Corona now and the impact of eliminating the consequences of Corona on the population, the schools that have to be financed, the health care system that has to be financed and ensured, the biotope network is, of course, one of many issues that the municipalities have to deal with" (Interview 3, l. 193 ff., own translation). Even if municipalities benefit in the long term from implementing the biotope network, since they can generate eco-points to create new commercial areas elsewhere, the short-term expenditures often weigh more heavily (Interview 3).

Notwithstanding, many people also benefit from the implementation of the biotope network: "[T]here are simply [...] effects in the local economy, of course: agriculture, which is involved by doing contract nature conservation [...], the planning offices, which of course also [...] benefit economically, and the municipalities, which can just use their funds, if they use them in the context of planning the biotope network, very purposefully and know they are used wisely" (Interview 3, l. 238 ff., own

translation). Since the planning and implementation of the biotope network take place locally in the municipalities, the involved partners are primarily located there (Interview 3). Local planning offices are commissioned for this purpose, as they are most familiar with the local flora and fauna (Interview 1). The planning offices thus benefit economically, as they receive funds for the planning. Furthermore, farmers who are active in contract nature conservation can benefit, e.g., by implementing measures within the biotope network framework and thus **creating an income** (Interview 3). For example, implementation of actions is mowing or grazing with livestock of open land areas to prevent scrub encroachment. For this, farmers then receive a subsidy per hectare and have an annually stable and recurring income (BUND, 2018). Furthermore, **new positions were created** by the state government of Baden-Württemberg in 2020: the biotope network ambassadors. These are to be employed in all rural and urban districts for the next five years to provide more targeted support to municipalities to implement the biotope network (Interview 1) so that the state achieves its legally defined goal of implementing the biotope network on 15% of the area by 2030 (Interview 2).

In addition to the direct effects mentioned, the biotope network also shows some indirect long-term effects. The interviewees mentioned effects such as CO_2 storage through extensively used grassland areas or biodiversity protection, which also has long-term societal and economic effects. Financial losses could be prevented as animals can also provide ecosystem services (Interview 1). Connecting individual biotopes, for example, could encourage the migration of pollinators. The **pollination function** of insects is essential for the existence of our society, and it is cheaper, in the long run, to protect biodiversity now than to have to compensate for the adverse effects of insect mortality in a few decades (Interview 3). In addition, another factor is the **containment of pests** if landscapes are made more natural overall and less dominated by monocultures (Interview 3).

However, these long-term effects also pose challenges, as it is difficult to measure the positive impacts of biotope connectivity and thereby make them visible (Interview 1). To quantify and successfully measure effects such as the CO_2 storage of extensively used grassland or the increased pollination performance through flowering strips, model areas must be monitored and evaluated over several years. But since the implementation of the biotope network has only recently begun, only very few indirect effects of ecosystem services on the economy can be determined with certainty.

4.4 Comparing Environmental, Social, and Economic Impacts

I elaborated on the positive and negative impacts of the biotope network on the environment, society, and the economy in the upper three chapters. With the help of the table in Appendix 1 (8.1), presenting which codes were found how often in which document and interview, SRQ3 can be answered. The sub-question asks, "*Which of these benefits does the Biotope Network seem to provide more of?*".

The table in Appendix 1 (8.1) shows that the biotope network's impact on the environment was coded most frequently in both the interviews and the documents (96 times). This is because the biotope network was developed to secure wild animals and plants' populations threatened with extinction and preserve their habitats. Besides, it aims to generate functional ecological interrelationships between biotopes and to enable an exchange of populations. The policy documents do indicate by far less often that the biotope network is designed to have economic benefits for the state of Baden-Württemberg or the municipalities that implement it (41 times). Only the possibility of implementing the biotope network as a compensation measure is listed more frequently (19 times). This is because the eco-points and eco-account system is widespread in Baden-Württemberg and thus encourages municipalities and cities to practice more nature conservation and environmental protection. However, the interviewees mentioned far more economic benefits (20 times). These include, above all, the creation of new jobs, the possibility of generating income through contractual nature conservation (direct effects), pollination services and general ecosystem services (indirect effects). Social effects, in contrast, were found numerically less often than ecological or economic impacts (29 times). Reference is made primarily to the possibility of using the biotope network for tourism purposes (14 times). However, social benefits associated with using the network for recreation was not mentioned. One interviewee even said that the biotope network was not intended for tourist use. Nevertheless, other interview partners affirmed that the biotope network could serve as a local recreation area and increase life quality. To sum up, the documents stated primarily that the biotope network is intended to halt biodiversity loss in Baden-Württemberg gradually. In contrast, the interviewees also mentioned economic and social effects.

5 Discussion

In this section, first, the results of the data analysis are placed in the theoretical framework. The classification of the findings in the literature serves to answer the fourth sub-question, which is, "*Does the Biotope Network as a nature-based solution fail or does it succeed, and why?*". Secondly, the limitations of the research are presented.

5.1 Placement of the Results in the Theoretical Framework

The question of whether the biotope network successfully meets the requirements of a nature-based solution can be answered by comparing the results of the data analysis with the benefits and challenges of NBS presented in the theory section (2.3).

Returning to the theoretical framework, nature-based solutions are designed to generate a threefold effect - for people, the planet and human wealth. The hope behind NBS is that they can address social challenges such as climate change and the resulting increase in health hazards. Above all, NBS should serve nature and keep ecosystems functional to continue to provide ecosystem services. To achieve this, ecosystems must be diverse, i.e., have a high level of biodiversity. Furthermore, they should be resilient, i.e., withstand sudden changes in temperature and difficult weather conditions and restore themselves after environmental disasters (Faivre et al., 2017; Marselle et al., 2019). When considering the theoretical framework, it should be noted that NBS have not yet been thoroughly researched. Therefore, to be successful as a nature-based solution, it is not essential to cover all aspects. However, specific aims should be met, and effects should occur that achieve benefits in all three sectors - environment, society, economy.

The results of the data analysis suggest that, according to expert assessments, the biotope network fulfils the requirements of nature-based solutions and has ecological, social, and economic effects. (1) It safeguards populations of wild and endangered animals and plants and conserves their habitats. Linking individual island biotopes ensures that the genetic diversity of populations is maintained. Furthermore, the biotope network provides that degraded ecosystems are restored. This supports essential ecosystem services such as the storage of CO_2 and the regulation of the water balance. By preserving existing ecosystems with a high storage capacity on the one hand and designating new protected areas, the biotope network even helps to filter CO_2 from the atmosphere.

(2) This also leads to the resilience of people dependent on ecosystem services. NBS should be able to contribute to human health and well-being. By creating natural areas that invite recreation, or with the help of man-made green spaces, tree planting and the managed opening of rivers, they can help

reduce heatwaves and improve air quality. Although the specialist plan for the biotope network does not include tourism use, several model municipalities have decided to integrate parts of the network into the landscape in such a way as to create a liveable nature for humans and other living creatures. Interview partners said that the recreational value of the biotope network could also be beneficial for the health of citizens. However, given its many benefits, in the future, NBS should be used more often in cities, as the National Strategy on Biological Diversity also aims to connect biotopes in urban landscapes. Since endangered species such as bats are usually found in cities, biotope connectivity should be expanded in settlement areas and densely populated areas as well. Currently, only a few model projects are implemented within settlements, such as dark corridors for bats. The biotope network does not fulfil the aim of connecting cities, as it concentrates on open land areas and regards settlements as barriers for animals and plants. Furthermore, not enough data could be gathered to make an accurate statement about the capacities of natural risk reduction. The data only suggests that hazard prevention is not a key benefit of the biotope network. In summary, in terms of social impacts, the network shows the slightest success.

(3) The results show that experts observe that the biotope network successfully generates economic effects. Since the implementation of the network means initially significant investments for its clients - i.e., for municipalities -, which many cannot afford, most of them do not assume economic benefits. However, the biotope network creates jobs: Planning offices receive mandates, farmers can engage in contractual nature conservation, and new positions for biotope network ambassadors have been established already in all districts. The long-term benefits should not be neglected either. Long-term effects such as the increase in pollination or the storage of CO_2 can bring financial services for municipalities in the long term.

The biotope network thus successfully fulfils the most important criteria of nature-based solutions, whereby the effects on the environment and the economy are more significant than on society.

5.2 Limitations of the Research

Like any research, the paper has limitations and can only provide a particular scope. Especially qualitative research like this is difficult to replicate, or the results are not always fully comprehensible. Limitations of this thesis are (1) the profile of the interviewees, (2) the small data set on the biotope network, and (3) the limited time frame.

Since the thesis is an exploratory case study, expert interviews were conducted. The selected experts deal with the biotope network in their daily work and were even partly involved in its creation and elaboration. Therefore, it is only understandable that the interviewees could have a bias, i.e., they portray, describe, or perceive the biotope network and its effects more positively than it is. Qualitative

studies are confronted often with the risk of subjectivity. A more diverse selection of interviewees might have resulted in even less bias.

Another limitation is the lack of data on the biotope network. Since the specialist planning has only been in practice since 2014 and the planning in municipalities was initiated years later, there is little to no data available to evaluate the actual effects of the biotope network in the field. The model municipalities will continue to be monitored in the following years, and an evaluation will occur. Still, many of the results of this thesis are based on assumptions and comparisons with similar projects. Therefore, all statements made here may change either positively or negatively after evaluating the Biotope Network.

In addition, there was a limited time frame for this bachelor thesis. This and the current pandemic have not made it possible to visit projects locally in model municipalities. As a result, descriptions of what measures have been implemented in municipalities are based on the documents and could not be observed in reality. Therefore, I lack the haptic and visual insight into the implementation of the biotope network that could have made the writing process and the paper even more vivid.

None of these limitations is detrimental to the research, compromises the data, or makes it unusable. However, an emergent study that follows a project in the field and works with evaluated data would be beneficial to confirm and further elaborate on the findings of this thesis.

6 Conclusion

In the following, the paper's central question will be answered by referring to the four sub-questions. Secondly, possibilities for future research based on the paper are listed. Finally, the thesis ends by breaking down the significance of the findings for policymakers and providing options for further actions.

6.1 Answer to the Research Question

In this section, I will answer the central question: " *To what extent does the Biotope Network in Baden-Württemberg generate environmental, social, and economic impacts?*". This bachelor thesis aimed to find out (1) what nature-based solutions are, what benefits they have for society, the environment, and the economy, and what challenges they have. Then, the biotope network in Baden-Württemberg was analysed with the help of expert interviews and policy documents (2) to find out which ecological, social, and economic advantages and disadvantages the network has and (3) which benefits it provided most. Finally, I combined the findings of the three sub-questions to determine (4) whether the biotope network fails or succeeds as a nature-based solution.

Based on my analysis and especially the statements of the interview partners, the research question can be answered. The data set indicates that the biotope network in Baden-Württemberg has positive effects on the environment, society, and the economy. Ecological effects include protecting biodiversity and preserving wet, medium, and dry biotopes and the ability of protected areas such as peatlands and wet meadows to filter CO_2 and store it in the soil permanently. Furthermore, the biotope network seems to benefits society by generating a liveable nature and landscape that invites nature-compatible recreation and leisure use. This enhances people's quality of life, which in turn contributes to their well-being. In addition, the biotope network also has economic impacts, for example, by creating new jobs, as with the biotope network ambassadors, or by offering farmers the opportunity to have another source of income through contract nature conservation. Furthermore, interviewees observe that the network generates long-term (indirect) positive economic effects for municipalities and the state of Baden-Württemberg, for example, by increasing the pollination performance of insects or improving air quality because green spaces become more extensive and are distributed over broad areas.

It proves that the biotope network successfully fulfils many factors of nature-based solutions. It is a solution based on natural processes and semi-natural areas that is cost-effective while providing a wide variety of ecological, social, and economic benefits. The network also ensures that resilience is built, allowing that ecosystems remain intact in the long term and can recover independently. The case

study using the example of the Biotope Network in Baden-Württemberg thus shows that it is possible to create solutions that generate services in harmony with nature and its creatures that positively impact society and the economy. Therefore, solutions that contribute to environmental protection and nature conservation are not always necessarily in contrast to economic interest and people's preferences. It is possible to create nature-compatible solutions that are socially just and open up new working areas.

6.2 Further Research

Several further research is possible based on this paper. As already mentioned in section 5.2, it would be crucial to test the results of this research in practice. For this purpose, certain model municipalities could be accompanied from initiation through planning and implementation to evaluation. However, this research would have to be conducted over several years since processes in nature change exceptionally slowly, and positive as well as negative effects often become visible only over a more extended period. By specifically monitoring the implementation of the project, the opportunities and challenges of the biotope network could be identified practically and compared with the results of this study. This will help determine whether the biotope network actually fulfils the goals stated by interview partners and documents and thus corresponds successfully to a nature-based solution.

Unfortunately, the following two further research opportunities were not possible to implement within the scope of the bachelor thesis. I would have liked to look at one of the following in more detail and hope to realize this in a future research paper. First, it would be interesting to see if the biotope network has transformative capacity. Urban transformative capacity (UTC) is the ability of an urban system to reconfigure and move towards a new and more sustainable state. The concept focuses on institutions and their ability to transform sustainably (Wolfram, 2016). UTC also looks at the capacity to increase ecosystem resilience, which in turn influences urban areas. Cities rely on the surrounding natural land- and seascapes, specially protected areas. They provide essential ecosystem services such as food, clean air, water supply, and protection from floods, coastal storms, and other natural disasters (Marselle et al., 2019).

The second exciting research would be to determine whether the biotope network fulfils Sustainable Development Goals (SDGs). The UN designed the SDGs to stimulate sustainable development worldwide. The seventeen SDGs refer to social, ecological, and economic developments and are to be fulfilled by 2030. The purpose of this research would be to draw attention to the fact that even inconspicuous and especially local projects can fulfil the UN goals and that their expansion can achieve many positive effects.

6.3 Implications for Policy Makers

In this section, I would like to make suggestions to those responsible for action in state and local politics on how they can use the results of this bachelor thesis and how they can further expand the potential of the biotope network to gain even more benefits from this nature-based solution.

The services provided by the Biotope Network in Baden-Württemberg make it a successfully functioning nature-based solution. NBS are currently receiving a lot of attention because they are seen to stop species extinction and climate change at the same time. Therefore, the functioning of NBS should be made public using concrete examples such as the biotope network. The ability to meet the goals of the Paris Climate Agreement by connecting biotopes should also be the focus of public attention. This could make policymakers more willing to implement such solutions. Also, more financial grants could be acquired for the implementation of the network. It is up to the stakeholders to put the biotope network at the centre of climate protection policy.

However, the potential of the biotope network has not yet been fully exploited, despite the benefits mentioned above. For example, the implementation of the network would also make sense within cities. The Biotope Network Specialist Plan recognises cities and settlements as barriers. But their integration would have many advantages for city-dwelling animals and people living in cities. Since the biotope network makes landscapes more natural, settlements could also become greener again. City-dwelling creatures would have the opportunity to continue finding food within the city, and it would be easier for them to migrate out of and back into the city. Citizens would also benefit, as green spaces regulate heat better than sealed surfaces and can be used for local recreation at the same time. The city-friendly expansion of the network would also have long-term positive effects on the economy, especially if cities overheat less quickly. As a result, the energy required for cooling is reduced.

Furthermore, a targeted linkage with other biotope networks both nationwide and Europe-wide would be desirable. A more robust and more extensive network of habitats can also provide more ecosystem services. Especially since plants and animals do not stop at man-made borders, Europe-wide linkage is the next logical step. If all countries and all people pull together and work together, biodiversity can be saved, and climate change can be stopped. But still, one question remains open: Will governments worldwide listen to Ban Ki-Moon and do everything they can to stop climate change?

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8 Appendix

8.1 Appendix 1: Codes per Document and Interview Transcript

Code/Document	Interview 1	Interview 2	Interview 3	LUBW Strategy Paper	LUBW Application Help	LUBW Information Brochure	BUND-NABU Position Paper	NABU Position Paper	BUND Evaluation Paper 1	BUND Evaluation Paper 2	Total
NBS and environmental impacts - total	11	14	11	9	7	18	5	4	7	10	**96**
Traffic	1	4	0	1	0	7	1	1	0	0	**15**
Reconnection	3	4	3	4	3	4	1	1	1	3	**27**
Landscape Elements	0	2	0	1	1	4	2	0	2	2	**14**
Climate Change	4	0	3	1	0	0	1	0	1	1	**11**
Biodiversity	3	4	5	2	3	3	0	2	3	4	**29**
NBS and social impacts - total	5	6	4	0	1	11	0	0	1	1	**29**
Risk Reduction	0	0	1	0	0	0	0	0	0	0	**1**
Tourism and Freetime	3	4	2	0	0	4	0	0	0	1	**14**
Urban	1	1	1	0	1	4	0	0	1	0	**9**
Health	1	1	0	0	0	3	0	0	0	0	**5**
NBS and economic impacts - total	10	2	8	0	3	14	1	0	1	2	**41**

Compensation	1	1	1	0	3	11	0	0	0	2	**19**
Direct Impacts	5	1	5	0	0	3	0	0	1	0	**15**
Indirect Impacts	4	0	2	0	0	0	1	0	0	0	**7**
NBS and Challenges - total	5	11	4	0	2	2	0	0	0	1	**25**
Conflict of Goals	3	5	4	0	2	2	0	0	0	1	**17**
Knowledge Gaps	0	4	0	0	0	0	0	0	0	0	**4**
Immeasurable Effects	2	2	0	0	0	0	0	0	0	0	**4**
Total	**31**	**33**	**27**	**9**	**13**	**45**	**6**	**4**	**9**	**14**	**191**

8.2 Appendix 2: Selected Policy Documents

Title	Publisher	Date	Source Type	Pages	Link
Fachplan Landesweiter Biotopverbund: Arbeitsbericht	Landesanstalt für Umwelt Baden-Württemberg	September, 2014	Strategy Paper	72	Fachplan Landesweiter Biotopverbund. Arbeitsbericht (lubw.de)
Fachplan Landesweiter Biotopverbund: Arbeitshilfe	Landesanstalt für Umwelt Baden-Württemberg	July, 2014	Application Help for the Strategy Paper	68	Fachplan Landesweiter Biotopverbund. Arbeitshilfe (lubw.de)
Naturschutzinfo: Biotopverbund Baden-Württemberg	Landesanstalt für Umwelt Baden-Württemberg	February, 2017	Information Brochure	108	Naturschutz-Info 2017 Heft 2 (lubw.de)
NABU-BUND-Position Biotopverbund in Baden-Württemberg	Bund für Umwelt und Naturschutz Deutschland & Naturschutzbund Deutschland	6th March, 2012	Position Paper	4	BUND-Position Biotopverbund (BUND und NABU) (bund-nordschwarzwald.de)
NABU-Position Biotopverbund (HH) 1 Baden-Württemberg braucht ein „Grünes Wegenetz“	Naturschutzbund Deutschland	7th March, 2011	Position Paper	7	Text (nabu.de)
Modellprojekt Biotopverbund Offenland: Stadt Stockach	Bund für Umwelt und Naturschutz Deutschland	17th May, 2018	Evaluation Paper	124	Planwerk Biotopverbund Offenland Stockach (bund-bawue.de)
Modellprojekt Biotopverbund Offenland: Nürtingen	Bund für Umwelt und Naturschutz Deutschland	January, 2017	Evaluation Paper	114	Planwerk Biotopverbund Offenland Nürtingen (bund-bawue.de)

8.3 Appendix 3: Overview about the Interview Partners

Interview	Respondents	Position	Date	Time	Length
Interview 1	Interviewee 1	Officer for Nature Conservation and Land Protection at LUBW	27.04.2021	15:30	00:49:47
	Interviewee 2	Officer for Nature Conservation and Land Protection at LUBW			
Interview 2	Interviewee 3	Nature Conservation Officer at the BUND	05.05.2021	14:00	01:11:51
Interview 3	Interviewee 4	Head of the Department of Protected Areas and Ecological Planning at the State Ministry of the Environment	18.05.2021	11:00	00:34:25

8.4 Appendix 4: Guideline for Interview Questions

The interview transcripts can be found in a separate zip file, which can be made available upon request. However, the interviews will not be published to ensure the anonymity of the interview partners.

Introduction

1. Can you tell me something about the origin of the biotope network? So, in general: What was the idea behind the biotope network? Who were the main actors/stakeholders at that time, how was the political implementation in the first months and what was the role of [INSTITUTION/ORGANISATION]?
2. Who are the main stakeholders today?
3. Who are the key players in the development of the biotope network? How do stakeholders cooperate with one another within the framework of the project? How would you evaluate this cooperation?
4. Who is funding the development of the network? Who provides funds for it? Who decides on their distribution?

Ecological effects

5. How does the biotope network contain or stop species' extinction in Baden-Württemberg, Germany, and Europe?
6. What other ecological effects does the biotope network have?

Social/societal effects

7. What are the benefits of habitat connectivity for society as a whole and specifically for local citizens? (Apart from the containment of species extinction and the influence on climate change).
8. Are there any challenges the biotope network has for society?
9. What are the primary uses of the biotope network? Should the biotope network also be used as a local recreation area for people from the region, or are the individual biotopes or connecting pieces and corridors accessible to visitors at all?
10. To what extent does the expansion of the biotope network meet social needs?

Economic effects

11. Do you think the biotope network has economic advantages? If yes, what are they? If no, why not/what can the [INSTITUTION/ORGANISATION] do to ensure that there are economic advantages? Is this even being strived for?

12. In expanding the biotope network, wildlife corridors should also lead through/across agriculturally used areas. Are farmers compensated for their loss of land, or do they consciously decide to make land available for the project?

Transformative capacity

13. How does the cooperation with NGOs/Political Institutions affect the biotope network project?
14. How important is the cooperation with citizens or volunteers for the realization of the project?
15. Municipalities play an essential role in the expansion of the biotope network. What measures are being taken to establish the biotope network at the lowest political level? How are municipalities supported in the implementation (funds, training, expert knowledge on site, etc.) and beyond (later evaluation of the results, a recalculation in case of failure, etc.)?
16. Do you think that the biotope network in Baden-Württemberg can be extended to all of Germany, perhaps even all of Europe? What hurdles do you see in this?

8.5 Appendix 5: Coding Guideline

Categories	Coding Rule	Key Words	Typical Examples	Code
NBS and environmental impacts				
Traffic	Code if discussing the road network or means of transport.	streets, railway, highway, road construction project, greenery along the road	"Fachlicher Hintergrund ist der, dass wir in Deutschland und insbesondere auch in Baden-Württemberg in einer stark zersiedelten Landschaft leben. Das heißt, wir haben einen hohen Siedlungs- und Verkehrsdruck [...]" (Interview 1).	NBS_En_Traffic
Reconnection	Code if artificially created connection options are mentioned.	animal crossing aids, amphibian protection system, green bridges, wildlife corridors, steppingstone biotope	"Ein solches Netz verbindet die größeren Schutzgebiete, die Kernlebensräume, mit Korridoren und Trittsteinen untereinander und schließt über die Landesgrenzen hinweg an den deutschen und internationalen Biotopverbund an" (NABU & BUND, 2012).	NBS_En_Reconnect
Landscape Elements	Code if natural connection possibilities are mentioned.	Feldrain, hedges, troughs, ditches, wood-cutting material, piles of wood	"An Stellen, an denen die Verkehrssicherheit nicht beeinträchtigt wird, können auch liegengelassenes Gehölzschnittgut und Holzhaufen zahlreichen Säugetier-, Amphibien-, Reptilien- und Insektenarten überlebenswichtige, naturnahe Lebensraumelemente zur Verfügung stellen" (LUBW, 2014).	NBS_En_LandEle
Climate Change	Code if it comes to climate change, temperature rises, CO_2 storage and climate change-induced animal migration.	sequestration, mitigation, CO_2, Migration, adaptation, repopulation, dispersal	"Ich denke, es spielt auf jeden Fall eine Rolle, auch im Zuge des Klimawandels, sodass Arten, die jetzt in ihrem angestammten Habitat verschlechterte Lebensbedingungen haben, durch Temperaturzunahme oder Rückgang von Niederschlägen, sich dann auch im Prinzip weiterwandern und ausbreiten können und vielleicht geeignetere neuere Habitate dann besiegen zu können" (Interview 1).	NBS_Env_Climate

Biodiversity	Code if animal and plant populations or the loss of biodiversity and species extinction are mentioned.	preservation, development, networking, populations, isolated habitats, isolated populations	"Ausgehend vom Landesweiten Biotopverbund mit dem Schwerpunkt im Offenland ergaben sich für die Priorisierung der Flächen folgende Prämissen: Der Fokus liegt auf Arten mit hohem Potenzial und konkretem Schutz- bzw. Maßnahmenbedarf" (BUND, 2017).	NBS_En_Biodiversity
NBS and social impacts				
Risk Reduction	Code if it refers to natural disasters and the possibilities to reduce or mitigate them.	flood prevention, natural hazards, natural disasters, tidal events, landslides, storms, desertification, stabilize soils	"Oder beispielsweise Maßnahmen Gewässerlandschaften können auch Auswirkungen haben beispielsweise auf die Reduktion von Hochwasserereignissen" (Interview 3).	NBS_S_Risk
Tourism and Freetime	Code if people' tourist use or search for recreation is mentioned.	recreation, tourist use, hiking trails, recreational benefits, cycle paths, recreation area, tourists, touristic control tool, green spaces, nature-people connection	"Der naturbezogene Tourismus wird in Albstadt intensiv entwickelt. Es wurden hierfür Wanderwege, Mountainbike-Strecken und ein ausgedehntes Loipensystem ausgewiesen, die einen großen Zuspruch erfahren" (LUBW, 2014).	NBS_S_Freetime
Health	Code, if natural landscapes contribute to improving quality of life and health.	heat reduction, cooling down cities, prevention from diseases, air quality, human well-being, drinkable water, mental health, quality of life, social needs	"Ich glaube schon, dass Naturschutz und Artenvielfalt und intakte Ökosysteme ganz viel für die Lebensqualität von Menschen machen [...]" (Interview 2).	NBS_S_Health
Urban	Code, if something is said about the biotope network in cities.	cities, towns, urban areas, settlement, buildings, metropolitan areas	"Natürlich können städtische Flächen auch zum Biotopverbund beitragen oder kommunale Flächen, insbesondere wenn es kleine Kommunen sind, sodass es eigentlich keine wirklichen Grenzen zwischen der Kommune und dem Umland gibt [...]" (Interview 3).	NBS_S_Urban

NBS and economic impacts				
Compensation	Code if it refers to compensation measures or ecopoints that can be used to compensate for biotope connectivity measures	Intervention compensation, eco-account, ecopoints, greening measures, municipalisation, compensatory measures	"Wenn man irgendwo eine Bauplanung hat oder neue Straßen plant, braucht man natürlich Ausgleichsflächen. Und diese könnte man natürlich im Vorgriff über Ökopunktemaßnahmen generieren" (Interview 1).	NBS_Ec_Compensation
Direct Impacts	Code if the biotope network has a direct impact on the economy.	jobs, energy savings, financial savings, profit from tourism	"Dann haben wir beispielsweise die Stellen bei den Landschaftserhaltungsverbänden, die Biotopverbund-Botschafter:innen-Stellen geschaffen, die für fünf Jahre zunächst da sind, um dann eben auch hier das, was bisher punktuell über Modellprojekte lief, in die Fläche zu bringen, in den flächenhaften Ansatz, sodass das ganze Land den landesweiten Biotopverbund schafft" (Interview 3).	NBS_Ec_Direct
Indirect/Longterm Impacts	Code if the effects of the biotope network are not directly measurable or only become visible after a more extended period.	improved air quality, food supply, financial savings, healthcare, flood protection savings, CO_2-Compensation, ecosystem services, pollination effects	"Also grundsätzlich ist es natürlich so, dass - die Tiere bringen ja Ökosystemleistungen, als Beispiel die Bestäubungsfunktion von Insekten, und dadurch das man dann die Biodiversität stärkt, haben eben auch die Bürgerinnen und Bürger, die davon profitieren, also beispielsweise Obstbauern, aber auch die private Grundstücksbesitzer, die Streuobstwiesen haben oder Streuobstbäume haben, profitieren natürlich davon" (Interview 3).	NBS_Ec_Indirect

Challenges of NBS				
Conflict of goals	Code if it relates to the conflict of two different parties over a landscape area.	Conflicts of use, conflicting goals in municipalities, in agriculture, through development plans, new industrial estates	"Die Bereitschaft der Landwirte, weitere Flächen umzuwidmen ist sehr gering, nicht zuletzt ausgelöst durch die zunehmende Konkurrenz um Flächen für den Anbau von Mais zur Gewinnung von Bioenergie" (LUBW, 2014).	NBS_Ch_Conflict
Knowledge Gaps	Code if there are gaps in knowledge, e.g., because expert knowledge is missing.	in the municipalities, lack of expert knowledge regarding implementation of measures, supervision, evaluation	"Es kann sein, dass die da eher noch was machen, aber ich glaube, dass zum einen die Kompetenz fehlt, um tatsächlich Pädagogisches aufzubereiten oder auch irgendwie das tatsächlich zu machen und auch das Personal gar nicht die Kapazität hat, um da aktiv zu werden" (Interview 2).	NBS_Ch_Knowledge
Immeasurable Effects	Code if effects of the biotope network (positive and negative) cannot be measured or are very difficult to measure.	indirect effects, long term effects, difficult to measure, pollination effects, long-term financial impact	"In solchen Bereichen könnte man auch über die Flächen an sich einen Effekt erwarten. Aber das ist natürlich sehr, sehr schwer messbar. Also da laufen jetzt gerade Forschungsprojekte überhaupt erstmal an" (Interview 1).	NBS_Ch_Unmeasurable

8.6 Appendix 6: Distinction of NBS from other Terms

In addition to nature-based solutions, there are also nature-derived and nature-inspired solutions. To avoid confusion, I will separate the three terms. Therefore, I will clarify what precisely a nature-based solution is and what is not one.

Nature-based solutions are based on functioning ecosystems. They use these as infrastructure to provide ecosystem services for society and the environment. Examples include the expansion of Green Spaces in Manchester, which have strengthened the mental and physical health of residents and relieved the burden on the healthcare system; the planting of mangroves in Senegal, which has stored thousands of tons of CO_2 while regenerating coastal fish stocks; or the sustainable use of farmland in China, which has doubled farmers' incomes and reduced the amount of fertiliser carried into the soil.

In addition, there are nature-derived solutions. These include wind and solar energy. These solutions use natural resources to help us, for example, reduce the need for high-carbon power and switch to renewable energy. Unlike nature-based solutions, nature-derived solutions are not based on functioning ecosystems, but they use natural sources to produce energy.

Furthermore, there are nature-inspired solutions. These solutions are inspired by nature and use biological processes to produce materials, structures, and systems. Like nature-derived solutions, they are not based on functioning ecosystems. Nature-inspired solutions use knowledge from nature to solve challenges and create innovative inventions. For example, biomimicry imitates nature and can produce innovations in all areas of life (IUCN, 2021).