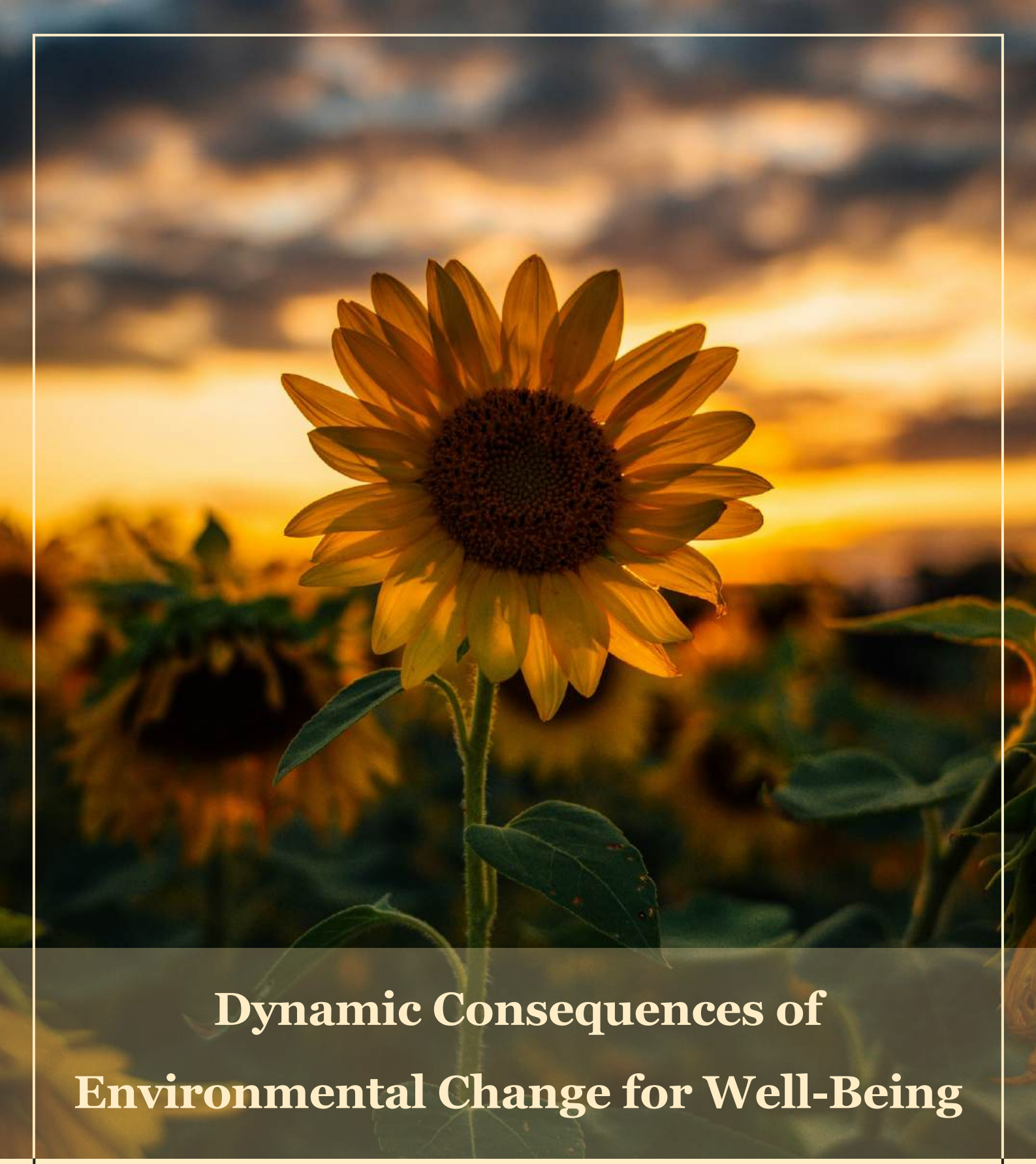

Dynamic Consequences of Environmental Change for Well-Being

A thesis submitted for the degree of Doctor of Philosophy

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Dr. Sophus zu Ermgassen, and Dr. Julia Baker

Abstract

In the face of escalating global biodiversity challenges, the objectives of ‘no net loss’ (NNL) and ‘net gain’ (NG) have emerged as crucial strategies adopted by governments, businesses, and financial institutions to mitigate the ecological impacts of economic development. These strategies are vital to advancing the global nature-positive vision. Ecological compensation aims to balance biodiversity losses incurred in one location by achieving equivalent gains elsewhere. For ecological compensation to be effective, it must address both ecological and social needs, integrating local perspectives to enhance sustainability and equity.

International best practices stipulate that an economic development and its associated ecological compensation, should ensure local communities are at least as well off, if not better, following project implementation. However, there remains a lack of clarity regarding how the environmental changes resulting from such a project impact the well-being of local populations over time, particularly given the varying perceptions of these changes among individuals.

This thesis explores these dynamics through a detailed case study in China, focusing on the local implications of ecological compensation. I begin with an evaluation of China’s ecological compensation system, which seeks to offset natural habitat losses caused by development through habitat creation. By synthesising a range of data sources, I identify several critical challenges, including inadequate pricing of forest restoration fees, the absence of required biodiversity metrics, and a lack of transparency in compensation outcomes. I then suggest improvements based on international best practice principles for compensation, including the adoption of higher compensation standards and the enhancement of governance for data tracking and monitoring conservation effectiveness.

Building on this understanding, I examine the Qunli New Town, a recent major urbanisation project that involved various ecological mitigation and compensation

measures. I first investigate shifting baseline syndrome (SBS), a phenomenon that distorts perceptions of environmental change and erodes societal expectations for nature recovery. I propose a framework that incorporates cognitive mechanisms contributing to these misperceptions. The utility of this framework is demonstrated through the Qunli case, where findings reveal that more accurate perceptions of environmental changes are associated with personal experience rather than indirect sources. Additionally, cognitive errors, such as omissions and commissions, are linked to processes of sensation, attention, learning, thinking, and memory.

Next, I assess the dynamic well-being impacts of the Qunli urbanisation, using a retrospective comparative survey where residents were asked to compare their current well-being with their previous state before the project. Results indicate that former agriculturalists, while perceiving no differences in fairness, reported lower levels of happiness following the changes, compared to non-agriculturalists. Furthermore, long-term residents viewed the economic aspects of the new town as fairer, while considering the ecological aspects less fair than newcomers did. This research highlights the importance of understanding the dynamic social impacts of developments involving ecological compensation in order to achieve genuine ‘no worse off’ outcomes for local people.

To address the negative well-being impacts of development projects, I review the social impact assessment policies and standards of financial institutions worldwide, critically evaluating the long-standing yet underexplored approach of applying the social mitigation hierarchy (SMH). This framework requires development projects to sequentially mitigate their social impacts through avoidance, minimisation, remediation, and offsetting. Drawing on the Qunli case study, I explore the complexities involved in implementing the SMH, including the selection of well-being indicators and compliance monitoring.

This research underscores the need to consider the dynamic impacts of development and its associated ecological compensation on local well-being. It calls for the

integration of established social standards, including the social mitigation hierarchy, into the operationalisation of the 'no worse off' principle. Moreover, addressing SBS is crucial for enhancing people's relational well-being, enabling them to better understand and respond to their environmental conditions. Tackling the dynamic social impacts of economic developments involving ecological compensation and promoting societal changes to improve awareness of the natural world are essential for fostering resilient, sustainable, and inclusive communities in line with the Sustainable Development Goals and the Global Biodiversity Framework.

摘要

面对日益严峻的全球生物多样性挑战，“无净损”和“净增”的环境目标已成为政府、企业和金融机构为缓解经济开发对生态的负面影响而采取的重要战略。这些战略对于推进全球“正向自然”愿景也至关重要。“生态补偿”旨在通过在异地实现同等收益，来平衡一个区域内的生物多样性损失。为实现生态补偿的有效性，它必须同时满足生态和社会需求，需通过整合在地视角以确保其可持续性和公平性。

国际最佳实践规定，经济开发及其相关的生态补偿应确保当地社区在项目实施后至少不恶化，甚至更佳。然而，此类项目造成的环境变化随着时间的推进如何动态影响在地居民的福祉尚不清晰，尤其在考虑到个体对这类环境变化感知差异时。

本论文通过对一个来自中国的案例研究来探究该类社会影响的流动性，重点关注生态补偿的在地影响。我首先对中国的生态补偿制度进行了评估——该制度旨在通过创造栖息地来抵消因开发而造成的自然栖息地损失。通过综合各种数据资料，我发现了几个关键挑战，包括森林恢复费定价不足、缺乏必要的生物多样性指标，以及补偿结果缺乏透明度。我进而根据国际最佳补偿实践原则提出了改进建议，包括采用更高补偿标准和加强数据跟踪和监测保护效果治理。

基于对中国生态补偿的评估，我继而探究以群力新区为案例深入分析——一个涵盖各种生态缓解和补偿措施的大型城市化工程。我首先研究了“基准线偏移综合征”，一种偏转人们对环境变化感知的社会-心理现象；其能削弱社会对自然恢复的期望。我提出了一个新的研究框架，涵盖了导致这些感知偏差的认知机制。该框架的效用进而在群力新区案例中得到了验证。在地结果表明，人们对环境变化的更准确的感知与直接经历有关，而不是间接来源。此外，认知谬误（包含遗漏和过失谬误）与知觉、注意力、学习、思考和记忆过程有关。

然后，我通过设计了“回顾性比较”调查法，评估了群力城市化对福祉的动态影响。在该调查中，居民回顾比较了他们当前的与城市化前的福祉感知变化。研究结果表明，非农业人口相比，虽然曾经的农业人口在感知公正层面不存在显著差异，但他们在城市化变化后的幸福感水平显著较低。此外，与城市化后的新移民相比，长期居民认为新区的经济结果更公正，而认为其生态结果更不公正。研究强调了探究涉及生态补偿的开发项目的动态社会影响的重要性，以确保能够有效落实在地社区“不恶化”原则。

为进一步探究对经济开发项目中负面福祉影响的缓解，我回顾了世界各地金融机构的社会影响评估政策和标准，并批判性地评估了长期存在但尚未被充分讨论的“社会缓解层次框架”：该框架要求开发项目通过避免、最小化、恢复和抵消的措施依次缓解其社会影响。通过群力案例的实证研究，我探讨了实施社会缓解层次框架的复杂性，包括福祉指标的选择和合规性监测等问题。

综上所述，本研究强调了考虑经济开发及其相关生态补偿对当地福祉动态影响的必要性。研究呼吁将现存的社会标准和工具（例如社会缓解层次框架）纳入“不恶化”原则的实施中。此外，解决基准线偏移综合征对于支持人们的“关系福祉”尤为重要，使其能更好理解其所处的环境条件，并对它们作出反应。研究指明我们应积极应对融入生态补偿的经济开发项目对社会的动态影响，并促进社会变革提高人们对自然环境的感知——与可持续发展目标和全球生物多样性框架一同促进弹性的、可持续的和包容的社区发展。

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Author Contributions

Chapter 1: Introduction

This chapter is entirely my own work and was reviewed by E.J. Milner-Gulland, Joseph Bull, and Sophus zu Ermgassen.

Chapter 2: Analysing the Outcomes of China's Ecological Compensation Scheme

I conceptualised the study with E.J. Milner-Gulland, Joseph Bull, and Julia Baker. I conducted the data collection and analysis and wrote the chapter. It was reviewed by E.J. Milner-Gulland, Joseph Bull, Julia Baker, and Sophus zu Ermgassen.

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Chapter 3: Psychological Mechanisms Underpinning Environmental Misperceptions

I conceptualised the study with E.J. Milner-Gulland, Joseph Bull, and Sophus zu Ermgassen. I conducted the data collection and analysis and wrote the chapter. It was reviewed by E.J. Milner-Gulland, Joseph Bull, and Sophus zu Ermgassen,

This chapter is in draft as: Gao, S., zu Ermgassen, S. O., Bull, J. W., & Milner-Gulland, E. J. Shifting Baseline Syndrome and beyond: Addressing environmental misperceptions for nature recovery.

Chapter 4: The Social Impacts of Nature-Inclusive Urban Development

I conceptualised the study with E.J. Milner-Gulland, Joseph Bull, and Sophus zu Ermgassen. I conducted the data collection and analysis - with assistance from Thomas Pienkowski - and wrote the chapter. It was reviewed by E.J. Milner-Gulland, Joseph Bull, Sophus zu Ermgassen, Wendee Zhang, Xiang Ao, and Renlu Qiao.

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Chapter 5: Operationalising Nature- and People-Positive Infrastructure Developments

I conceptualised the study with E.J. Milner-Gulland, Joseph Bull, Sophus zu Ermgassen, and Amber Butler. I conducted the data collection and analysis and wrote the chapter. It was reviewed by E.J. Milner-Gulland, Joseph Bull, Sophus zu Ermgassen, and Helen Newing.

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Chapter 6: Discussion

This chapter is entirely my own work and was reviewed by E.J. Milner-Gulland, Joseph Bull, and Sophus zu Ermgassen.

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List of Acronyms and Abbreviations

ADB	Asian Development Bank
BBOP	Business and Biodiversity Offsets Programme
BNG	Biodiversity Net Gain
CBD	Convention on Biological Diversity
CI	Confidence Interval
CIEEM	Chartered Institute of Ecology and Environmental Management
CNY	Chinese Yuan Renminbi
CoP	Conference of the Parties
COVID-19	Coronavirus Disease 2019
EIA	Environmental Impact Assessment
EU	European Union
FVRF	Forest Vegetation Restoration Fee
GBF	Kunming-Montreal Global Biodiversity Framework
GDP	Gross Domestic Product
GRP	Gross Regional Product
GIBOP	Global Inventory of Biodiversity Offset Policies
GVRF	Grassland Vegetation Restoration Fee
IAIA	International Association for Impact Assessment
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
IFC	International Finance Corporation
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPLCs	Indigenous Peoples and Local Communities
IsDB	Islamic Development Bank
IUCN	International Union for Conservation of Nature
LNRN	Local Nature Recovery Network
MAM	Minimum Adequate Model

MEA	Millennium Ecosystem Assessment
MEE	Ministry of Ecology and Environment
MH	Mitigation Hierarchy
MoF	Ministry of Finance
NDF	Nordic Development Fund
NG	Net Gain
NNL	No Net Loss
OECD	Organisation for Economic Co-operation and Development
OR	Odds Ratio
SBS	Shifting Baseline Syndrome
SMH	Social Mitigation Hierarchy
UK	United Kingdom
UN	United Nations
US	United States
USD	United States Dollar
WEF	World Economic Forum
WRF	Wetland Restoration Fee
WWF	World Wildlife Fund

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CHAPTER 1

INTRODUCTION

Land clearing for development threatens nature. Dominik Vanyi/Unsplash

"We are part of nature and our well-being depends on a healthy relationship with it."

- Georgina Mace

1.1 Background

1.1.1 Biodiversity Impacts of Infrastructure Development

The Earth had left the Holocene and entered a new geological epoch, the Anthropocene (Crutzen, 2002; Rockström et al., 2009; Zalasiewicz et al., 2017), in which human activities have become the foremost driver of global environmental change, driving a crisis for the natural world (Steffen et al., 2007 & 2015; Newbold et al., 2016; Díaz et al., 2019). Monitored wildlife populations have, on average, declined by roughly 69% over the past four decades (WWF, 2022), though the extent of these losses varies significantly across different species and regions, creating distinct patterns of survival and decline amid global environmental shifts (Blowes et al., 2019; Leung et al., 2020). Ongoing declines in nature pose serious risks to human society, as biodiversity is vital for well-being in various ways; it provides essential services such as food, energy, and medicine, regulates climate and water purification, and offers cultural benefits that enrich traditions and artistic expression (MEA, 2005; Díaz et al., 2006 & 2018).

The world is experiencing the fastest expansion of built infrastructure in human history, with countries prioritising infrastructure investment at the centre of their post-COVID economic recovery plans (Steffen et al., 2015; Krausmann et al., 2018; OECD, 2021; Gundes, 2022). As of 2020, the mass of human-made materials had already surpassed that of the entire biosphere, with built infrastructure constituting the majority of this (Elhacham et al., 2020). According to the Global Infrastructure Hub, global investment in new infrastructure is projected to reach an additional $60 trillion by 2040. We have also entered the era of the infrastructure megaproject -

defined as projects costing over $1 billion (Flyvbjerg, 2014) - with China's Belt and Road Initiative standing out as one of the most ambitious. This initiative aims to connect two-thirds of the global population through an integrated network of transport, trade, and industry (Ascensão et al., 2018).

The biodiversity impacts of infrastructure development are projected to be immense, particularly in relation to urbanisation and expansion. Simkin et al. (2022) estimate that, if the biodiversity impacts of urbanisation continue to be inadequately mitigated globally, over the next 30 years it could affect more than 30,000 species of native terrestrial vertebrates, with 855 species directly threatened. However, for a considerable time, global biodiversity agreements, such as the now-expired Aichi Biodiversity Targets, have largely overlooked the impact of urbanisation on natural habitats compared to agriculture and forestry (Simkin et al., 2022). This issue has now been addressed in the new Global Biodiversity Framework (GBF), which was agreed upon in 2022.

1.1.2 Global Biodiversity Framework

To reverse the trend of biodiversity decline, countries united in 2010 at the 10th Conference of the Parties (CoP10) to the Convention on Biological Diversity (CBD) to create the 10-year Strategic Plan for Biodiversity, subdivided into 20 Aichi Targets. Despite conservation efforts, the international community has fallen short of fully meeting any of the 20 targets (IPBES, 2019). The successor to the plan, the Kunming-Montreal Global Biodiversity Framework (GBF), has been adopted at CoP15 in 2022. It sets out new goals and targets to "*halt and reverse biodiversity loss*" within the coming decade, with a long-term aspiration of "*living in harmony with nature*" by 2050 (CBD, 2022). Notably, the GBF advances in mainstreaming socially-just outcomes for local people while pursuing positive outcomes for nature (Obura et al., 2023; Obura, 2023; Pascual et al., 2023). The term "Indigenous peoples and local communities" (IPLCs) is referenced 16 times within the framework (CBD, 2022).

The framework also introduced a new target that promotes "*biodiversity-inclusive urban planning*", aiming to "*significantly increase the area and quality, and connectivity of, access to, and benefits from green and blue spaces in urban and densely populated areas sustainably*" (CBD, 2022). This is in recognition of the fact that land conversion for urbanisation and urban expansion is, and will continue to be, a major driver of the global nature crisis, destroying and fragmenting the habitats of many species (WWF, 2022; Semenchuk et al., 2022). This target, aligned with the GBF's general social principle, should also be pursued in a manner that properly addresses any negative impacts on local people's well-being.

1.1.3 Mitigation Hierarchy and Ecological Compensation

To advance towards achieving this global target, the 'mitigation hierarchy' (MH) approach can be applied to guide the mitigation of ecological impacts from urban development activities, aiming for 'no net loss' (NNL) and preferably 'net gain' (NG) for nature (Fig. 1.1; Birkeland & Knight-Lenihan, 2016; Arlidge et al., 2018; Birkeland, 2020). In the MH framework, ecological compensation (e.g., biodiversity offsets) is considered the last resort for impact mitigation, to be implemented only after impacts have been prevented whenever possible (Gardner et al., 2013; Pilgrim et al., 2013; Ives & Bekessy, 2015; Arlidge et al., 2018; Hahn et al., 2022; Droste et al., 2022). Justified by the 'polluter pays' principle (Wende et al., 2005; Vaissière et al., 2020; Damiens et al., 2021a), over 100 countries have incorporated or are incorporating ecological compensation policies into their environmental legislation (Fig. 1.2; Table 1.1), typically associated with the environmental impact assessment (EIA) framework (IUCN, 2019; Deutz et al., 2020).

Ecological compensation - while addressing residual impacts that were previously uncompensated and unmeasured (von Hase & ten Kate, 2017) - remains a controversial topic in the literature. Debates focus on its ethical foundations (Spash, 2015; Ives & Bekessy, 2015; Apostolopoulou & Adams, 2017; Björnberg, 2020), technical concerns (Bull et al., 2013; Gardner et al., 2013; Maron et al., 2016 & 2018),

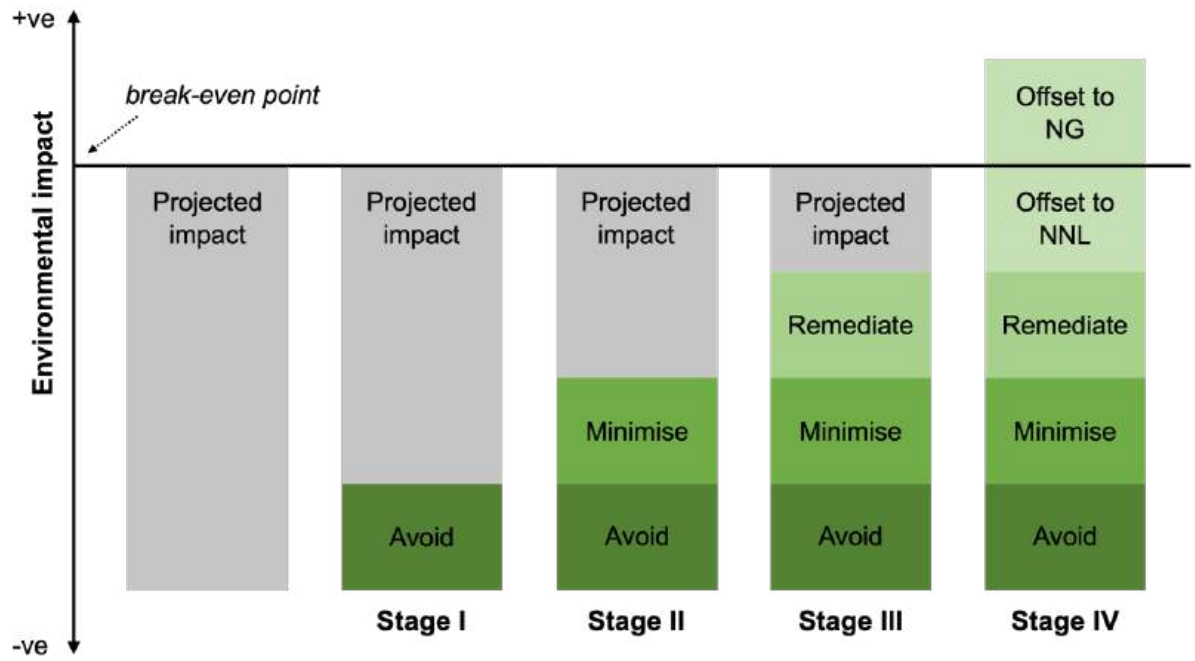


Fig 1.1: A graphical representation of the mitigation hierarchy. Developers can follow the conceptual framework to sequentially avoid, minimise, remediate, and offset environmental impacts. To remediate means to restore temporary environmental loss within the development site during or after the development. To offset means to deal with any residual impacts not captured by the first three steps of the hierarchy.

governance challenges (Bull et al., 2013; Maron et al., 2016; Primmer et al., 2019; Damiens et al., 2021a), and potential efficacy (Lindenmayer et al., 2017; May et al., 2017; Josefsson et al., 2021; zu Ermgassen et al., 2023).

There is also a growing discussion around the social impacts of implementing the MH, as development and associated ecological mitigation activities, particularly ecological compensation, can drive changes in the environments where people live (Griffiths et al., 2019a & 2019b; Jones et al., 2019; Tupala et al., 2022). These environmental changes affect access to ecosystem goods and services, impacting local well-being not only through what is delivered, but also how, with procedural and recognition justice playing a crucial role (Bidaud et al., 2017; Jones et al., 2019; Kalliolevo et al., 2021; Milner-Gulland, 2024). Consequently, the 'no worse off' principle has been proposed (Bull et al., 2018; Griffiths et al., 2019a). This principle requires that development and ecological mitigation activities address their impacts

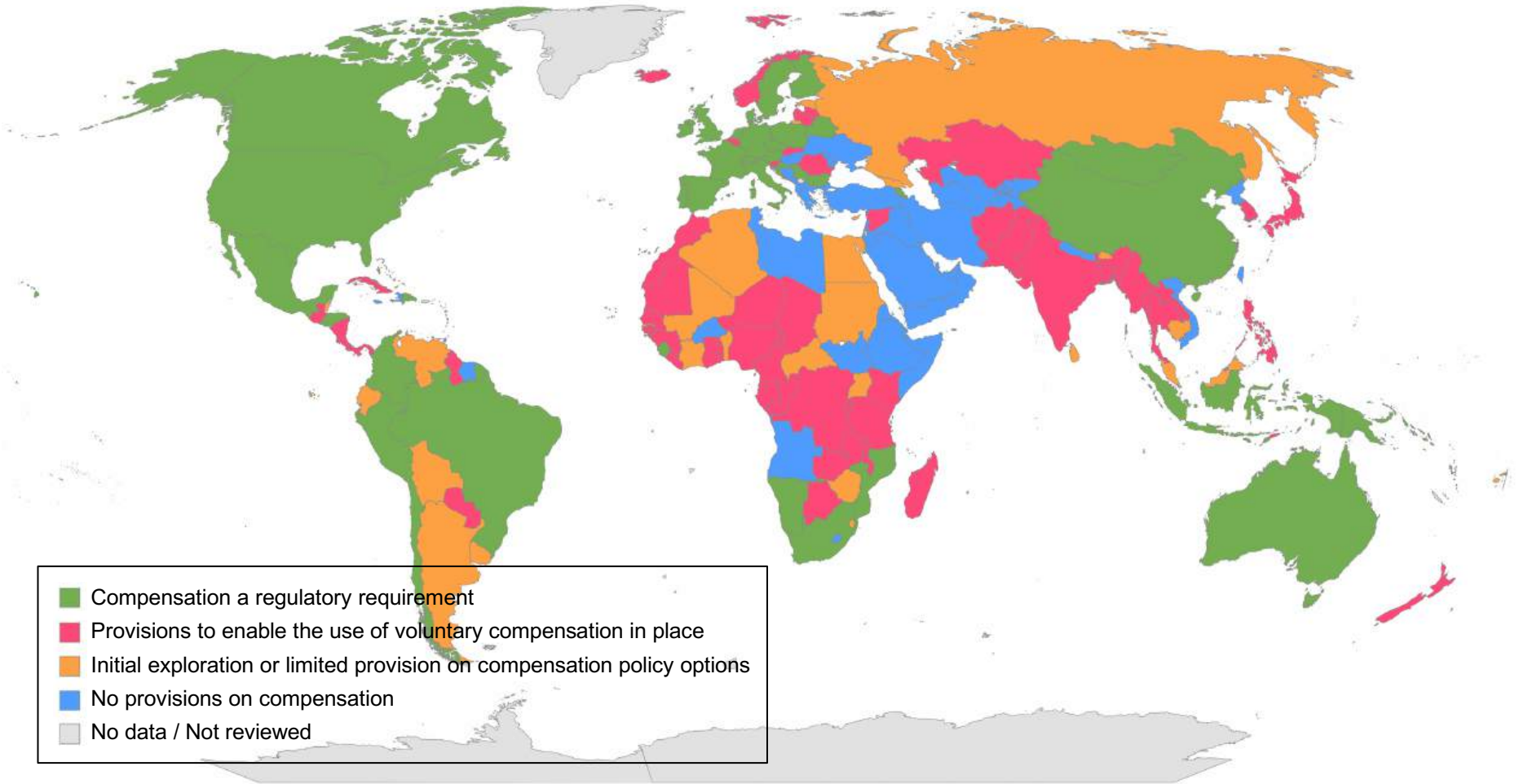


Fig. 1.2: National compensation policy development across the world. A global database compiling information on the use of compensatory conservation demonstrates that over 100 countries have compensation policies in place or enabled; compensations are legally required in 37 countries including US, UK, and China, primarily embedded in the EIA framework. (Data source: Global Inventory of Biodiversity Offset Policies, GIBOP).

Table 1.1: Terminology for different types of 'ecological compensation' mechanisms across languages. (Adapted from Bull et al., 2016).

Language	Equivalent terminology for ecological compensation	English direct translation	Relevant countries
Chinese (simplified)	Shengtai buchang	Ecological compensation	China
Danish	Kompensation	Compensation	Denmark
English (Canada)	Conservation offset	Conservation offset	Canada
English (UK)	Biodiversity offset	Biodiversity offset	Australia, New Zealand, South Africa, UK
English (United States)	Compensatory mitigation	Compensatory mitigation	United States
French	Mesures de compensation; compensation écologique	Compensation measures; ecological compensation	Canada, France, Madagascar
German	Ausgleichsmaßnahmen; Ersatzmaßnahmen	Compensation measures; substitution measures	Germany
Japanese	Satoyama Banking	[*Satoyama* is the term for a semi-agricultural ecosystem type in Japan]	Japan
Portuguese (Brazilian)	Cota de reserva ambiental	Environmental reserve certificate	Brazil
Russian	биоразнообразия компенсация	Biodiversity compensation	Kazakhstan, Russia, Uzbekistan
Spanish	Compensaciones de biodiversidad; medidas compensatorias	Biodiversity compensation; compensatory measures	Argentina, Chile, Colombia, Mexico, Peru, Spain, Venezuela
Swedish	Ersättning; ekologisk compensation; miljökompensation	Compensation/substitution; ecological compensation; environmental compensation	Sweden

on local communities, ensuring that people are no worse off, and preferably better off, in terms of their perceived well-being after these activities than they were before (Bull et al., 2018; Griffiths et al., 2019a). This principle is underpinned by moral arguments (e.g., human rights), a practical rationale (e.g., a social licence to operate), and policy or regulatory mandates (e.g., IFC Performance Standards).

1.1.4 Human Well-Being

Operationalising the 'no worse off' principle requires the proper identification, assessment, and mitigation of any negative impacts arising from the implementation of a mitigation hierarchy (MH) on the well-being of local communities (Griffiths et al., 2019a). Human well-being is multi-dimensional (Gough & McGregor, 2007; Ng & Fisher, 2013; Schreckenberg et al., 2018; Austin, 2020), and in the literature well-being is regularly positioned as a construct involving material, relational, and subjective aspects (Fig. 1.2; White, 2010; McGregor & Sumner, 2010; Milner-Gulland et al., 2014; Woodhouse et al., 2015; Loveridge et al., 2020). The material aspect focuses on what a person has, the subjective aspect on what they think about what they have, and the relational aspect on what they can do with what they have (Gough & McGregor, 2007; Milner-Gulland et al., 2014; Woodhouse et al., 2015). This multi-dimensional nature of well-being means it cannot be fully assessed through objective measures alone; it's crucial to understand how objective means are converted into subjective ends (Anand, 2021).

Well-being is also a dynamic concept (Gough & McGregor, 2007; Ng & Fisher, 2013; Schreckenberg et al., 2018), which means that both immediate and long-term consequences of an intervention should be investigated to build a more comprehensive understanding of its well-being impacts, so as to better manage these impacts towards improved social performance. As for ecological mitigation and compensation, understanding its well-being impacts in the long term, and properly mitigating any negative impacts, are not only socially important; this may also contribute to more sustainable ecological outcomes of these projects.

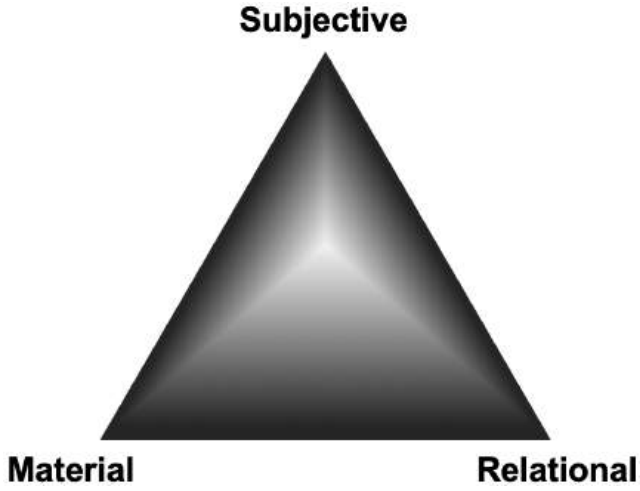


Fig. 1.3: Dimensions of human well-being. The concept of well-being can be depicted as a pyramid, where the material and relational aspects are the basis, rising to the subjective dimension at the apex. (Reproduced from White, 2010).

1.1.5 Shifting Baseline Syndrome

A globally-evidenced social-psychological mechanism that can influence well-being dynamics is shifting baseline syndrome (Pauly, 1995; Papworth et al., 2009; Soga & Gaston, 2018 & 2024), where people perceive environmental changes differently from the actual changes to varying degrees, leading to differing expectations and standards about what should or shouldn't be altered. For example, Ostergren et al. (2008) found that rural residents, accustomed to denser forests, were less supportive of environmental measures like thinning and prescribed burns, illustrating shifting baseline syndrome, where their perception of a 'healthy' forest aligns with their experience of relatively dense forest conditions.

Shifting baseline syndrome may be closely linked to human well-being. In terms of subjective well-being, people's differing perceptions of actual environmental changes can lead to varied evaluations and judgements of how these changes affect their lives. In addition, environmental misperceptions can undermine relational well-being by limiting people's ability to respond effectively to environmental degradation. This, in turn, may hinder the achievement of the sustainable development goals related to sustainable and resilient societies and the well-being of future generations.

1.2 Study System

Previous studies examined the impact of ecological compensation on local well-being within particular social-ecological systems (e.g., Bidaud et al., 2017; Griffiths et al., 2019b). Building on the knowledge of how ecological compensation operates in China, this study takes a similar approach to explore a major urbanisation programme in China, where extensive infrastructure developments, combined with ecological mitigation and compensation measures. The potential trade-offs between economic development, the natural environment, and human well-being are particularly evident in China - a nation with a rapidly expanding economy, a global biodiversity hotspot, and a population exceeding 1.4 billion. Understanding how China designs and implements ecological compensation for development-related impacts, and how the associated environmental changes may affect local communities, provides valuable insights not only for China's improvements but also for other countries adopting ecological compensation in urban and densely populated areas.

This thesis focuses on a major urbanisation in Harbin, China, namely the Qunli New Town (Fig. 1.4). Harbin, the capital and largest city of Heilongjiang Province, is the largest provincial capital by land area in China and serves as a major political, economic, and cultural hub in northeast China. Between 1982 and 2010, Harbin's population expanded from 2.5 million to 10 million. The Qunli New Town, covering 2,733 hectares, has thus been established on the western outskirts of Harbin. As a key part of the city's development in the 2000s, the new town replaced the predominantly rural old town, triggering significant population movement and social change.

Qunli New Town took over a decade to be built from scratch, from the early 2000s to the late 2010s (Fig. 1). The government's urbanisation plan for the town was based on the "*principle of ecological priority*," with the goal of creating a "*ecological garden city*" whose aim is to "*increase the proportion of green space, water surfaces, and park areas, establishing an ecological urban area characterised by a clean and beautiful environment, a sustainable urban ecosystem, and the coordinated development of the environment,*

Fig. 1.4: The location of, and current land use in, Qunli New Town (45°44'19.7"N 126°33'01.9"E), Harbin City, Heilongjiang Province, China. a. The location of Qunli New Town within Heilongjiang Province. b. The location of Qunli New Town within Harbin City. c. The land-use map of Qunli New Town in 2023, showing the newly created Qunli Bund Wetland and Qunli National Urban Wetland Park, both of which are replacing degraded wetlands, with green corridors connecting the various urban spaces.

economy, and society" (Qunli Development Office, 2010). Under these ecological values and goals, numerous landscape-level ecological mitigation and compensation measures were implemented to restore existing natural areas and create new green spaces. Local ecological surveys have suggested that the creation of the Qunli Bund Wetland has led to its use as habitat by many species listed as threatened in the IUCN Red List, for example, the Oriental stork (*Ciconia boyciana*; Endangered) and the white-naped crane (*Grus vipio*; Vulnerable). In addition, the Qunli National Urban Wetland Park (Fig. 1.4c) has been established through restoring a degraded marsh.

Listed as an example of an avoidance-driven measure by the UN Human Settlements Programme, the Park contributes to protecting native habitats, acts as a "green sponge" to address climate change risks, and provides wider cultural benefits for residents and tourists (Austin & Yin, 2016; Zhu et al., 2020; UN-Habitat, 2022). Additionally, restoration of the river has enabled population growth of threatened fish species, for example, the Kaluga (*Huso dauricus*; Critically Endangered).

These measures resulted in an initial decline, followed by a subsequent improvement in local environmental conditions. Local official documents indicate a U-shaped recovery in water quality (Fig. 1.5), with improvements beginning in 2009. It was also reported that fish species richness in the river rebounded following the improvement in water quality. Official records show that the number of fish species declined from 79 in the 1970s to 56 in 1990, and further to 34 in 2000, before recovering to 64 by 2010 as water quality improved. While the available information is limited and relatively simple, it provides one way to reveal local environmental trends over time and represents the best data that could be obtained.

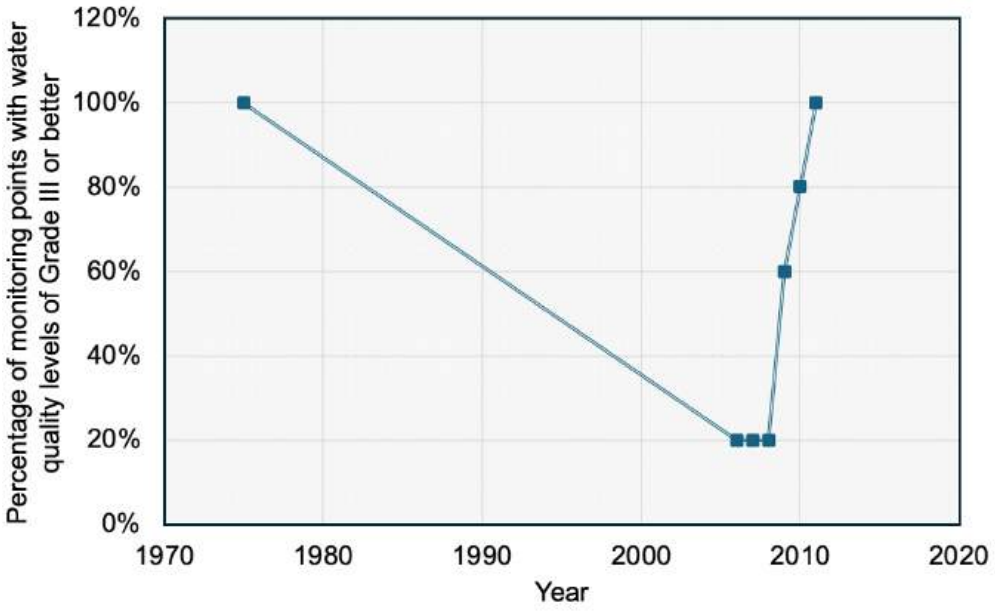


Fig. 1.5: The change in water quality in Songhua River (Harbin Section). Data points were collected from local official reports (see Appendix A). Grade-III water is defined as lightly polluted water that can be used for farmland irrigation, industrial cooling and other purposes that do not come into direct human contact. The midpoint of 1975 is used to represent the reported state during the 1970s for clarity in the figure.

1.3 Aims and Objectives

The overarching aim of this thesis is to contribute to the equitable design of ecological mitigation and compensation activities that counterbalance the impacts of urban development, delivering positive outcomes for both nature conservation and human well-being, using a Chinese study system. The main research objectives of this thesis are to:

(i) analyse the outcomes of China's ecological compensation scheme for development-related biodiversity loss;
(ii) explore the different types of shifting baseline syndrome present at the study site and the psychological reasons behind these phenomena;
(iii) examine how an urbanisation programme that incorporates ecological values and goals can impact local well-being; and
(iv) explore ways to effectively operationalise positive outcomes for both people and nature in urban development.

While the focus of this study is on a specific country and site, particularly for objectives 2-4, the overarching aim is to develop frameworks and conceptual approaches that can be broadly applied to various economic developments and their associated ecological mitigation and compensation efforts.

1.4 Thesis Outline

This thesis comprises an introduction, four main chapters, and a discussion chapter. Following this introductory chapter, the thesis is structured as follows:

Recognising a knowledge gap in the literature regarding China's ecological compensation and NNL policy (Bull & Strange, 2018), Chapter 2 offers the first overall review of China's ecological compensation approach, defined as reactive, disincentive-based compensation for contemporary ecological impacts caused by development activities (see Table 2.1). I conceptualise how compensation and NNL

are regulated in China, evaluate the compensation practices of developers and local governments, and provide policy recommendations based on established international best practice principles for ecological compensation and NNL implementation.

Building on the context provided in Chapter 2, I then conduct an in-depth case study using Qunli New Town (Chapters 3 to 5). In Chapter 3, I explore how residents perceive local environmental changes, discussing the reasons why people may misperceive them. I propose a framework that expands the concept of shifting baseline syndrome by integrating cognitive mechanisms underlying environmental misperceptions. This framework not only addresses misperceptions related to nature loss but also considers those related to environmental recovery. I demonstrate the utility of the framework in Qunli where I examine the role of experience of the place, information sources, and socio-demographic features on respondents' accuracy of perceptions. Analysing the qualitative interview data, I also propose a framework of errors of 'omission' and 'commission' to outline the cognitive reasons behind deviated perceptions of environmental baselines.

In Chapter 4, I assess how environmental changes in Qunli have impacted local well-being, taking into account the dynamic effects of shifting baseline syndrome. Using locally-defined, environmentally-based well-being indicators derived from stakeholder interviews, I measure the long-term impacts of the new town's establishment on well-being through an ex-post baseline comparison survey. This survey evaluates perceived changes in well-being following the Qunli urbanisation, which took over 10 years. Additionally, I analyse variations in residents' perceptions of fairness in relation to their socio-demographics, including their status as different waves of settlers in the area.

In Chapter 5, I review the social impact assessment policies and standards of key financial institutions worldwide and critically evaluate the long-standing yet underexplored 'social mitigation hierarchy' (SMH) approach which has been long

embedded in multilateral and international safeguards yet to date never formally substantiated. I use semi-structured interviews to understand the negative well-being impacts associated with the Qunli urbanisation and its ecological mitigation, and explore relevant impact mitigation measures with local stakeholders. Based on this information, I provide guidance on how the SMH approach can be effectively implemented to operationalise development projects towards the global nature-positive and people-positive aspiration (Obura et al., 2023).

Finally, in Chapter 6, I integrate the key strands from the preceding chapters of this thesis, revisiting the original aim and objectives of the research. This chapter outlines the novel contributions made by the study and highlights the cross-cutting themes that have emerged. Additionally, I critically assess the limitations encountered and propose directions for future research.

1.5 My Positionality

Grounding social research in the interpretivist tradition, sociologists, anthropologists, and human geographers normally approach people as subjects, aiming to qualitatively investigate the ways they perceive the world in as near to their own terms as possible, privileging depth over breadth. In contrast, economists and psychologists usually take a positivist view, applying quantitative and more objective approaches (e.g., pre-determined well-being scales) to achieve breath of insights, via representativeness. This interdisciplinary thesis analyses social data collected with both interpretivist and positivist epistemologies; semi-structured interviews are paired with large-scale surveys to produce mixed-methods research designs, thereby reaching both breadth and depth of insights.

When carrying out social studies to survey the social world, the relationships between researchers and subjects are interactive, and a researcher's positionality, defined as their unique combination of social identities (e.g., background, education, expertise, experiences), can bias their epistemology (Takacs, 2003; Moon et al., 2019). Since my

positionality will have uniquely affected the knowledge this thesis produces, it is essential to practice reflectivity, as it can demonstrate how I interact with people and places, which influences how I explore, gather, synthesize, interpret, and communicate information (Moon et al., 2019). Thus, the following sections present a brief reflection on my social identities, and my intellectual position and conservation philosophy, with reflections on how they may influence the research process.

1.5.1 My Social Identities and Background

I grew up in the city centre of Harbin, China. As a child, I witnessed significant environmental changes in the city, including the expansion of Daoli District, where wetlands were transformed into the new Qunli New Town. Throughout this landscape transformation, I observed the underlying environmental costs and how such developments could impact local stakeholders' livelihoods and well-being, including farmers whose land was acquired for urban development or related ecological mitigation and compensation.

I studied economics as an undergraduate in China, with my epistemology firmly rooted in positivism. Motivated by my interest in 'planetary boundaries', I pursued a master's degree in environmental economics in London to explore how market-based approaches could help address environmental challenges and support a transition towards a 'safe and just space for humanity'. During my time at the London School of Economics, I developed an understanding of compensatory conservation tools (e.g., biodiversity offsets in the UK) to address global biodiversity loss. This journey also led me into the fields of behavioural economics and the science of well-being, exposing me to diverse epistemologies. Courses on 'environment and development' further fuelled my passion for understanding and addressing inequality and injustice.

During this period, I began to move away from my previous philosophy of knowledge, recognising that social-ecological problems are contextually situated and that there are no one-size-fits-all solutions. My experiences in both China and the UK have

provided me with a diverse cultural and academic lens, which shapes my understanding of environmental and social issues. This dual perspective enriches my analysis but also introduces potential biases.

1.5.2 My Intellectual Position and Conservation Philosophy

My social identities and experiences have driven me to seek effective and socially-just ways to save the planet. I support market-based approaches not only for their cost-effectiveness and economic efficiency but also for their practical value in providing real-world solutions. This does not mean I oppose transformative change - I firmly believe it is crucial for successfully delivering the GBF - but the urgency of conservation requires us to find a pragmatic middle ground. Overall, while idealism can be a catalyst for radical change, I believe we should not let perfection be the enemy of progress.

Fig. 1.6 presents my results from 'The Future of Conservation Survey' (Sandbrook et al., 2019; https://www.futureconservation.org). It indicates that I lean more towards 'conservation through capitalism' than most conservationists. This can be largely attributed to my identities and background. Furthermore, I believe that the natural sciences play a crucial role in developing conservation strategies, such as informing the selection of biodiversity components to compensate for development impacts. However, I think these programmes should be tailored to local contexts, taking into account the perspectives and priorities of local stakeholders, and should not result in injustice or negatively impact people's well-being.

1.5.3 Advantages and Limitations

Insider/outsider status is recognised in social studies as an essential aspect of positionality. As a native of the city under study, Harbin, my familiarity with the Chinese language, the Harbin dialect, and other related social contexts gives me an advantage in surveying local communities about academic concepts (e.g., human well-being, shifting baseline syndrome) in ways that are meaningful within the local

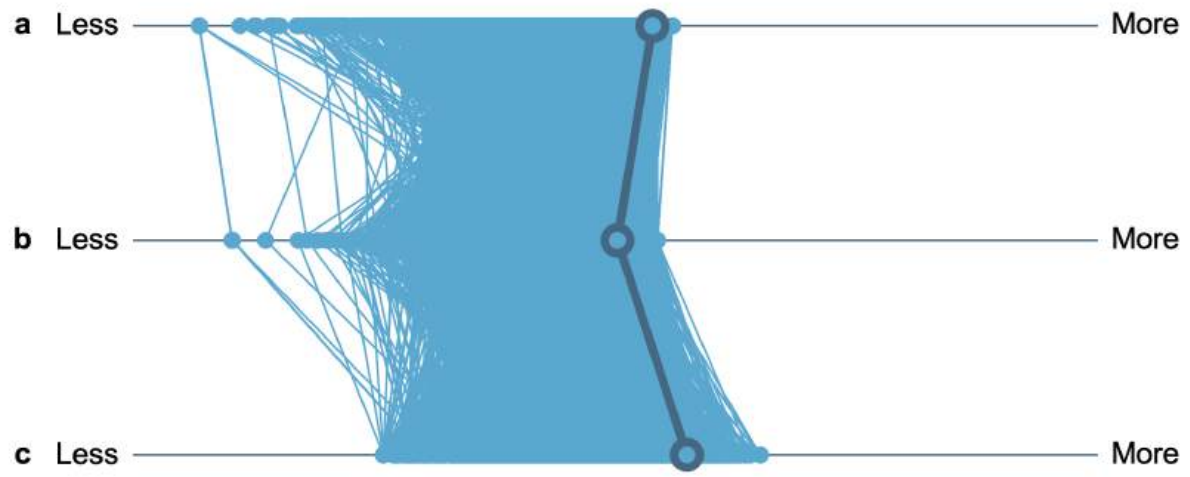


Fig. 1.6: My results from 'The Future of Conservation Survey'. a. People-centred conservation (relating to the role people should have in conservation, as active participants, stakeholders, and potential beneficiaries). b. Science-led ecocentrism (regarding the appropriate role of science in conserving species and ecosystems for their intrinsic value). c. Conservation through capitalism (concerning the desirable role of corporations and market-based approaches in conservation).

context. However, I am also aware that my background and education may inadvertently introduce biases into the study (i.e., investigator effect).

To minimise the investigator effect as much as possible, I employed three local research assistants who have lived in Harbin for multiple years or decades. They are all fluent in both the Chinese language and the Harbin dialect, and they represent different social groups: one is a low-income senior male who has lived in the city since birth, another is a middle-income middle-aged female who moved to the city two decades ago, and the third is an unemployed male student who moved in more recently.

The aim of employing local research assistants was to make participants more comfortable when responding to the semi-structured interviews and questionnaires, particularly as I am collecting information from diverse social groups (e.g., age, income, and years living in the study site; Newing et al., 2011). Additionally, the local research assistants were instrumental in defining certain terms in ways that resonate with local contexts, such as 'environmental change'. They also played a crucial role

in the translation and back-translation exercises carried out during the research design and data analysis phases.

In general, this study adopts a pragmatist research paradigm, which means it is guided by the principle of 'what works' and that research should be contextually situated rather than committed to a single philosophical position, with questions being addressed through interdisciplinary research (Creswell, 2009; Scott & Marshall, 2009; Robinson, 2011; Moon & Blackman, 2014). To conduct the interdisciplinary research in this thesis, I draw on various fields, including anthropology, sociology, psychology, economics, and policy studies, in addition to biology and ecology. Since I cannot possess all the skills and knowledge in each field, the way I integrate ideas and methods from different disciplines may not be perfect. I acknowledge that researchers with a deeper and more thorough understanding of these fields might recommend alternative approaches to integrating ideas and methods to answer the research questions.

CHAPTER 2

ANALYSING THE OUTCOMES OF CHINA'S ECOLOGICAL COMPENSATION SCHEME

Abstract

Over the past three decades, China's government has implemented many projects under its ecological compensation policy, including paying compensation fees for habitat creation to redress natural habitat losses caused by development. However, a critical evaluation of both the policy design, and its ecological outcomes, has not previously been carried out. I assemble diverse data sources to provide the first evaluation of China's eco-compensation policy and practice, identifying several challenges. In policy, the pricing of forest restoration fees is insufficient in several provinces, and there is no requirement for use of biodiversity metrics or for ecological equivalence of compensation and losses. In practice, only 23% of a sample of 31 developments applied quantitative biodiversity metrics, and fewer than 1% of China's local governments have disclosed information regarding compensation implementation. Thus, to improve the validity of its compensation policy and practice to better secure biodiversity, China may need to embrace higher compensation standards, having first prevented ecological losses where possible. Equally important, China may also need to improve compensation governance for data tracking and conservation effectiveness monitoring.

2.1 Introduction

Human overexploitation of land and natural resources has been identified as among the most substantial anthropogenic drivers of biodiversity loss (Maxwell et al., 2016; Newbold et al., 2016). As humanity endeavours to remain within a safe operating space defined by planetary boundaries (Rockström et al., 2009; Díaz et al., 2019), compensatory conservation has become a widely employed approach to reconciling potential losses caused by economic development with goals for nature (Maron et al., 2018; Damiens et al, 2021a; Simmonds et al., 2022). Compensatory actions are the last steps of the biodiversity 'mitigation hierarchy', which should be implemented after the preventative steps of avoidance and minimisation (McKenney & Kiesecker, 2010; Gardner et al., 2013; Arlidge et al., 2018). Over 100 countries globally have incorporated, or are incorporating, compensatory actions to mitigate biodiversity impacts into their national environmental policies, according to the Global Inventory on Biodiversity Offset Policies database (IUCN, 2019). Compensatory actions mitigate and compensate for negative impacts on biodiversity associated with a given development project by enhancing biodiversity elsewhere, typically seeking an overall outcome of no net loss (NNL), and preferably a net gain (NG), in biodiversity. How compensatory actions and NNL/NG goals are institutionalised and implemented to address development impacts varies between countries (Maron et al., 2018). Yet there has been little quantitative work exploring China's ecological compensation policy and its implementation in China.

Filling this knowledge gap is important because nowhere is the potential trade-off between economic development objectives and biodiversity protection more extreme than in China. One of the world's mega-biodiverse countries, China's fast urbanisation and industrialisation after market reforms starting in 1978 has fuelled an approximately thirtyfold increase in GDP per capita and lifted 850 million people out of poverty (World Bank, 2022), but it has also brought tremendous costs for the natural environment. Developments have destroyed a great number of natural

habitats, including forests, grasslands, and wetlands, resulting in massive environmental losses: For instance, within China's Pearl River Delta, 1,518 km^2 or 26% of the natural habitat and 760 km^2 or 42% of the local wetlands were lost from 1992 to 2012 (He et al., 2014). Over the last decade alone, China has undergone the most rapid infrastructure expansion observed in human history - it has been estimated that China consumed more concrete in 2011-2013 than the USA did in the entire 20th century (Smil, 2016).

To reverse ecosystem losses, in the late 1990s and early 2000s China's government gradually launched a comprehensive national eco-compensation strategy with a number of subsidiary policies and programs, with the primary principle of internalising both positive and negative environmental externalities of human activities (Shang et al., 2018). The strategy has supported a steady increase in habitat area in China; for example, China's forest area (% of land area) has increased from 18.9% to 23.4%, according to the World Bank. Based on this primary principle, in a broad sense China's eco-compensation strategy encompasses both reactive and proactive measures for redressing environmental losses caused by economic activities, both legal and illegal, which have both taken place in the past and are currently ongoing (Table 2.1). Understanding the policy landscape in China is complicated by different nuances in the usage of the word 'compensation': but the first type of compensation measure in Table 2.1 is close to the 'compensation' or 'offsetting' tools applied elsewhere, such as the 'biodiversity offset' of Australia, 'compensatory mitigation' of the US, and 'conservation offset' of Canada. This type of measure is the focus of this study, which I will refer to as 'compensation' from here on.

To implement compensation to counterbalance development impacts, China has designed and established a compensatory mechanism, including the forestry vegetation restoration fee (FVRF), grassland vegetation restoration fee (GVRF), and wetland restoration fee (WRF). FVRF was launched through China's first Forestry Law in 1998. It was the earliest developed and, to date, the most widely applied

Table 2.1: The multiple meanings of 'eco-compensation' in China's policy mix. In this chapter I focus on eco-compensation measure type 1 (compensation for contemporary development impacts).

Eco-compensation measure	Description	Externality	Liability	Example
Compensation for contemporary development impacts	Reactive, disincentive-based compensation for legal, contemporary, attributable impacts	Negative	Polluters/developers pay for public interest	Forest vegetation restoration fee (Madsen et al., 2010; OECD, 2016; IUCN, 2019)
Compensation for previous development impacts	Proactive compensation for both (previously) legal or illegal, past, indirect, diffuse impacts	Negative	Governments pay for public interest	Yangtze river protection and restoration action (World Bank, 2022)
Payments for ecosystem services	Proactive, incentive-based compensation for previously permitted, long-lasting impacts	Positive	Governments pay, providers get	Grain for Green (also known as Conversion of Cropland to Forest Program) (Liu, 2002; Song et al., 2021; World Bank, 2022)
Compensation for illegal use of natural resources	Reactive compensation for illegal, contemporary, attributable impacts	Negative	Offenders pay for public interest	Compensation fees or rehabilitation projects for illegal activities such as illegal fishing and illegal land reclamation (Kong et al., 2021)

compensatory instrument in China. Given that it incorporates a legal commitment to realising NNL of forest cover alongside development activities, FVRF is also internationally regarded as China's principal NNL instrument (Madsen et al., 2010; OECD, 2016; IUCN, 2019). The reason that FVRF has been broadly implemented is not just because of its early adoption, but also as a result of China's prioritisation of forest protection and afforestation as a primary focus for the provision of regulating services and promotion of sustainability on land. Intensive afforestation and forest restoration measures have been launched since the mega-floods in 1998 exacerbated by soil erosion and siltation, which swept through many of the country's major rivers, including the Yangtze, Songhua, Nen, Min, and Pearl rivers (Lang, 2002; Zhang & Wen, 2008; Du et al., 2019). Moreover, afforestation and forest restoration programs have contributed to reducing China's long-standing issues with regional sand and dust storms in the dry north and rocky south arising from denudation and desertification (Wang et al., 2010; Bryan et al., 2018; World Bank, 2022).

Despite the widespread application of China's compensatory mechanism (the first approach in Table 2.1), there has been little to no research into the outcomes and efficacy of these compensation policies. Previous studies published in Chinese focused on compensation for past development impacts, incurred before environmental issues were more seriously addressed by government (i.e., the second type of compensation shown in Table 2.1), especially in protected areas or ecosystems of high conservation priority (Liu et al., 2022). Although massive developments and associated compensatory activities are currently occurring in China's urban and semi-natural rural areas, their scale and mechanisms have not yet been comprehensively explored. Additionally, discussions around China's compensatory mechanisms are topical; in 2021 China's central government has made commitments to increasingly prioritise biodiversity conservation in future development, to enhance its ecological compensation method for better redressing the consequences of removing natural habitats, and to seek better approaches to assessing the biodiversity impacts of

development activities, such as construction and mining (State Council, 2021a & 2021b).

I address three research questions in this study:

- How is compensation conceptualised in China's policy?
- How does compensation work in practice in China?
- Can China learn from international best practice in compensation to enhance its compensation approach, better securing its national biodiversity?

Investigating China's compensation policy and practice can help elucidate whether China's long-standing compensation approach supports or clashes with China's other or more recently set biodiversity goals and commitments. For example, China has an overall conservation goal of "*maintaining biodiversity*", as indicated in its Forestry, Grassland, and Wetland Protection Laws (MEE, 2021a, 2021b, & 2022). The Forestry Law also requires the forest compensation fees collected to provide sufficient revenues for developing the same area of forest elsewhere as has been lost. However, how China's compensation fee approach works has not yet been studied. Additionally, although compensation has been implemented in many countries, including the US, Australia, Germany, and France, in each case, the ecological outcomes of previous compensation programs have been mixed (Bull & Strange, 2018; zu Ermgassen et al., 2019). Given this lack of consistent progress, it is crucial to evaluate the outcomes of compensation in different contexts. As major global financial flows and policy efforts are currently being directed towards compensatory actions and biodiversity restoration, evidence from China can contribute towards developing a general understanding of whether and when compensation can be effective. To address the proposed research questions, I review the compensation system being used in China and link it with the desired conservation goals proposed in China's legislation - I then discuss the approach China is taking in the context of the fundamental ecological principles required for effective compensation.

The remainder of this study is constructed as follows. The next section discusses the materials and methods used for evaluation. Then, I present my results to answer the three proposed questions in order: (a) how China conceptualises ecological compensation, (b) how China practices ecological compensation, and (c) how China can improve based on what I found in (a) and (b). Finally, I conclude with a summary of policy suggestions and recommendations for future work.

2.2 Materials and Methods

This study takes a process-based approach to analysing the outcomes of China's compensation. Because the concept of compensation is interpreted heterogeneously in different contexts around the world (Damiens et al., 2021b), before carrying out an assessment of its outcomes, I first conceptualise compensation in China and review previous compensation literature, in order to develop a set of indicators to assess compensation in a way that is meaningful in China's context.

1) *Review of policy, regulations and government documents relevant to China's compensation mechanism*. Due to the lack of public information about China's compensatory mechanism, I collected information from different sources to provide the first overview of how the compensatory mechanism works in China. I reviewed two sets of government documentation at both central and local levels. First to understand the mechanisms behind how China's compensation policies function, I reviewed all relevant policy, regulation publications and other relevant government reports provided by the central government, including *Forest Vegetation Restoration Fee Levy, Use and Management Provisional Measures*, and *Guiding Opinions on Formulating Conditions for Restoration of Vegetation and Forestry Production*, as well as relevant policy papers published by China's 31 provincial-level governments, through searching on the 31 provincial-level governments' official websites using the keyword of forest vegetation restoration fee (*senlin zhibei huifufei*).

2) *Sampling of developers' environmental impact assessment (EIA) reports that recorded developments' biodiversity impacts*. I identified the biodiversity indicators implemented in Chinese compensation plans using developers' EIA reports. To my knowledge there is currently no official database that records all EIA reports in China. Some EIAs have been collected in some voluntary document-sharing databases, such as Doc88 (*Daokebaba*) (https://www.doc88.com). However, the database is not systematic; it provides a sample of reports that were uploaded by database users. I used the keyword of 'environmental impact assessment reports' (*huanjing yingxiang pingjia baogao*), to screen complete EIA reports on this database. Thirty-one economic development projects were selected from a total of 500 results; I first removed all incomplete reports (e.g., documents that only present half or one module of the entire assessment) and then manually selected projects whose titles contained keywords regarding infrastructure or real estate development (e.g., housing, hospital, road, railway) to present the developments that are most likely to be associated with ecological impacts.

The number of development projects I collected may not generate a full picture of EIA in China, given the massive scale of China's development (Smil, 2016). In order to make my results as generalisable as possible, I sampled projects that covered different development types and geographical regions: out of China's 31 provincial-level administrative regions, I included a total of 31 developments projects across 15 regions with 13 provinces and 2 municipalities, which covered 6 types of developments (from housing to bridge construction, see Section 2.4.1).

3) *Understanding China's compensation system through exploring local government disclosures*. Some EIA reports also contain some compensation practices planned voluntarily by developers to improve the likelihood of the projects being permitted by the planning authorities, and possibly to reduce the cost of restoration fees paid to the government (or increase the size of their rebate). This information is also shown in Appendix B. Yet, most of China's development and compensation practices

are carried out independently: compensation practices are mostly completed by the forestry and environmental authorities using the restoration fees they have collected. I thus searched Baidu, the biggest Chinese search engine, with the keyword of 'forest vegetation restoration fee' (*senlin zhibei huifufei*), 'grassland vegetation restoration fee' (*caoyuan zhibei huifufei*) and the many translations of 'expense' and 'spending' (including *huafei*, *zhichu*, and *shiyong*) and the domain name of 'gov.cn'. The search was performed between November 2021 and January 2022. I reviewed a total of 1,315 pages and identified all government pages that documented government spending financed through the restoration fee and compensation implementation practices. I screened out the pages simply recording the charging requirements and general information about collection and transfer of the fee, and ultimately identified 10 local governments which had released the required information.

4) *Evaluating China's forest vegetation restoration fee*. I also aimed to see if the prices paid by a developer to compensate an area of natural habitat loss induced by its development project enable the recreation of the same area of natural habitat elsewhere. This study investigates the price levels of China's most widely applied compensation fee, the FVRF (Jeffrey & Qi, 2012; Gong et al., 2014; Zhen & Zhang, 2011), to see if the prices used can actually cover the total costs needed to enable NNL of forest areas in the same region. I thus calculated the unit cost of forest investment from 2016 to 2018 using different regions' annual total investments in forests, and the yearly increase of afforestation areas in each region, collected from China's National Statistics Data from 2017 to 2019 (http://www.stats.gov.cn). The investments in forest development, as claimed by the government, involve investments in degraded forest restoration and compensation, forestry planning and development, forestry loss prevention, and other forestry management activities. The yearly increase in afforestation area includes the increases from all the means used to develop forests, including both creating new forests and restoring degraded forests. The data published from 2020 are no longer applicable to the analysis because the statistical accounts changed, with the government spending in grassland

development merged with its spending in forest development. The data on gross regional product (GRP) per capita across China from 2016-2018 were collected from the nation data page of National Bureau of Statistics of China (https://data.stats.gov.cn).

The measurement of total investment in forest management reported by the government is used to estimate the sum of all the costs spent, including both explicit reforestation costs and implicit transaction costs (e.g., misappropriation), to deliver reforestation. The details of how such investments by China's government have been spent in different regions are usually impenetrable or unavailable, and China's forestation funds are in practice allowed to be used to deliver a wide range of natural capital benefits for people's well-being in addition to habitat compensation. Here, I aim to reveal how much input (i.e., total spending on forest development) is required to be invested to realise the expected nature-related output (i.e., NNL of forest area) without unpacking the black box of government spending, and to compare the unit costs with the current FVRF levels in different regions. As information about the areas of every type of forest land delivered each year is unavailable, a sensitivity analysis is performed to consider the best, worse, and average situations. The best situation assumes all the forest development investment was used for developing the type of forest land with the highest FVRF prices (i.e., arbour forest land, defined in Table 2.2). The worse situation assumes all the investment went to develop the type with the cheapest FVRF (i.e., young afforested land). The average scenario supposes all types of forest land - arbour forest land, bamboo forest land, nursery land, shrub forest land, sparse forest land, and young afforested land - are developed equally by area.

This quantitative analysis assumes (i) China's statistical body correctly reports its investments and forest area increases, and (ii) government spending is the primary driver of afforestation, due to China's top-down system within which land and forest are mostly treated as public property and managed by the government. The analysis is limited by uncertainty in China's statistical manuals, such as the lack of description

of the method used to collect and compute data, as well as linguistic uncertainty. For example, there are no clear definitions of terms such as forestry loss prevention and forestry management practices. Together with other unclear definitions (e.g., "*important wetlands*") in China's policy papers, standards, and laws and regulations relevant to its compensation approach, it is not possible to analyse its outcomes with full confidence. I endeavour to make a rigorous assessment, after first understanding China's context as well as possible via cross-referencing documents, to reduce any inaccuracies as far as possible.

2.3 Conceptualisation of Compensation in Chinese Policy

Since China's first Forestry Law, published in 1998 (followed by the Grassland Law in 2002 and Wetland Protection Law in 2021), China's central government requires compensation to be implemented by development projects that remove forest, grassland, or wetland habitats (Madsen et al., 2010; MEE, 2021a, 2021b, & 2022). Correspondingly, three mandatory compensatory fees are used to address the ecological externalities of developments: FVRF, GVRF, and WRF. According to China's Forestry, Grassland, and Wetland Protection Laws, the three fees implicitly have an NNL-like goal; to "*maintain biodiversity* (*weihu shengwu duoyangxing*)" (MEE, 2021a, 2021b, & 2022).

Given China's prioritisation of forest habitat (World Bank, 2022; Xi et al., 2022), FVRF has become a widely applied measure across China. By contrast, to date, GVRF has only been used in some regions while WRF is still in its infancy. FVRF uses an NNL goal – NNL in the area of forest cover undifferentiated by forest type (Madsen et al., 2010; MEE, 2021a) – while WRF aims to compensate for the loss of "*important wetlands*" with the same quantities and qualities elsewhere (MEE, 2022), though which wetlands are considered important is not yet clearly defined. In contrast, GVRF to date does not have any explicit NNL target (MEE, 2021b).

China's government to date has not provided a clear overview of how the compensatory mechanism works. Therefore, here I summarise the procedure based on a review of policy papers published by China's national and local governments and some case studies across China (Fig. 2.1). After a developer has conducted an EIA and has been granted consent to construct a development scheme by the government, the developer must pay restoration fees to the state. Unlike the compensatory schemes of the US and Australia, developers in China are not required to negotiate prices with compensation providers, and prices paid to the government are not calculated on a case-by-case basis, unless they plan to enact compensation by themselves. For instance, the prices applied in FVRF are set via a unified approach jointly by the China's Ministry of Finance (MoF) and National Forestry and Grassland Administration. The prices are estimated to cover the total costs required to enable full compensation for the lost area of habitat cover in place, disregarding the quality of that habitat or its ecological functional role or species. For example, in terms of forest compensation, the estimation of FVRF is based upon the sum of costs of: (i) ecological survey, design and planning for forest cover regeneration, (ii) afforestation or reforestation, and (iii) forest management and monitoring. The two central government bodies published their first compensation prices in 2003 and an update in 2015 with all price levels increased (MoF, 2015). As the GVRF and WRF have not yet been as widely applied nationwide as FVRF with clear price levels defined, this study evaluates China's compensation fee approach with a focus of FVRF.

In contrast with compensation approaches employed, for example, in the US, Australia, Germany, and France, China's compensation policy is underlain by a 'low-replaceability' principle (Koh et al., 2019), that is, they do not have to be 'like for like'. According to China's National Forestry and Grassland Administration's policy paper and the national standard (GB/T 15776-2016) *Afforestation Technical Regulations*, species used in compensation projects should ensure the restored forest is long-lasting and resilient to extreme conditions in the area, but ecological equivalence is not required. The national standard *Afforestation Technical Regulations* provides a

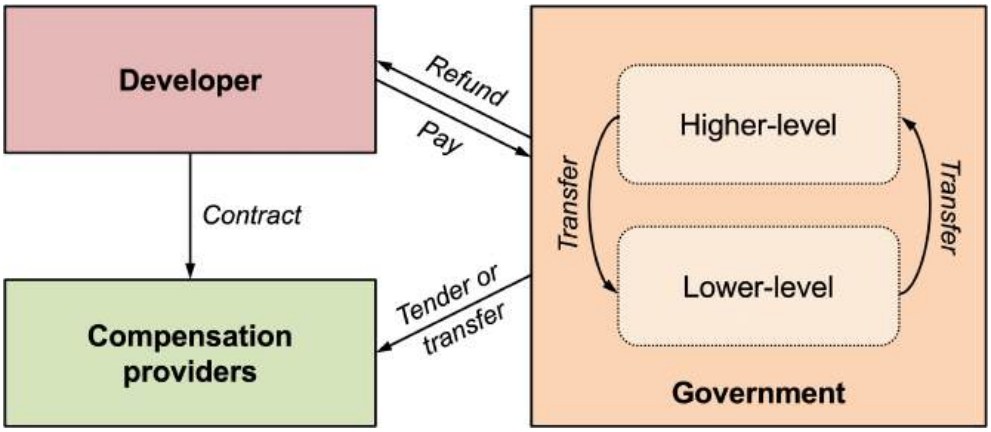


Fig. 2.1: Procedure for China's compensatory approach. (i) A developer calculates the total restoration fee based on the area of each habitat type and makes a payment to the government. As different habitats can be managed by different levels of government, the developer pays the level(s) of government (i.e., forestry and grassland office) that manages the relevant habitat(s). (ii) The collected fees may be transferred within the government, and is finally transferred to the local (i.e., county- or district-level) Treasury after a certain period (e.g., a quarter or half-year). (iii) If the developer eventually clears less habitat area than they first predicted, or restores some habitat area (e.g., by contracting a compensation provider), the government needs to refund the corresponding part of the fee. Once the local government comes up with spending plans and negotiates contracts with providers for sourcing young trees and for transplantation to create natural habitat(s) and/or restore existing natural habitat(s), the money is then transferred to the corresponding office to make the necessary payments. This money can also be transferred from the Treasury to other governmental bodies for other natural resource management activities such as forestry planning and fire prevention.

recommended list of species from which compensation practitioners can choose to develop afforestation or reforestation projects.

It is hard to precisely define 'forest' (Sasaki & Putz, 2009), and different countries and organisations do so differently. China's government defines 'forest' in multiple ways based on regional context. Table 2.2 demonstrates China's typologies of forest land as used in the FVRF instrument, and the standard price levels that developers need to follow for occupying each type of forest land (MoF, 2015). Within the top-down governance system, after the central state releases the goals, principles, and minimum requirements, lower-level governments have the autonomy to make adjustments based on their local situation. In turn, China's different provincial-level

governments (i.e., governments of provinces and direct-administered municipalities) have the autonomy to increase the restoration price levels set by the central state, after considering the total costs of carrying out the compensatory actions in their regions.

Table 2.2: Types of forest lands and national standard fees, as set in 2015.

Forest Land	Description	Standard Fees (CNY/m^2)[a]
Arbour forest land	Forest land composed of arbour species (i.e., trees that have a distinct trunk, with tree height > 5 m and diameter at breast height > 5 cm at maturity), with a crown density ⩾ 20%; or a crown density < 20% but retention rate ⩾ 80% with steadily growing young trees in planted stands.	No less than 10
Bamboo forest land	Forest land composed of bamboos with a minimum diameter at breast height of 2 cm	No less than 10
Nursery land	Land permanently used for cultivating tree seedlings and saplings.	No less than 10
Shrub forest land	Land composed of shrubs and/or bushes with a canopy cover more than 30%.	No less than 6
Sparse forest land	Arbor forest land, but with a canopy cover of 10%-19%.	No less than 6
Young afforested land	Afforestation land, with no closed canopy, but the actual number of planted trees is no less than 85% of the planned number	No less than 6
Suitable land for forest[b]	*Land suitable for forestry development.*	*No less than 3*

[a] CNY (Chinese yuan renminbi) is official currency of People's Republic of China; 1 CNY = 0.14 USD.

[b] This by China's definition includes cut-over lands, slashed and burned lands, glades and other barren hills and wastelands unsuitable for crops but suitable for trees. This type of land is not considered as a forest land type in this article.

2.3.1 An Evaluation of China's Forest Vegetation Restoration Fee

Fig. 2.2 presents an overview of the prices each provincial-level government put on forest vegetation restoration, as of 2015. Most (74%) of China's provincial-level

governments set price levels consistent with the minimum price levels released by the central bodies, while Chongqing sets the highest prices on forest land compensation on average, at CNY 16/m^2. I then calculated the total costs of forest land development per square meter in China's 31 province-level administrative units using national statistics. Fig. 2.3 further presents the ratio of the costs of forest land development to forest vegetation restoration prices from 2016 to 2018 across China; a ratio >1 means the cost of forest compensation is likely to be higher in practice than the fee charged to developers. I found that higher price levels enable sufficient coverage of the costs required for forest development in many regions, such as Chongqing, Guangdong, and Fujian, but not in other some provinces, such as Heilongjiang and Zhejiang. In particular, the costs of implementing forest compensation in some economically developed regions such as Beijing and Shanghai are much higher than in other places (Fig. 2.4, Appendix B), while the prices set in these places are too low to cover these costs.

2.4 Delivery of Compensation in Practice

2.4.1 Impact Assessment and Compensation on the Development Side

In practice – as is common for good practice biodiversity impact mitigation globally – development projects in China are legally required to first identify and prevent development impacts on irreplaceable ecological components, following such regulations as the List of endangered and protected species of China and the 'no-go' areas where development impacts are not permitted as determined by China's ecological redline policy (Xinhua, 2017; Bai et al., 2018; Jiang et al., 2019). The redlines identify areas that provide key ecological functions as well as ecologically sensitive and fragile areas. Developers can design compensation schemes in their environmental impact assessment (EIA) reports in order to gain governmental consent for their projects. The 31 development projects I sampled consist of 11 housing developments, 8 road constructions, 7 hospital buildings, 2 railway infrastructures, 1 school development, 1 bridge project, and 1 dam construction. All

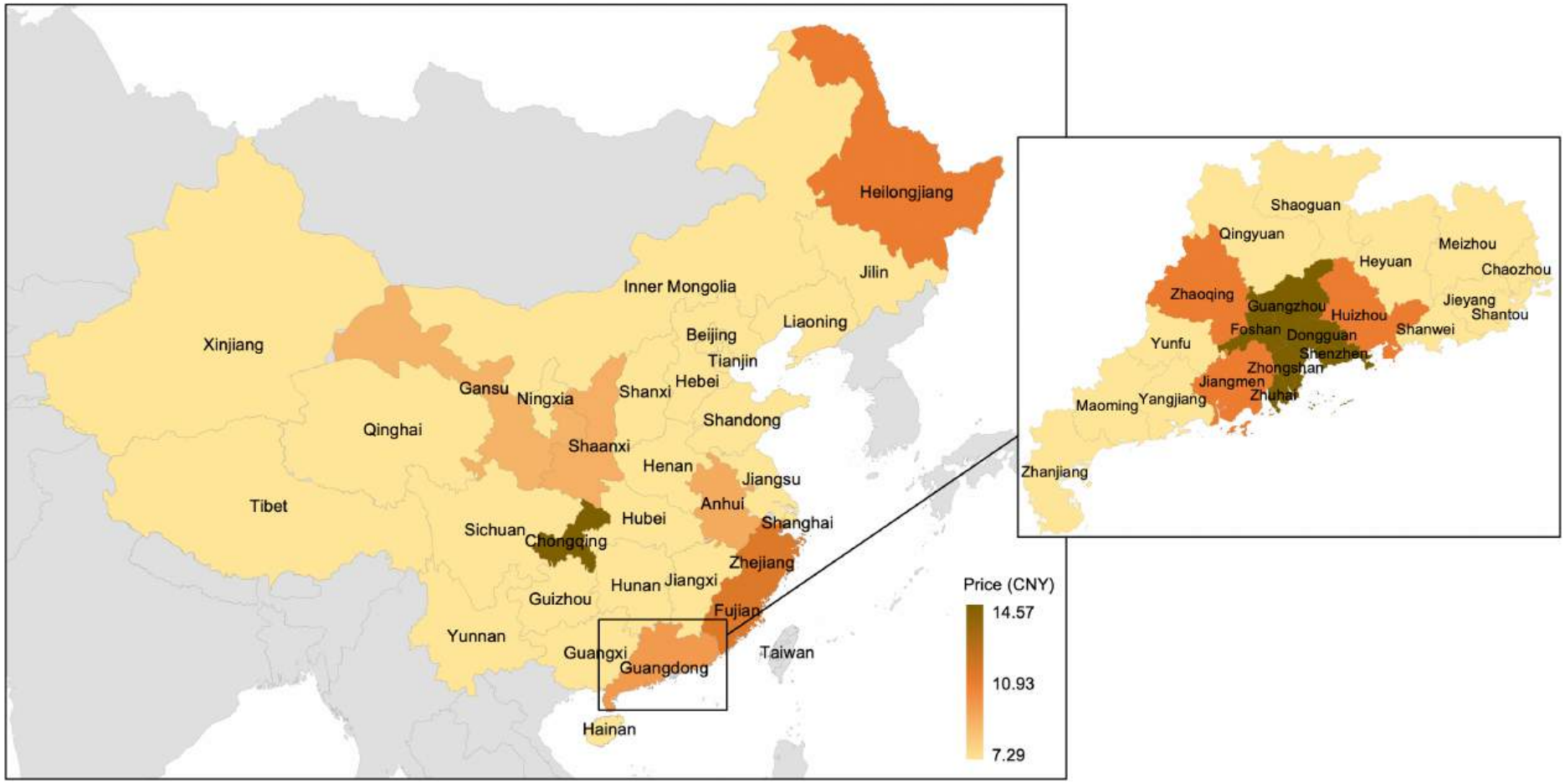


Fig. 2.2: An overview of FVRF in China's 31 administrative divisions, as set in 2015. Mean of the seven price levels of FVRF applied in each provincial-level administrative region in China, calculated based on 31 regional policy papers; most provincial-level governments set the fees for all the sub-regions under their command, except that Guangdong Province set more detailed price levels for its sub-regions.

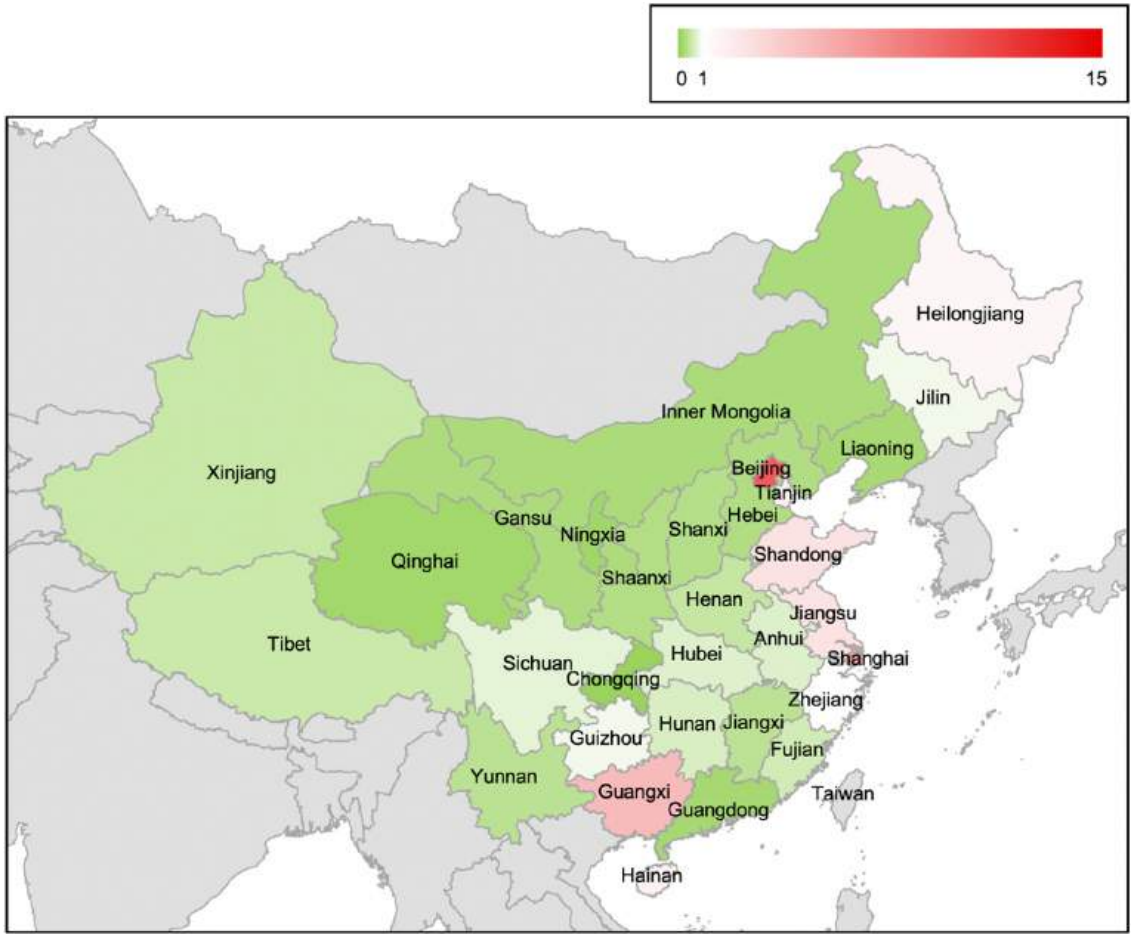


Fig. 2.3: Cost-price ratios for forest development in China's 31 administrative divisions. The ratio of the total provincial government spending on forest development in each region to the price levels applied in China's FRVF in 2018 under the average-case scenario. The full result of a sensitivity analysis considering best, average, and worse-case scenarios is presented in Appendix B. The current price levels renewed in 2015 were less than the cost of compensation - which includes, if any, government corruption and misappropriation - in some regions including Beijing, Shanghai, Guangxi, Jiangsu, Shandong, Tianjin, and Heilongjiang. Suitable lands for forest (Table 2.2) are not considered in this analysis.

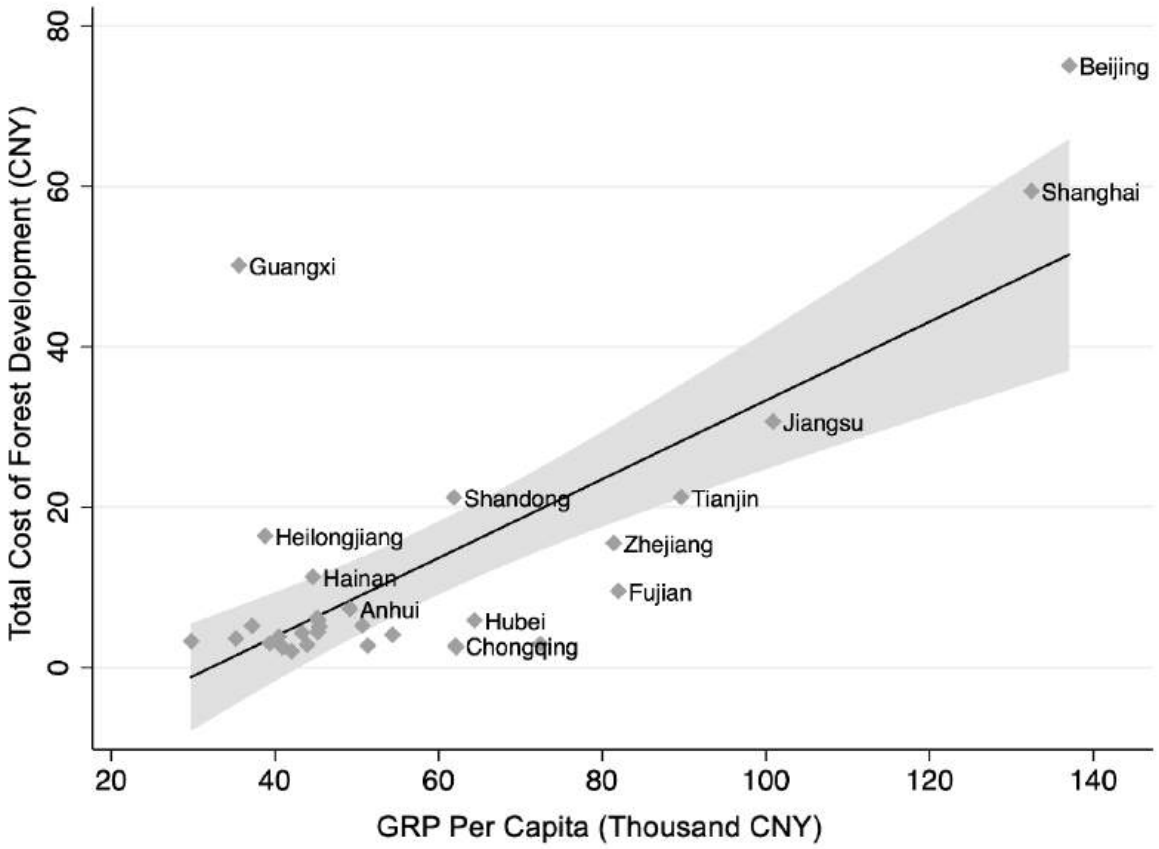


Fig. 2.4: Relationship between total cost of forest development and GRP per capita in China. Three-year mean of total cost of forest development and GRP per capita from 2016 to 2018 in each provincial-level administrative region (mean: black line; 95% confidence interval: grey shaded area). In general, developing a given amount of forest is more expensive in economically more developed areas (e.g., Beijing).

the projects have been permitted by the local authorities, though the Jiasajiang Level 1 Hydropower Station project has now been postponed due to a public lawsuit.

As shown in Fig. 2.5, most (77%) of the cases studied did not employ any quantitative biodiversity indicator, as this is not a requirement for developers. In 45% of cases, the report describes "*low levels of biodiversity on the development site*" or "*no protected or endangered animals or plants have been found*", with the EIAs concluding with statements such as "*biodiversity* (or *the natural environment*) *has not been affected*", or "*the influence on biodiversity* (or *the natural environment*) *is negligible*". 32% of the EIA reports listed the names of affected family, genus, or species only; for example, the Chinese sumac (*Rhus chinensis*), the Chinese parasol tree (*Firmiana simplex*), magpies

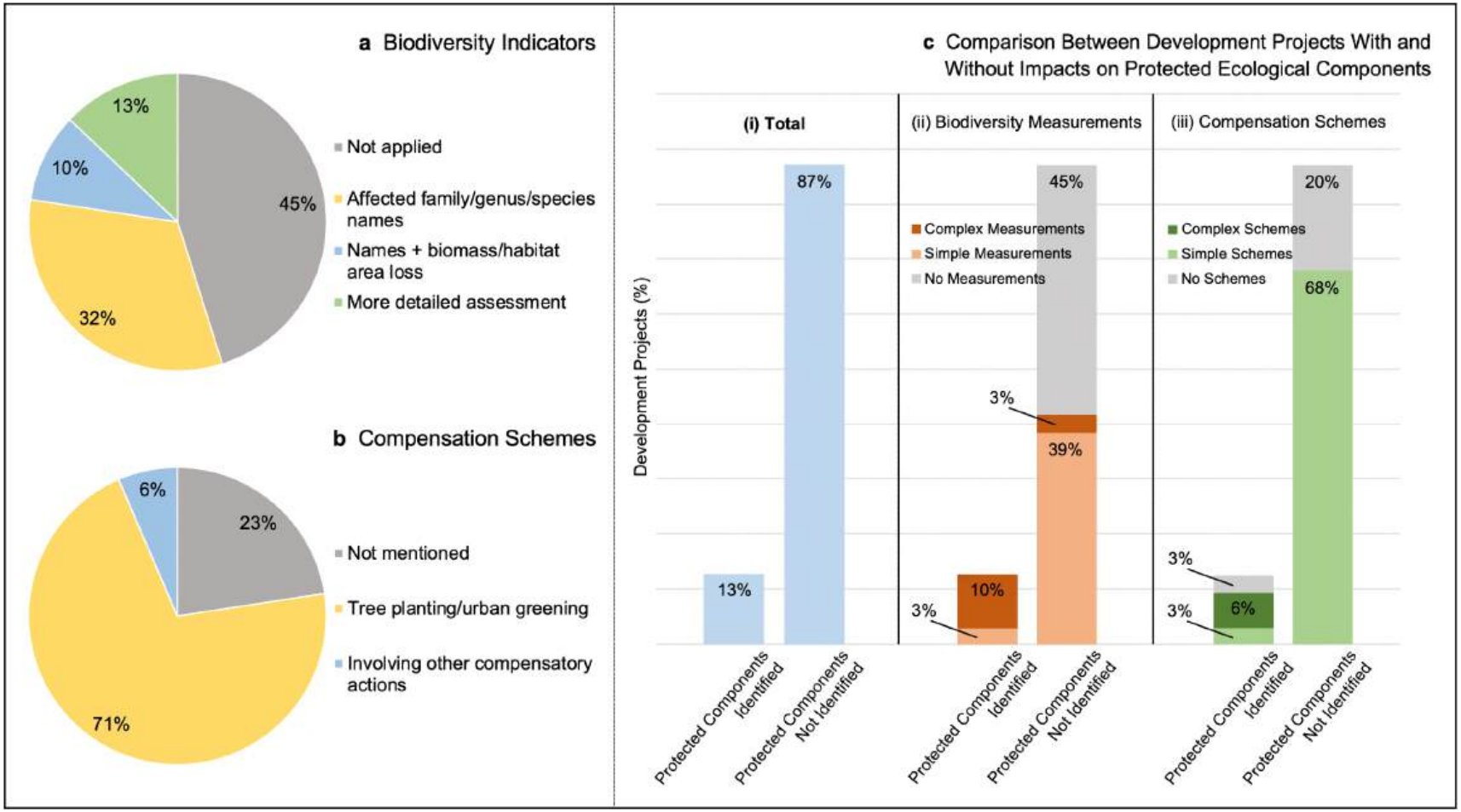


Fig. 2.5: Characteristics of sampled EIA reports. Panel a demonstrates how developers characterise biodiversity. Panel b shows what types of compensatory actions are planned. Section c shows differences between EIA reports that (i) identify some (13%) or no impacts on protected species or habitats (87%), and (ii) methods used for biodiversity measurement, and (iii) types of compensatory schemes. If impacts on protected ecological elements are not identified, EIAs tend to employ less detailed biodiversity measurements and come up with less complicated plans for compensations. 'Simple measurements' means recording names of affected family/genus/species with or without an indication of the area of biomass/habitat lost. 'Complex measurements' means an assessment that includes more detailed indicators, such as species abundance. 'Simple schemes' include compensations that only deliver tree planting or urban greening. 'Complex schemes' include schemes including other compensatory actions (e.g., fish ladders).

(*Pica pica*), or sparrows (*Passer montanus*). 10% of them incorporated an additional quantitative indicator of biomass or habitat area loss, while 13% carried out a more detailed assessment. For instance, the EIA report for Jiasajiang Level 1 Hydropower Station applied biodiversity indicators including forest patch indices, habitat area, primary productivity, biomass loss, species traits, and species abundance. In EIAs which reported no impacts to important species or habitats (87% of cases), there was a clear trend towards using less complex biodiversity indicators.

Developer-led compensation practices tended to mix habitat-level activities with more elaborate landscape-level practices. Among all my sampled EIAs, 71% planned to carry out tree planting or urban greening projects, in order to "*to some extent redress development impact*" by restoring a certain area of natural habitat. They are incentivised to replant vegetation and restore habitats on their own to reduce the risks of developments being rejected as well as to reduce the financial costs of restoration fees paid to the government. Six per cent of all EIAs planned to conduct more detailed compensatory actions. For example, the 353 Provincial Highway (Yangzhou East Section) Project intended to (i) restore onsite grassland using medick *(Medicago*) and white clover (*Trifolium repens*), (ii) restore old and develop new fish ponds, and (iii) develop an offsite 1035.5-mu (~69 hectare) tree planting project. In my sample of EIAs, I only identified the implementation of more complex compensation practices in projects which had identified an impact on protected ecological elements (e.g., ecosystems, habitats, or species). The one assessment that reported protected ecological elements but did not apply biodiversity indicators or design compensation actions was an EIA identifying impacts on one of China's protected bird species, magpies (*Pica pica*). The report concluded there would be no effect on the species, assuming that they would be capable of finding new habitats by themselves. In fact, all the EIA reports which identified impacts on birds and reptiles assumed their unrestricted ability to move elsewhere, with no critical interrogation of this assumption.

2.4.2 Impact Compensation Delivered by Local Governments

Out of 2,844 county-level governments, I found a total of 10 local governments that had disclosed information on their compensatory activities (Table 2.3). For example, Table 2.4 details the specific compensation land-management practices reported by the Forestry Bureau of Longhui County in 2020. The restoration fees by law should be spent on development or renewal of natural habitats. In China's compensation policy, out-of-kind compensation is legally acceptable, and in practice, devising appropriate, ecologically-equivalent, in-kind compensation is hampered by the EIA procedure not requiring developers to use biodiversity measurements. Many local governments' compensation actions are similar to the developers' tree planting/urban green projects, such as a monoculture forest development using the Chinese red pine (*Pinus tabuliformis*) in Yangqu County in 2022 (Table 2.3).

Due to China's flexible replaceability standards, some local governments' compensation activities have also been designed as nature-based solutions that provide wider environmental benefits to the economy and society (Table 2.3). For example, the Forestry and Grassland Bureau of Ganluo County of Sichuan invested its entire CNY 500 thousand (c. USD 70 thousand) FVRF fund in walnut tree development, including two enhancement projects that covered in total 1,700 mu (~1.13 hectares), because the walnut industry is a means to reduce poverty and support local people's livelihoods (Cao et al., 2016). The Forestry Bureaus of Yongxing County and Longhui County of Hunan also implemented a range of different compensation measures which generated local livelihood opportunities, including spending part of their restoration fees on developing a base for Camellia (*Camellia oleifera*) cultivation and enhancing the quality of Camellia forest in order to improve its yield (Table 2.4).

2.4.3 Compliance and Monitoring

According to China's Forestry and Grassland Laws, the funds generated by compensation fees must be spent on: (i) ecological survey, design, and planning, (ii)

habitat restoration and development, and (iii) conservation management and monitoring. China's National Forestry and Grassland Administration's policy paper *Guiding Opinions on Formulating Conditions for Restoration of Vegetation and Forestry Production, and Standards for Replanting of Trees* also suggests that compensation work should be done to provide additional benefits that would not have been delivered if the compensation had not been implemented, in order to reverse trends of environmental degradation. Otherwise, their spending will be regarded as the misuse or misappropriation of compensation funds; for example, in 2011, the Forestry Department of Xinjiang Autonomous was adjudged to have misappropriated CNY 4.24 million from the FVRF fund to pay expenses for the work of the department and its subordinate units (Wang, 2012). In the case study of Longhui County in Table 2.4, it is not immediately clear why programs of "*forest highway development*" and "*building/maintaining the Centre for Forest Public Security, Resource Protection and Case Handling*" should be considered additional conservation actions rather than misappropriations.

Yet, because of the lack of transparency in reporting by local authorities, it is difficult to assess whether many of China's compensation activities deliver additional benefits in the long term. On the biodiversity loss side, not all EIA reports are made transparent, or at least easily accessible, to the public; to my knowledge there is no online database containing developments' full EIA reports for public scrutiny. Thus, it can be difficult for the public to understand how a development project might affect biodiversity before the development is carried out. On the compensation side, other than the information from the 10 county-level governments assembled in Table 2.3, I failed to find any public information on how much compensation payment has been collected from developers and how they are utilised by the other 2,834 county-level governments. However, even among the published reports analysed in this research, there are still large information gaps, such as the specific locations where compensation takes place.

Table 2.3: Local governments' compensation practices funded by restoration fees.

Local Agency	Year	Fee Type	Expenditure (CNY)[a]	Disclosed Compensation Practice
Forestry Bureau of Mianchi County, Henan	2018	FVRF	11.14 million	Railway greening, improving the surrounds of Shaoshan forest park, mine land reclamation, village greening/green space improvement.
Financial Bureau of Fugu County, Shaanxi	2019	FVRF	940 thousand	Barren hills afforestation, subsidy for village greening projects.
Forestry Bureau of Yongxing County, Hunan	2019	FVRF	200 thousand	Subsidy of camellia improvement for increasing yield.
Forestry Bureau of Longhui County, Hunan	2020	FVRF	4.96 million	Urban greening, riverside greening, existing wetland protection, old-growth tree protection, roadside greening, young forest tending, highway development for forest accessibility, seedling base development, camellia base development, building/maintaining forestry management office
Forestry and Grassland Bureau of Ganluo County, Sichuan	2020	FVRF	500 thousand	Walnut tree planting.
Dunhuang Natural Resources Bureau (Forestry and Grassland Bureau), Gansu	2020	GVRF	5.30 million	Monoculture grassland planting (*Onobrychis*), pest control, vegetation restoration with fence building, hiring ranger, making signs and billboards, road development in field, publicity of grassland laws & regulations.
Changsha Natural Resources and Planning Bureau Wangcheng Branch, Hunan	2021	FVRF	300 thousand	Soil preparation, afforestation forest restoration, pest control, resource management.
Aksai Kazak Autonomous County Grassland Supervision Station, Gansu	2021	GVRF	747.10 thousand	Fence development, grassland quality improvement, grass seeds purchase, grassland reservoirs, weir, settling basin, pipeline laying, signage.
Forestry Bureau, Yangqu County, Shanxi	2022	FVRF	1.6 million	Fire prevention, monoculture forest planting (*Pinus tabuliformis*).
Ordos City Natural Resources Bureau Dongsheng District Branch, Inner Mongolia	2022	FVRF	1.11 million	Afforestation (*Prunus armeniaca* and *Pinus tabuliformis*)

[a] 1 CNY = 0.14 USD.

Table 2.4: Compensation Case Study: Longhui County, Hunan Province, China.

Number	Compensation Programmes in Longhui County[a]
1	CNY[b] 615 thousand was used for improving green coverage in 12 villages
2	CNY 310 thousand was used for riverside greening in 6 villages
3	CNY 823.919 thousand was refunded to a wind power development due to project cancellation
4	CNY 1963.881 thousand was used for Wetland Protection in Weiyuan Lake Wetland Park; actions included forest protection project design, forest fire prevention, forest resource database construction, and forest pest control
5	CNY 70 thousand was spent for old-growth tree protection in two villages
6	CNY 347.2 thousand was used for roadside greening
7	CNY 20 thousand was invested into management of young forest in Qinglongjiang Village
8	CNY 500 thousand was used for a forest highway development to provide improved access to forest areas for logging, afforestation and forest protection
9	CNY 50 thousand was used for seedling production in the Shouzhu Garden
10	CNY 100 thousand was used for the development of a base for cultivation of Camellia
11	CNY 160 thousand was spent for building/maintaining the Centre for Forest Public Security, Resource Protection and Case Handling

[a] Longhui County is located in Shaoyang City within Hunan Province. It has more than 200 families and over 1,000 species of vegetation. The county is a national-level production base for pepper, tea, and oranges. In 2019, the County's CNY 4.96 million forest vegetation restoration fee was invested into forest development in the area. This information is collected from the documentation released by the government of Longhui.

[b] 1 CNY = 0.14 USD.

2.5 Learning from Best Practices in Compensation

China's compensation policy is based on a restoration fee system applied nationwide. My analysis of China's forest vegetation restoration fees suggests that it is likely that compensation prices are insufficient to cover the costs of forest development in certain regions (Fig. 2.4). This in turn suggests that the fees in these regions should be set higher to cover the actual costs of compensation, or the policy will not deliver

on its aim of NNL of forest cover. A compensation target (e.g., NNL of forest cover) may not necessarily be fulfilled only through one restoration fund, and it is common practice in China's political setting that, even if local governments stick to the insufficient price levels of FVRF, the residual costs of forest development can still be covered by other restoration funds transferred horizontally from other government revenue (e.g., from other taxes) or vertically from the central state. This may explain why China has still experienced an increase in forest area despite these issues with the current price levels. Yet, the economic theory behind compensation is 'polluter pays', which accords with the ethical basis of China's compensation approach (Table 2.1). Thus, though China's current strategy appears to be leading to the desired compensation results, China's government may still need to consider revising its price levels, not only in order to increase the finance available for compensation, but also for increased economic efficiency within the system.

However, before raising the fees, the apparent disparity between forest restoration fees and restoration costs must be investigated. For example, the disparity in more affluent regions such as Beijing and Shanghai could relate to less purchasing power (e.g., higher land prices), more costly afforestation practices (e.g., implementing more polycultures instead of monocultures only), or systematic issues like administrative corruption. It could be that simply raising fee levels might lead to better conservation outcomes, both through improving funds for compensation and as a financial disincentive to clear land and an incentive for active compensation. However, it is ethically and economically important to more clearly understand which costs should be shouldered by the developers, versus those which should be mitigated through other measures, such as addressing misappropriations of the restoration funds (Maron et al., 2016).

If prices are increased to meet the actual costs of carrying out restoration, China's restoration fee system could be an effective and efficient method for redressing the natural habitat area losses caused by developments and supporting China's goal of

conserving and planting 70 billion more trees before 2030 (WEF, 2022). However, there is still the issue that China's compensation policy only relates to habitat area and does not account for a habitat's quality, functional role within an ecological network, conservation value, species richness and many other such attributes. In addition to habitat area, compensation needs to account for such features to realise its target of "*maintaining biodiversity*" (Niu et al., 2023). Since China has prioritised economic development as a developing nation, the government's long-standing 'develop first, fix later' model has situated its compensation policy on top of a 'weak replaceability principle' that assumes two different biodiversity resources are exchangeable with one another (for example a wetland forest with roadside tree planting). Thus, to meet the targets set in the central government's recent commitments to embed conservation into the economic and social fabric of China and improve China's biodiversity (State Council, 2021a), the government may need to revise its replaceability principle towards the international best-practice standards of 'like-for-like' or 'like-for-like or better', whilst strengthening the use of mitigation hierarchy (Gardner et al., 2013; Bull et al., 2013; McKenney & Kiesecker, 2010). Embracing higher replaceability standards requires the design and delivery of better avoidance and minimisation policies that prevent impacts to irreplaceable biodiversity, followed by a strengthened compensation policy that carefully replaces all biodiversity losses (not merely habitat cover).

As defined by international good practice, measurability is a fundamental attribute of biodiversity offsetting (Maron et al., 2016; Bull et al., 2013 & 2016; Baker et al., 2019). Quantification of biodiversity impacts is an important precursor to precise evaluation of the performance of compensation and whether or not it meets its conservation goal (e.g., NNL or maintaining biodiversity). To measurably record the biodiversity impacts of developments, China's developers would need to use well-structured biodiversity indicators that can capture diverse biological components and some degree of ecological processes behind the habitats (Mayfield et al., 2022). The current absence of policy requiring the use of robust biodiversity measurement represents a

significant risk to biodiversity, especially when the redline policy cannot recognise some important areas in a clear and timely manner (Xinhua, 2017; Jiang et al., 2019). For instance, the EIA report on Jiasajiang Level 1 Hydropower Station recorded many vital biodiversity components on the development site (Appendix B), including seasonal tropical forest and green peafowl (*Pavo muticus*), which is categorised as Endangered on the IUCN Red List. Though it applied indicators to capture the biodiversity elements which were present, it assumed that birds can migrate to other places and thus failed to address the ecological disturbance caused by the development; for example, flooding of the dam destroying the Red River upstream area which has been identified as the last habitat for green peafowl in China (Tang et al., 2019; Wu et al., 2019). Since the biodiverse zone had failed to be officially recognised within an ecological redline, the development was being implemented and listed as a key project by the local government. In fact, all the EIA reports I reviewed assumed that birds and reptiles would not be impacted by the development because of their ability to find new habitats. Though this may occasionally be true, the case study shows that this assumption may also permit serious and irreversible biodiversity losses.

The green peafowl case also indicates the importance of defining biodiversity indicators using a common and consistent framework. Otherwise, some important biodiversity effects might unintentionally be disregarded in practice. Currently, since the compensation policy is devoid of biodiversity measurement requirements, there is wide variation in the indicators used. However, if there is unrestricted flexibility in the choice of indicators used to measure a development's impacts on biodiversity, there is a great scope for selective reporting that may undermine the conservation of specific, unreported biodiversity components in order to increase the probability of project approval (Bull et al., 2014). Additionally, a common indicator framework could be used to measure biodiversity gains from compensation, whether implemented by developers themselves or local governments. This can make what is lost on a development site comparable to what is gained on a compensation site,

producing the ecological equivalence which is missing in China's compensation policy but is well established in international good practice (McKenney & Kiesecker, 2010; Quétier & Lavorel, 2011). This is essential for tracking the effectiveness of the policy in actually compensating for biodiversity losses.

Similar to the current requirement introduced in China's compensation legislation, best practice also requires compensation which provides additional and positive effects on biodiversity (Bull et al., 2013; Overton et al., 2013; Moilanen & Kotiaho, 2018). Evidence is required to prove the effectiveness of compensation practices (such as fence building in Table 2.3), but currently the compensation information disclosed is insufficient for researchers to conduct impact evaluations and develop a robust understanding of policy effectiveness. Furthermore, best practice requires compensation to persist for at least as long as the adverse biodiversity impacts from the development project (Bull et al., 2013; Gonçalves et al., 2015; Damiens et al., 2021a). Evaluation of whether compensation persists over time requires time-series information supported by adequate monitoring (McKenney & Kiesecker, 2010; Gordon et al., 2015). The current ambiguous disclosures practiced in China impair compliance monitoring; in compensation systems in other countries, compliance failures have been found to be widespread (zu Ermgassen et al., 2019; Theis et al., 2020), and this is, therefore, a concern for China as well. Establishing a public national offset register supported by well-established biodiversity indicators, including information on how local governments spend their restoration fees, ex-ante ecological assessment, and ex-post compensation implementation and outcomes, would be a major step forward (Hunter et al., 2021; Gao et al., 2022; Kujala et al., 2022). Additionally, developers should be required to precisely report their compensation activities in their EIA reports, detailing in a measurable way how these actions are expected to counterbalance the losses they are generating. These EIA reports should be made public to improve transparency, helping to identify ecologically-risky development activities and misappropriations of the compensation funds, and facilitating improved compensation performance assessment and monitoring.

2.6 Conclusions and Recommendations for Future Research

I provide the first overall evaluation of China's eco-compensation policy and practice. Based on the evidence I have assembled, I also provide recommendations for China to align with international best practices in biodiversity impact compensation. First, in policy, I found that the pricing of forest restoration fees is insufficient in several provinces. I recommend these regional governments conduct a more careful and up-to-date evaluation of the costs required for local forest management and evaluate whether current price levels should be increased. Also, I found that there is currently no policy requirement either for biodiversity metrics to be used to measure development impacts on biodiversity, or for ecological equivalence of compensation and losses. Thus, I recommend that the central government should consider legislating for biodiversity impact measurement using a unified indicator framework, and, if possible, make it compulsory for all development activities. There are many examples in other countries from which China could draw lessons; for example, though not perfect, the latest version of the biodiversity metric in the England is an example for China to learn from (zu Ermgassen et al., 2021).

In practice, without a regulatory safeguard for biodiversity metrics and ecological equivalence, I unsurprisingly found that only 23% of a sample of 31 developments applied quantitative biodiversity metrics, drawing on a range of indicator frameworks. This evidence strengthened my recommendation to make the application of a unified framework mandatory. Also, fewer than 1% of China's local governments have disclosed information regarding compensation implementation. This highlights a key problem for future studies of eco-compensation in China: publically-available information in its current form does not permit an assessment of biodiversity losses and gains under the policy, which hinders a robust assessment of the policy's effectiveness at achieving its goals.

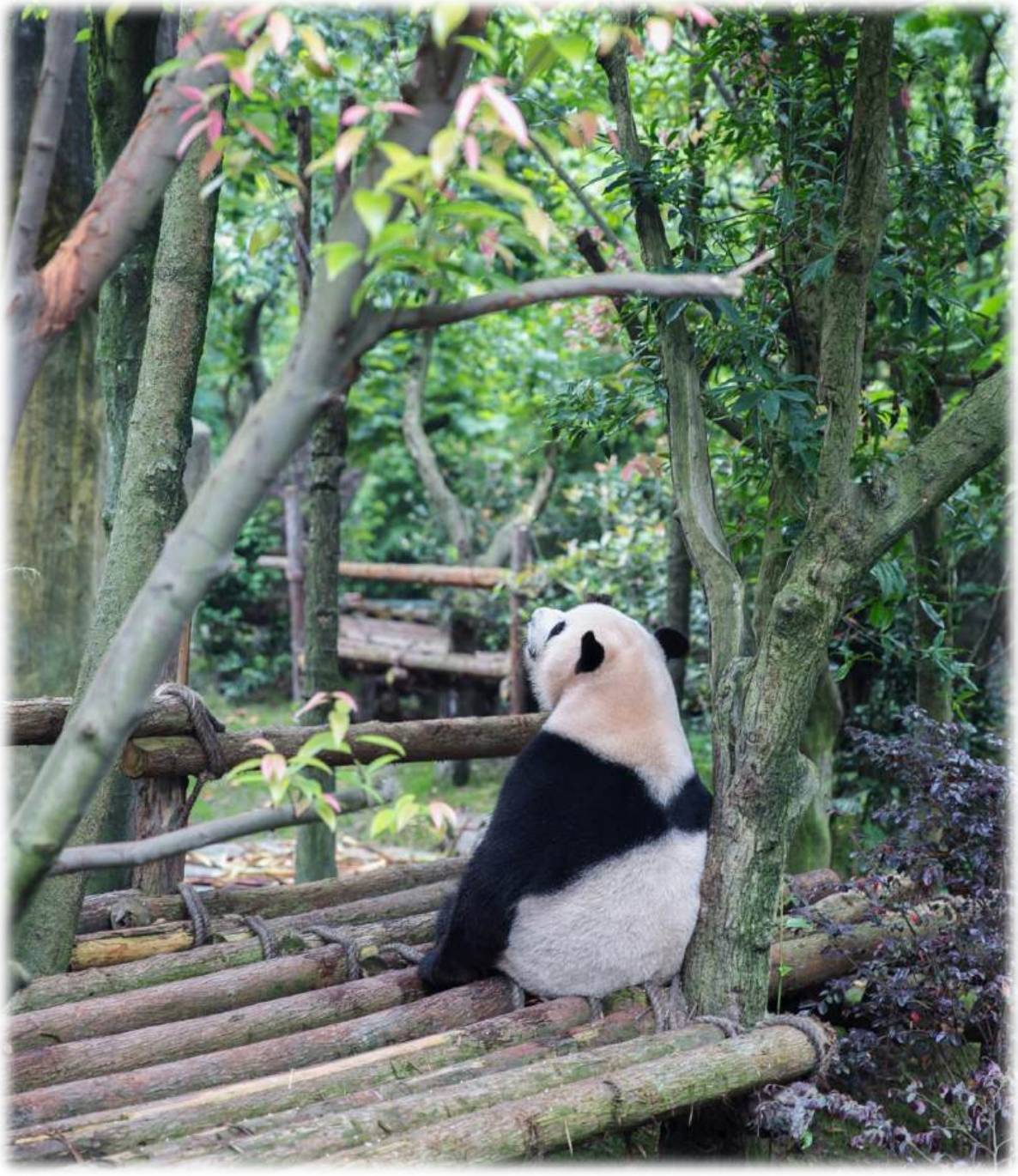
Recently, China's government has strengthened its strategic aspiration to actively participate in biodiversity governance through collaboration and international

knowledge exchange (State Council, 2021b). The government can meet this aspiration by improving first its avoidance and minimisation policies, and then improving its compensation approach. This is important as China's future development plans are substantial, and likely to have major biodiversity impacts; a recent estimation predicts that by 2100, China's urban area will be 121,199-142,982 km^2, 34-58% higher than the urban area in 2020 (Huang et al., 2022).

Equally, there are some special features of China's compensatory mechanism which might be informative for compensation design in other countries. For instance, the government charges upfront compensation fees and then reimburses developers for delivering biodiversity impacts which are less than those expected in their EIAs. This feature differs from other countries' compensation approaches and could encourage developers to avoid and minimise their biodiversity impacts at the early stages of their projects. Thus, future research studying China's compensation approach could provide empirical evidence that supports effective avoidance and minimisation, which are the most critical steps of the mitigation hierarchy (Phalan et al., 2018; Milner-Gulland et al., 2021; Bull et al., 2022).

Compensation design also faces trade-offs between biodiversity and social values, since conservation is not always prioritised over economic development (Taherzadeh & Howley, 2018; Griffiths et al., 2020; Jin et al., 2021), while the well-being impacts of development and associated compensatory actions on local people are often ignored (Bidaud et al., 2018; Griffiths et al., 2019a & 2019b; Jones et al., 2019). Future assessments of China's compensation approach could provide understanding of when and where social well-being has been prioritised and how solutions that work for both nature and people can be designed and implemented. I found some of China's compensation programs in the late 2010s strived for nature-based solutions that help address livelihood insecurities in some of the most underdeveloped communities. These practices may have led to less compensation for loss of natural habitats, if 'like-for-like' or 'like-for-like or better' compensation is set as the benchmark (Maron et

al., 2016; Bull et al., 2016; Baker et al., 2019). However, in some situations it may be preferable to put an emphasis on supporting people's well-being alongside nature conservation (Newing & Perram, 2019; Maron et al., 2020; Domínguez & Luoma, 2020). Studying the interaction between human well-being and biodiversity in the context of China's eco-compensation practices would provide substantive insights to support the future design of socially just ecological compensation, particularly given that China is both a major developing economy and a highly biodiverse country.



CHAPTER 3

PSYCHOLOGICAL MECHANISMS UNDERPINNING ENVIRONMENTAL MISPERCEPTIONS

Abstract

Countries worldwide have collectively agreed to halt and reverse nature loss. However, a poorly understood and systemic challenge to this vision is shifting baseline syndrome, wherein people misperceive the extent to which nature has been changed, with erosion of the baseline of what 'good' nature looks like over time, either between generations or for an individual. This can diminish societal expectations for nature recovery. Here, I propose a framework that incorporates cognitive mechanisms underlying environmental misperceptions, broadening the conceptual framing of SBS to include other mechanisms behind misperceptions of environmental change, and including not just nature loss but also recovery. I demonstrate the utility of the framework using a mixed-methods study in Qunli New Town, Harbin, China, consisting of in-depth interviews (N=42) and a population-based quantitative survey (N=1018). My results show that more accurate perception is associated with gaining information about an area from personal experience rather than indirect information sources. Cognitive errors, including errors of 'omission' and 'commission', were related to the processes of sensation, attention, learning, thinking, and memory. Minimising SBS is important to ensure that people affected by environmental change are able to perceive it accurately, so that they can better respond to it; this is essential to pursuing resilient, sustainable, and inclusive societies under the Sustainable Development Goals and the GBF.

"*No one will protect what they don't care about, and no one will care about what they have never experienced*."

- David Attenborough

3.1 Introduction

Nature recovery is a salient topic embraced globally by governments, businesses, financial institutions, and the conservation sector (Bull et al., 2020; Locke et al., 2020; zu Ermgassen et al., 2022; Maron et al., 2024). As nations commit to taking urgent actions to support a nature-positive future (zu Ermgassen et al., 2022; Maron et al., 2024), it is vital for the general public to be able accurately to perceive trends in their natural environment, so that they can hold governments and companies implementing nature recovery to account. The socio-psychological phenomenon known as shifting baseline syndrome (SBS; Pauly, 1995; Papworth et al., 2009; Soga & Gaston, 2018), wherein people misperceive the extent to which nature has been degraded or improved, can diminish societal expectations and imaginations about how much nature a society wants (Miller et al., 2005; Ostergren et al., 2008; Soga & Gaston, 2018; Jarić et al., 2022), posing a barrier to realising the transformative change needed to move us back within planetary boundaries that we have transgressed (Raworth, 2017; Díaz et al., 2019; Richardson et al., 2023). Therefore, SBS needs to be addressed as part of the path to nature recovery.

SBS can be personal or generational, namely a change in perceptions experienced by a person in their own life or between generations; therefore it is mostly conceptualised as related to someone's age (Papworth et al., 2009). Previous literature has largely focussed on research reporting resource users' perceptions regarding changes in natural resources, but SBS in principle can occur across diverse environmental conditions, ecosystems, and stakeholders (Soga & Gaston, 2018), and

its features may differ between societies (particularly if there is rapid social change accompanying the ecological change). Besides, although SBS provides a logical explanation for inaccurate reporting of past environmental states, other mechanisms causing mismatches between perceptions and reality have also been identified, for example change blindness and memory illusion (Papworth et al., 2009; Daw, 2010). Additionally, most previous studies set SBS within the context of environmental degradation. Yet, it is essential also to understand how SBS plays out as nature recovers given that, in some places, effective conservation action and legislation are improving the environment for new generations (Roman et al., 2015; Passoni et al., 2023).

To understand and tackle the mechanisms underpinning environmental misperceptions is both ecologically and socially important (Soga & Gaston, 2018; Ford et al., 2020; Swanson et al., 2021; Hidalgo Pizango et al., 2022; Soga et al., 2023; Soga & Gaston, 2023). Lack of reliable baseline information is recognised as a fundamental barrier to resolving a broad swathe of contemporary environmental issues[7]. Baselines established through inaccurate environmental perceptions can weaken the validity of participatory monitoring, community-based conservation, and environmental education (Papworth et al., 2009; Swanson et al., 2021). Socially, it is vital to understand how environmental change impacts people's interpretation of the environment, as this underlies their experiences of and responses to (or lack thereof) the change (Hackmann & St Clair, 2014; Downing et al., 2019). One immediate consequence of SBS could be a decreased awareness of environmental degradation, potentially reducing pro-environmental attitudes and behaviours (e.g., pressure on government or businesses to undertake restoration actions; Soga & Gaston, 2016 & 2018; Jones et al., 2020). This indifference and inaction in the face of worsening environmental situations could potentially take a toll on people's environmentally-based well-being, for instance, access to fresh water and basic materials, security from natural disasters, or recreational and cultural benefits (MEA, 2005; Díaz et al., 2006; Bryce et al., 2016). These well-being effects can be intertemporal or telecoupled

(Agyeman, 2013; Robles-Zavala et al., 2018), such that people who suffer the heaviest well-being losses are not necessarily the ones who possess inaccurate or inadequate environmental knowledge. A lack of awareness of environmental improvements could also be dangerous, by reducing the strength of calls for further nature recovery if people do not recognise the well-being benefits that it generates (Shoyama et al., 2013; Hausmann et al., 2016).

For these reasons, researchers have called for better understanding of how people perceive and recall environmental change (Daw, 2010; Essl et al., 2015; Jarić et al., 2022), and how to prevent and reverse SBS (Soga & Gaston, 2018). However, to my knowledge, few studies, if any, have explicitly attempted to address this problem. Also, similar to other interventions in the psychology field, interventions to restore environmental knowledge can be difficult to scale up without properly understanding the psychological mechanisms behind misperceptions. To my knowledge, there is little to no research that explicitly discusses the psychological mechanisms behind mismatches between perceived and actual environmental change. Together with the academic need to explore SBS beyond the natural resource context, and consider how SBS interacts with social change (Soga & Gaston, 2018), I aim to present a framework that can be applied to study environmental misperceptions in any local context.

3.2 Materials and Methods

3.2.1 A Framework to Study Environmental Misperceptions

I present a framework that conceptualises people's environmental misperceptions, drawing on and extending the typology of Papworth et al. (2009), as shown Fig. 3.1. SBS encompasses generational and personal amnesia (Fig. 3.1b; Papworth et al., 2009; Jones et al., 2020). 'Generational amnesia' refers to the phenomenon where individuals shape their perceptions solely based on their own experiences, and do not transmit these experiences to succeeding generations. 'Personal amnesia' characterises individuals adjusting their perception of what is normal, to the extent

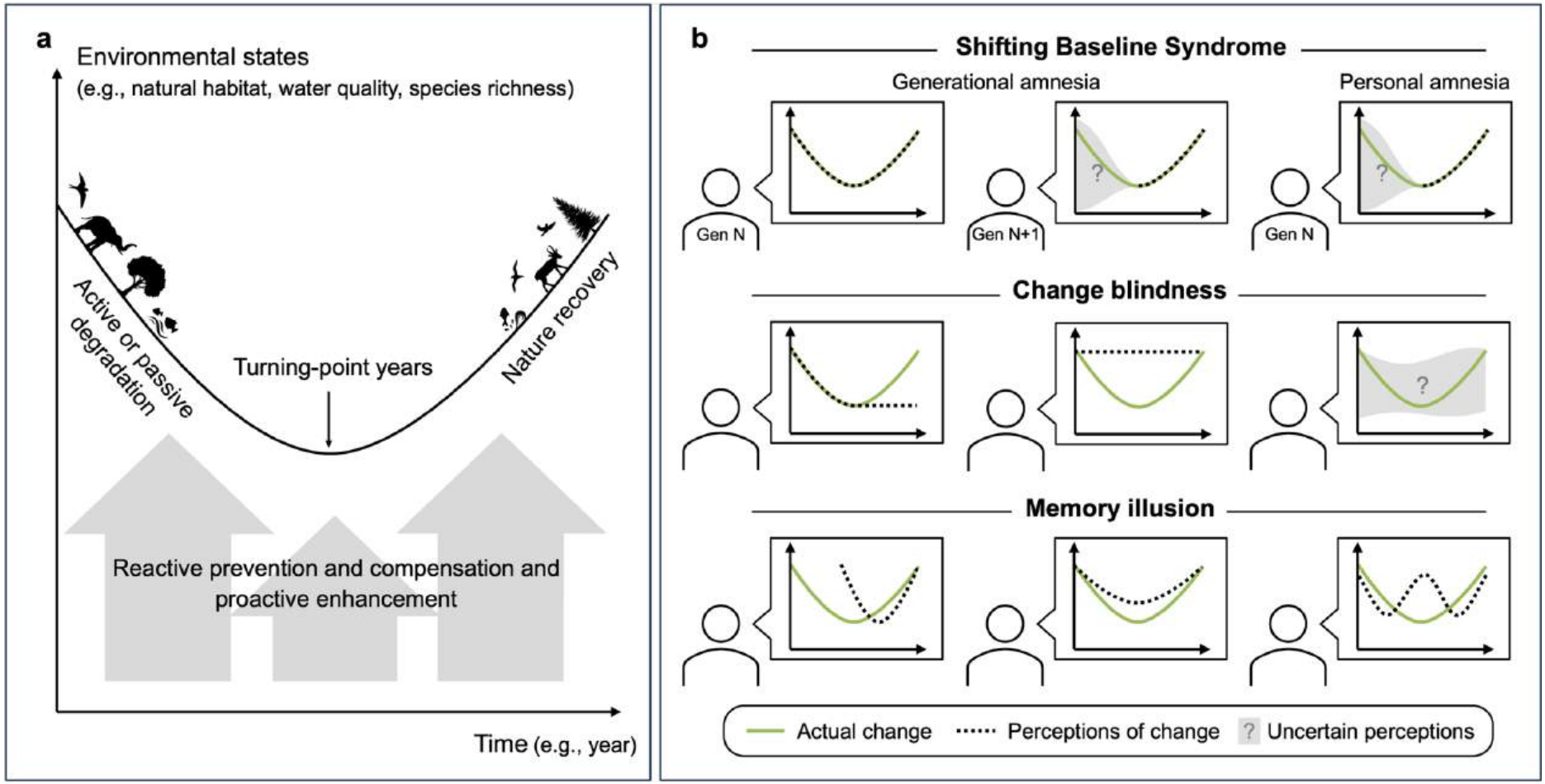


Fig. 3.1: A conceptual model of (mis)perceptions of environmental baselines within a social-ecological system. **a**. presents the environmental trend in a local ecological system; the trend also represents the general trends in area of greenspace, water quality, and fish species richness in my case study of Qunli New Town and Songhua River (Harbin section); **b**. describes local people's multiple (mis)perceptions of change within the local social-ecological system, within the typology of the four mechanisms for environmental misperception (i.e., SBS related to generational amnesia or personal amnesia, change blindness, memory illusion).

that even those who encountered different past circumstances come to believe that present conditions mirror those of the past. However, by definition, SBS also encompasses 'change blindness' and 'memory illusion'. Change blindness denotes the perceptual phenomenon wherein individuals exhibit an inability to discern a change; people can be blind to a change partially or entirely. A memory illusion, a false recollection of past events, can distort individuals' perception of the timing, magnitude, or/and nature of change.

SBS at the societal level

Studies exploring SBS in a social-ecological system need to compare people's environmental perceptions with actual environmental data, in order truly to evaluate the presence and nature of SBS (Papworth et al., 2009). At the societal level, it is important to answer questions such as who experiences environmental misperception, what factors (e.g., direct or indirect experience with nature, socio-demographic and economic characteristics) explain the degree of environmental misperception, and how do different types of misperceptions take place in a specific context (Fig. 3.1b). This knowledge could provide valuable insights that can inform targeted interventions to prevent future or restore past misperception.

SBS at the cognitive level

From the perspective of cognitive psychology, knowing is a process, not a product. To take my enquiries further into psychological understanding of how cognitive events drive misperceptions, I apply information processing theory from psychology (Reitman, 1964; Newell & Simon, 1972; Lindsay & Norman, 1972; Simon, 1978; Oppenheimer & Kelso, 2015). This theory views the human mind as a processor of information, likening it to a computer. This widely-accepted metaphor suggests the human mind receives, processes, stores, and retrieves information. I adopt this theory to study environmental misperceptions (Fig. 3.2). According to the theory, environmental stimuli – such as changes in vegetation, water quality, species

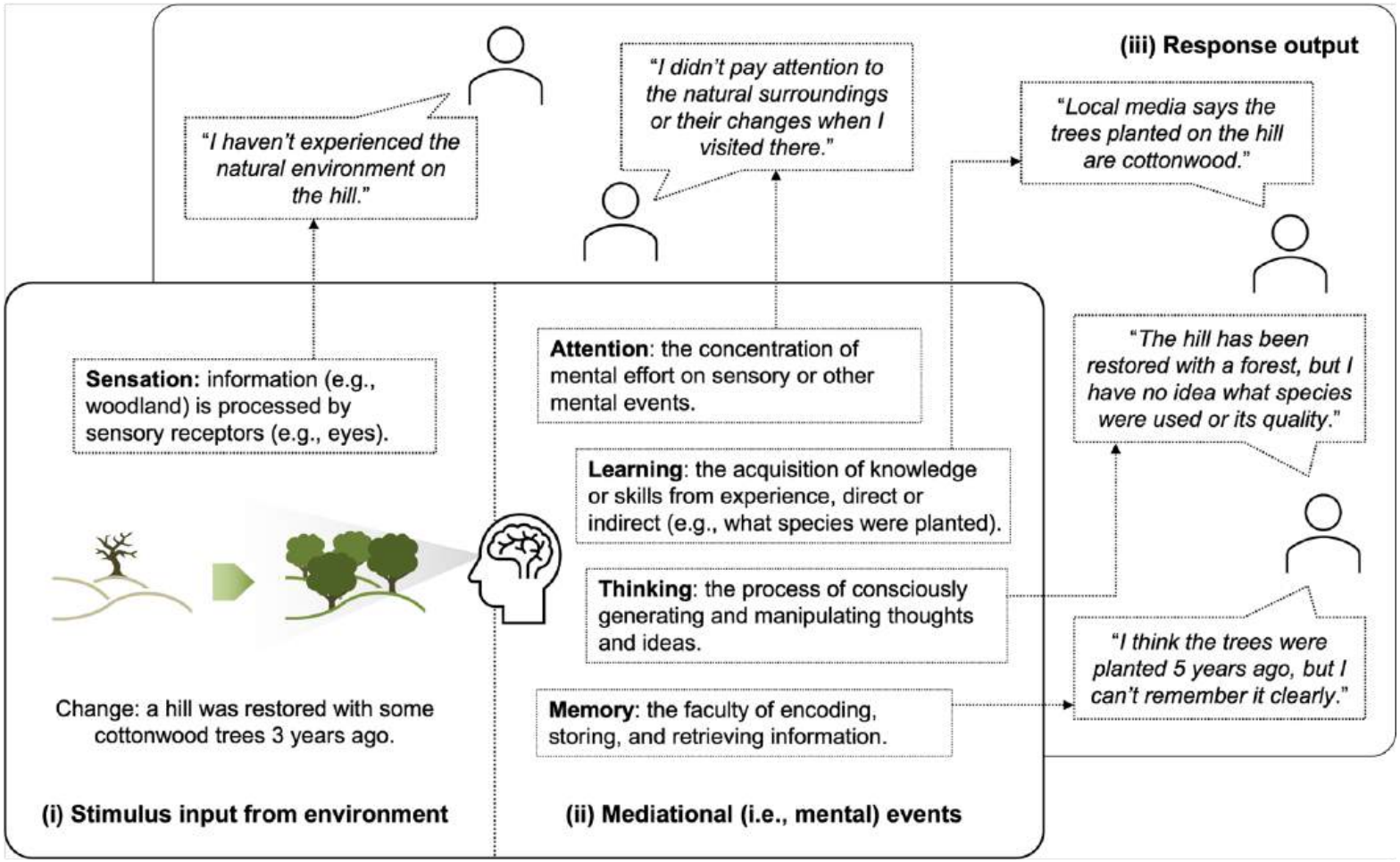


Fig. 3.2: A conceptual model of (mis)perceptions of environmental baselines within a psychological-ecological system. This model, based on the information processing theory, illustrates how individuals undergoing various cognitive processes may understand a piece of environmental information differently (Mesulam, 1998; Pisoni, 2000; Solso et al., 2005; Kausler, 2012). This diversity in processing can result in varied responses when individuals are questioned about the information. The conceptual diagram is not a comprehensive presentation of all mediational/mental events, or all possible responses from the local stakeholders. Instead, it is for conveying the general cognitive processes that can lead to SBS and other mechanisms demonstrated in Fig. 3.1.

populations, and landscape alterations – serve as sensory input. From the view of bottom-up processing, the detected information is then relayed to higher brain areas for further processing and interpretation. For example, when observing a flower in a particular habitat, bottom-up processing involves the sensory system detecting features such as shape, colour, and smell, which are then integrated to recognise the flower.

Information processing can be top-down too (von Stein et al., 2000; Engel et al., 2001; Gilbert & Sigman, 2007; Makino & Komiyama, 2015; Teufel & Nanay, 2017). Top-down processing involves the influence of higher-level cognitive processes, such as prior knowledge and expectations, on the processing and interpretation of sensory information. This means that cognitive processes can shape perception, such as by guiding attention, biasing ideas, and filling in missing information. For example, if an individual expects to see a certain flower species (e.g., lavender) about which they have sufficient prior knowledge, their expectations may influence how they pay attention to other plant species in the habitat, and can affect how they interpret ambiguous sensory information, leading them to perceive the flower even if it's partially obscured (Yuille & Kersten, 2006; 49. Himberger et al., 2018). In contrast, if the individual has insufficient knowledge, top-down processing can lead to biased perceptions, such as mistaking sage for lavender, due to the many shared similarities between the two species in appearance.

Applications of the framework

Understanding people's environmental misperceptions at the societal level can inform the design of interventions to restore these perceptions, if the goal is to make them as accurate as possible. Investigating misperception at the cognitive level can allow us to understand the phenomenon more fundamentally, guiding the design of more powerful interventions to address it. When designing interventions, distinguishing errors of 'omission' and 'commission' can be helpful (Schacter, 1999, 2002 & 2022). Errors of 'omission' include the many cognitive processes that can lead

to losses of 'information input or storage', for example, being inattentive or failing to memorise situations through time. They may also involve blocking, for example, the 'tip-of-the-tongue' (or 'tip-of-the-mind') syndrome where people know a piece of information, such as a past environmental feature, but struggle to recall it fully or accurately (Maylor, 1990; Brown, 1991). Errors of "commission" mean people have inaccurate knowledge due to a range of biases that distort their recollections of the past. This might include being subject to misinformation that implants incorrect knowledge, or being overconfident about their ability to notice and understand environmental changes.

3.2.2 Case Study Site

I apply my framework to a case study in the Qunli New Town (see section 1.2), where major societal change has happened (specifically replacement of a rural population with an incoming urban population as a result of a large urban development), and in which there has been loss of natural areas, but also compensatory efforts to produce new and enhanced natural areas associated with the development. This is a novel setting which allows a more nuanced and complex exploration of the interactions between societal and environmental change in an increasingly typical scenario of development and associated ecological compensation (Bull & Strange, 2018; Jacob et al., 2020; Damiens et al., 2021b).

3.2.3 Data Collection

The study employed a mixed-methods approach that consisted of two stages (see Methods). In stage one, I applied an exploratory case study methodology (Yin, 2009). Stage two involved a city-wide questionnaire survey to gain quantitative information on the prevalence and characteristics of SBS. I used my exploratory study and official documentation to design questions asking respondents to report their knowledge of the environmental context and perceptions of environmental change, which could be compared against three ecological indicators for which I had real data on ecological

change over time, including the area of natural habitat, water quality, and fish species richness. The questionnaire also asked respondents to identify the plant species used in the implementation of compensation within the town, and I compared answers with the species that were actually used. The questionnaire and/or interview data will also be used in Chapters 4 and 5.

1) Qualitative inquiries into perceptions of environmental change. The aim of this stage was to qualitatively document local people's (mis)perceptions of environmental change within the urban ecosystem and discern the many cognitive processes involved, through in-depth semi-structured interviews coupled with thematic analysis (Braun & Clarke, 2006). In addition, by contextualising the concept of SBS and building knowledge of the local situation, stage one played an essential role in designing the large-scale survey at stage two and interpreting its results.

I carried out semi-structured interviews using the local language and dialect through 'semi-randomised' street-by-street sampling within the study area (Igudia et al., 2022; Ackrill et al., 2023). Data were collected from all main roads (including all natural parks) within the new town and from the west and south edges of the town where residents of the old town have been relocated. Besides, I lived in the town from November 2022 to May 2023, and from August to September 2023, allowing for informal conversations with local people, including the local authorities, and extensive field observations in local natural areas. Participants were approached in public areas and asked to participate in the interviews. My sampling therefore targeted residents found outdoors.

I decided when to stop interviewing based loosely on data saturation (Glaser & Strauss, 1967; Small, 2009; Gerson & Damaske, 2020; Braun & Clarke, 2021). I recognised that complete saturation is generally not possible as new information can always emerge from more interviews (Wray et al., 2007; O'reilly & Parker, 2013; Low, 2019); in my research, interviewing another experienced respondent could always bring in new environmental features that they perceived personally, for example a

different bird behaviour in a particular place. Thus, I aimed to achieve 'depth and richness of analysis' (Small, 2009), and regarded my dataset as saturated once (i) the responses provided evidence of whether SBS was an issue at the site, and (ii) new participants were no longer providing new understanding about the cognitive mechanisms behind people's (mis)perceptions of environmental change. I here focused on respondents' basic cognitive processes, including sensation, attention, learning, thinking, and memory (Mesulam, 1998; Pisoni, 2000; Solso et al., 2005; Kausler, 2012). In total, I carried out 42 interviews, lasting from 25 minutes to 1.5 hours. The respondent demographics reflect the age and gender composition in the latest (2020) census of the city.

A thematic analysis was then performed to analyse data from the 42 interviews, following the six-phase guide of Braun and Clarke (2006). All content was transcribed and translated into English before coding. The translated content was re-translated from English back to Chinese (i.e., back translated) with the help of local assistants, to provide an accuracy and quality check (Brislin, 1970 & 1986). I coded the themes based on a deductive top-down approach, driven by the pre-established concept of SBS and the cognitive components. The goal of the thematic analysis was not to explore new themes. Instead, it was for exploring and evidencing how cognitive processes can cause misperceptions of the natural environment. Further, the aim of this exploration was not to exhaust the cognitive processes but to give a general exploration, as the many subdivisions of a process and the complex interactions between processes, such as selective attention or sensory memory, were beyond the scope of this thematic analysis.

2) A population-based questionnaire. The questionnaire involved fourteen closed questions to examine people's knowledge of pre- and post-land conversion environmental states. Two scores were generated to evaluate respondents' knowledge of previous and current environmental states respectively, by counting the number of indicators for which their responses were aligned with the official data on

ecological change over time. Respondents were also asked to state the date when they started to experience the case study site (both the currently-urban area, and the river). Respondents were also asked to report their certainty that they had correctly answered the quiz questions, as well as the reasons why they felt uncertain (if applicable), using closed questions. The reasons supplied include elements which aimed to uncover different cognitive drivers (see Table 3.3).

The questionnaire also included components that assessed people's experience, including frequency of visits to the previous town, frequency of visits to the natural area in the new town, time spent per visit, level of interaction with nature, and knowledge sources (including direct, personal experience, and indirect means, including relatives and friends, printed media, TV, official websites or social media, and unofficial websites or social media). There was also a section inquiring about their socio-demographic features.

The questionnaire data were collected using *Wenjuanxing* (http://www.wjx.cn/), one of China's largest online survey platforms, akin to Qualtrics, which also offers survey services. The first round of data collection was collected online by the surveying company in the study region. As the results were biased toward younger people, a complementary second round was carried out by me, specifically targeting people aged over 45, with a final combined sample size of 1326. I examined the statistical differences between the results for the over-45s in the second round of data collection and the same age-group in the earlier sample. I conducted three statistical tests based on the total scores the two groups obtained for correctly answering all environmental elements: Wilcoxon Rank-Sum Test showed no significant difference in the medians (W = 22960, p = 0.8618); Welch Two-Sample t-test indicated no significant difference in the means (t = -0.13888, p = 0.8896); Levene's Test for Homogeneity of Variance revealed no significant difference in variances between the groups (F = 0.0332, p = 0.8556). Based on the results of all three tests, there is no evidence of significant differences, suggesting that the two groups can be merged for further analysis.

Due to incompleteness, 308 questionnaires were excluded, as they did not provide responses to key questions concerning respondents' perceptions of the factors driving change, which are essential for the research. Within the 1018 questionnaires left, 4 respondents responded to all perception questions but incompletely reported their socio-demographic features. They were therefore excluded from regression analysis and were only used in representing different types of misperceptions (see Fig. 3.3).

3.2.4 Analysis

The accuracy of respondents' perceptions of environmental states and trends were compared with officially-reported environmental states and trends, which I took to represent the actual states and trends of the area. I evaluated the trends in three ecological indicators: area of greenspace, water quality, and presence of specific fish species. I chose these because of (i) the potentially different perceptibility of the three features and (ii) the availability of information on their actual changes for comparing perceptions with realities. Area of greenspace can be the most obvious feature to people who engage in the area. Water quality is not as perceptible but links closely with local people's basic well-being. Fish species is less perceivable by the majority but would be well-known to people with more specialist knowledge (e.g., fishers). The turning-point years (Fig. 3.2) for each indicator were estimated based on evidence from local official reports (Appendix A). The turning-point year for the area of greenspace was 2009, when the affected land had been cleared for development and the first set of terrestrial compensatory restoration projects was completed. The turning-point years for water quality and fish species presence were also 2009, when ecological data showed that local river restoration projects began to take effect and reverse the trend.

I asked about the previous land use in the area before land conversion took place, primarily for assessing if people recognised the previous existence of the large marsh wetland and multiple communities with farmland and fishponds. I also asked about the plant species used for delivering compensation projects in the town; I applied

multiple-choice questions with both correct and incorrect items (i.e., plants used and not used in local compensatory plantings).

Table 3.1 shows all the variables I collected to evaluate the association between years of experience, quality of experience, knowledge sources, and socio-demographic characteristics and local environmental knowledge. I used three models to separately analyse people's overall knowledge about local environmental change, and their knowledge about previous and current environmental states. Generalised linear models (GLMs) were used, after data dredging was performed for variable selection (see Appendix C). The `glm()` function from the `stats` package was used to fit the GLMs, and the `dredge()` function from the `MuMIn` package was employed for model selection and comparison. As the dependent variables were count data, I used Poisson regressions (Whitmore, 2020). My hypothesis was that the earlier a respondent started to experience the location, the more likely they were to understand both previous and current environmental states, so the variable of *perceived baseline year* was used in all models. Factors evaluating people's experience with the previous town and the new town, their information sources, their interest in natural visits, ways to interact, socio-demographic features were also incorporated in all three models.

Table 3.1: Variables included in the generalised linear models.

Variable	Data type	Description
Dependent variables		
Overall knowledge score	Count	Out of fourteen questions asking about pre- and post- land expansion environmental states, the number of questions that the respondent reported correctly
Pre-land conversion knowledge score	Count	Out of five questions asking about pre-land expansion environmental states, the number of questions that the respondent reported correctly
Post-land conversion knowledge score	Count	Out of nine questions asking about post-land expansion environmental states, the number of questions that the respondent reported correctly

Table 3.1 (*continued*)

Variable	Data type	Description
Independent variables		
Experience		
Perceived baseline year	Continuous	The year in which the respondent started to experience the place
Frequency of visiting the old town	Ordinal	Frequency of visiting the previous town before land conversion; 0=never went to the old Qunli Town before the development of Qunli New Town began, 1=went there one or a few times in total, 2=went there from time to time, 3=went there often, 4=lived in the old Qunli Town
Time spent out of the town (last year)	Ordinal	Time spent out of the town during the last year; 0=never or no more than 1 month, 1=1-3 months, 2=3-6 months, 3=more than 6 months
Frequency of visiting the natural area (last year)	Ordinal	Frequency of visiting the natural area in the new town during the last year; 0=never, 1=less than three times in total, 2=less than once per month, 3=about once per fortnight, 4=about once per week, 5=Most days;
Time spent per visit (last year)	Ordinal	Time spent per visit during the last year; 0=never been there, 1=less than 30 minutes, 2=around 30 minutes to an hour, 3=over an hour
Interest in visiting nature	Ordinal	Interest in visiting the natural areas in general; 0=very low, 1=low, 2=neutral, 3=high, 4=very high
Interacting directly	Dummy	Interacting with nature directly by being within it, so I can touch, smell, and see it; 0=no, 1=yes
Information sources		
Relatives or/and friends	Dummy	Acquiring local environmental information from relatives or/and friends; 0=no, 1=yes
Printed media	Dummy	Acquiring local environmental information through printed media; 0=no, 1=yes
Television	Dummy	Acquiring local environmental information through TV; 0=no, 1=yes

Table 3.1 (*continued*)

Variable	Data type	Description
Information sources		
Official websites or social media	Dummy	Acquiring local environmental information from official websites or social media; 0=no, 1=yes
Unofficial websites or social media	Dummy	Acquiring local environmental information from unofficial websites or social media; 0=no, 1=yes
Socio-demographics		
Age	Interval	0=18-30, 1=30-45, 2=45-60, 3=>60
Education level	Ordinal	0=no education, 1=primary, 2=lower secondary, 3=upper secondary, 4= college diploma, 5=bachelor's degree; 6=master's degree; 7=doctoral degree
Local (Qunli)	Dummy	0=non-Qunli resident, 1=Qunli resident

3.3 Results

3.3.1 Age, Experience, and Socio-Demographic Features

My exploratory interviews with a sample of residents (N=42) showed younger people were not necessarily less knowledgeable about local nature and its change than older people. Instead, the amount of knowledge they reported related strongly to the number of years they had experienced the locality; people who had lived in the area before land acquisition for development (2006) reported more knowledge about past environmental conditions and change than people who had moved in after that year. Respondents who demonstrated more interest in nature generally tended to know more and their perceptions were more accurate, with some exceptions. Perceptions were constructed directly (e.g., through personal visits to natural areas) or indirectly (through other information sources):

> "*I used to live near the town… and moved in after it's developed… I wouldn't choose to visit natural parks for fun, but I've been there a few times with my mom cause she made me… She took many pictures of*

> *colourful flowers and shared them in our family group chat… One of my classmates at [a local university] whose family moved from the old Qunli … (s)he told me there were some grassland, bungalows, and factories.*" [female, aged 22, student]

Also, people's general interest in and time spent visiting local nature can change over time, due to internal (e.g., acclimatisation to new experiences) or external factors (e.g., a pandemic):

> "*[My interest in local natural parks] was sky-high when I first came here… People were curious to see what the new town looked like when the development just completed. I visited [the parks] quite often when I first came here… I observed what's been changed in the [bund] wetland… [The parks] are not as enthralling now*." [male, aged 59, factory worker]

> "*[My husband and I] used to stroll in those parks years ago. Now I prefer staying indoors, [because] COVID-19 is just so frightening!*" [female, aged 83, retired]

Through these interviews, I found that people's information sources are heterogenous, including direct visits or indirect information from families and friends, TV, or social media. They also showed different ways of processing the environmental information they had acquired, leading to correct or incorrect knowledge about past and current environmental conditions. Ideas about how the place had changed could even be generated without any direct or indirect experience of it (See erros of commission Table 3.3).

I used generalised linear models to explore the effects of length of experience, quality of experience, and knowledge sources on respondents' knowledge of local environmental states (Table 3.2). Results suggested that length of experience, rather than age, predicts environmental knowledge. Interest in visiting nature and time spent per visit significantly determined how much knowledge respondents had about

local environmental situations. The effect of close interactions with nature was marginally significant. Interestingly, gaining information from (state-run) television was associated with less accurate knowledge of the previous ecological state of the area.

I also found people who lived in, or frequently visited, the old town before it was developed had significantly less knowledge about the environmental state of the new town. This finding is relevant to three interviewees who mentioned the loss of incentive to visit and explore the town after the removal of farmland, factories, and friends in the old town. For example:

> "*I went there before; I worked in the pumping plant there… I don't go there now. Why would I?*" [male, aged 88, retired engineer]

I also examined the role of socio-demographic factors. I found that only education level is significantly-positively associated with people's knowledge of both previous and current environmental states. Especially, age was not significantly related to people's knowledge of environmental states. Also, people who currently live in the area were not significantly more or less knowledgeable about the previous state of the environment than those who don't.

3.3.2 Information Processing, Misperceptions, and Shifting Baseline Syndrome

My exploratory interviews evidenced the role of environmental information processing in engendering environmental misperceptions and SBS. They demonstrated the role of many cognitive elements in information processing, including sensation, attention, learning, thinking, and memory, in SBS (Fig. 3.2; quotations in Table 3.3).

Based on the exploratory study results, I devised a questionnaire survey delivered in person and online to 1018 residents and former residents of Qunli. I quantitatively

Table 3.2: Regression-estimated effects of experience and knowledge sources on environmental knowledge (N=1014). I present the results for three GLMs, with the dependent variable being a composite knowledge score. Model 1 relates overall knowledge to variables related to respondents' experience of the area, knowledge sources, and socio-demographic characteristics. Model 2 relates to knowledge about conditions before the point at which nature recovery began, and Model 3 relates to knowledge about current conditions. Minimum Adequate Models (MAMs) are presented, based on a model selection process. Blank cells are variables which do not appear in the MAMs.

	(1) Overall knowledge			(2) Pre-turning point knowledge			(3) Current conditions knowledge		
	Estimate	Std. Error	Signif.	Estimate	Std. Error	Signif.	Estimate	Std. Error	Signif.
(Intercept)	35.450	3.329	***	47.751	5.856	***	31.618	4.566	***
Experience									
Perceived baseline year	-0.017	0.002	***	-0.024	0.003	***	-0.015	0.002	***
Frequency of visiting the old town				0.034	0.019	.	-0.044	0.015	**
Frequency of visiting the natural area (last year)	0.020	0.012	.				0.030	0.014	*
Time spent per visit (last year)	0.055	0.018	**				0.080	0.023	***
Interest in visiting nature	0.061	0.016	***	0.102	0.024	***	0.047	0.020	*
Interacting directly with nature	0.065	0.035	.				0.077	0.044	.
Knowledge sources									
Relatives or/and friends	0.039	0.026							
TV	-0.056	0.026	*	-0.086	0.043	*			
Socio-demographics									
Age				-0.038	0.025				
Education level	0.063	0.010	***	0.099	0.019	***	0.043	0.012	***
Local (Qunli)	-0.045	0.028		-0.072	0.044				

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

assessed residents' perceptions of the change in the area of greenspace, water quality, and the number of fish species, by comparing people who started to live in Qunli New Town before and after the turning-point years in which environmental conditions started to improve (Fig. 3.1), and framed the results within my conceptual framework (Fig. 3.3). All the potential options for the shape of the environmental change curve set out in Fig. 3.1 were represented in the answers received. Overall, the majority of respondents were correct in their assessment of environmental change across all three biodiversity dimensions, despite some dimensions (e.g., area of land) being easier to observe than others (water pollution, fish species). There were more 'don't know' responses for the number of fish species, which is not surprising given that this is the least observable dimension, but even so, most people (88% and 83%, respectively) felt able to give an answer. There was also a general tendency towards saying that things had improved across all three dimensions; in those who were present before the turning-point, this represented personal amnesia (i.e., SBS as defined by Papworth et al., 2009).

Although different cognitive processes can lead to erroneous environmental reporting, some processes – such as emotional memory (Kensinger, 2009) and multi-sensory learning (Dinh et al., 1999) – appeared to be helping prolong respondents' understanding of past environmental situations:

> "*My husband often went to the previous swamp and collected wild duck eggs. I would use them to make pickled eggs … I remember those eggs were fresh and tasty because those wild ducks grew up eating fish from the Songhua River… They were much more delicious than the eggs nowadays laid by ducks raised on feed.*" [female, aged 69, cleaner]

Some cognitive elements appeared to be particularly dominant in people's explanations of their lack of ability to describe environmental change. For example, some interviewees stated that they had little to no experience with local nature due to having only recently moved into the area or lack of interest, hence they were not

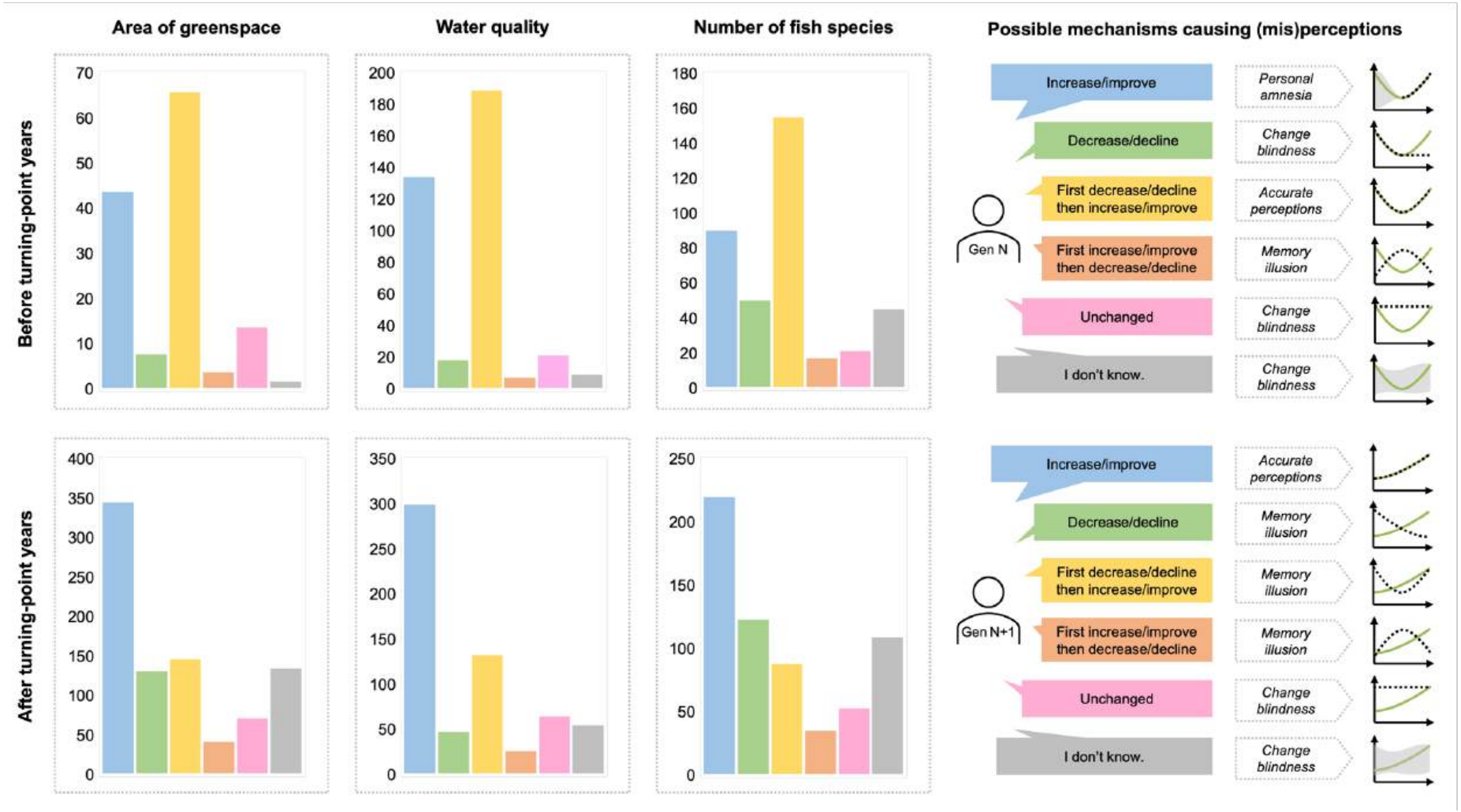


Fig. 3.3: The number of residents reporting local environmental trends (N=1018). Participants who set their baseline years before the turning point years were placed in the top row, and those who set their baseline years after the turning point years were placed in the bottom row. The correct answers for the two groups are thus 'first decrease/decline then increase/improve' and 'increase/improve'. Therefore, in the top line, the correct answers are shown by the yellow bars, while in the bottom line the correct answers are shown by the blue bars.

able to develop a sensory engagement with the area (the first stage of perception in Fig. 3.2). Memory was also frequently cited as an issue when interviewees failed to recall past events.

Using my qualitative and quantitative results, I propose a framework to classify different cognitive elements underlying environmental misperceptions as errors of 'omission' or 'commission' (Table 3.3).

3.4 Discussion

Transformative change is required to achieve a nature-positive future in which humanity remains safely within planetary boundaries. To realise such a future, environmental misperceptions must be effectively tackled, as they can lower people's expectations as to how much nature recovery is needed. I proposed a framework for studying environmental misperceptions and carried out a case study to demonstrate its application. I employed a mixed-methods approach to initially explore and subsequently explain environmental misperceptions at the societal level and then at the cognitive level, through interviews and a survey.

My study shows how important it is that more academic attention is given to the cognitive mechanisms underpinning people's experiences of nature loss and recovery. The 'cognitive revolution' in 1950s has significantly shifted the psychology field from studying human behaviour without opening the black box of mind (i.e., behaviouralism), to unpacking this black box and examining the many mental processes which underlie perceptions of the outside world, including sensation, attention, learning, thinking, and memory (Gardner, 1987; Miller, 2003; Núñez et al., 2019). This has led to more nuanced psychological understanding. In my study, I have illustrated how people's experience of nature is significantly associated with their perceptions of its state and trends. Direct and immersive personal experience can correctly shape people's environmental perceptions, while indirect experience with unreliable information sources can implant incorrect knowledge that deviates

Table 3.3: Examples of errors of omission and commission and relevant cognitive processes, derived from qualitative and quantitative results. See Fig. 3.2 for the framework related to cognitive processes.

Error Types	Cognitive processes	Statistics (N=1018)	Exemplar quotations
Errors of omission	Sensation (lack of ability or opportunities to detect environmental features)	• 5% think they have no interest to visit or learn knowledge about local natural environment. • 34% believe they are unable to know local nature a lot because they are newcomers to the town.	"*I prefer indoor activities … to outdoor ones*." [male, aged 23, college student] "*I don't know much about this place for now, but I'll know more if I live here longer*." [male, aged 60, construction engineer]
	Attention (e.g., change/inattentional blindness)	• 20% state they are too busy to carefully feel local nature though being around; • 32% believe they paid little attention to the natural environment during visits.	"*I came to Qunli every day during high school … I didn't notice the change of natural surroundings. I only noticed, through our class window, that some high-rise buildings nearby were under construction*." [female, aged 28, bank clerk] "*I travelled to cities like Beijing and Shenzhen for many times every year … In a year, I may live here for 3 months and there for 4*." [female, aged 52, millionaire]
	Learning (e.g., lack of information sources to acquire new knowledge)	• 25% think there is lack of knowledge sources to learn local environmental situations.	"*I can't find any database that has recorded the previous situations in Qunli … Media also rarely reported them. Very few did but most of those pages are no longer available now.*" [male, aged 30, junior researcher]
	Thinking (e.g., lack of knowledge to identify a species)	• 31% think they do not have sufficient ecological/scientific knowledge to identify or distinguish natural elements.	"*We can see new types of birds flying in every couple years … I cannot identify every kind of them, but it seemed that they were in different shapes, colours*." [male, aged 61, former farmer] "*There grows a vast area of lavender* (Lavandula) [which should be sage (*Salvia officinalis*)] *in Qunli Bund*." [female, aged 70, retired worker]

Table 3.3 (*continued*)

Error Types	Cognitive processes	Statistics (N=1018)	Exemplar quotations
Errors of omission	Memory (e.g., childhood amnesia or age-related memory loss)	• 16% suppose they used to have some environmental knowledge, but they cannot remember it now.	"*My dad told me he has brought me to there [the old Qunli Town] when I was a kid, but I can't remember that."* [male, aged 25, graduate student] "*There were no factories or communities … I'm not very sure. It's been years."* [male, aged 89, retired pump engineer]
Errors of commission	Learning (e.g., misinformation or disinformation)	• 37% feel uncertain about their previously acquired environmental knowledge. • Especially, people who receive information from state-run TV programmes are significantly less likely to report correct previous or current environmental situations.	"*[State-run] TV programmes reported that the ecological environment in the (Songhua) river has gradually become better … In the 21st century it's never been seriously polluted* [which is untrue]*… as the government has taken good care of it."* [female, aged 28, bank clerk]
	Thinking (e.g., overconfidence bias; unreality-based speculation)	• Some people assert they know local environmental situations very well but report inaccurate previous (12%) and current (16%) environmental states with below-average scores.	"*This place was empty with no nature and no people living all along. That's why it was planned and developed into an urban area."* [male, aged 55, electrician]
	Memory (e.g., memory illusion; misattribution)	• 48% select the wrong years in which restoration of the Qinli bund wetland begun.	"*Development of the Qunli New Town started from around 2010… Around that year, the nature in the town, like the bund wetland, started to be restored*." [female, aged 35, business owner]

their perceived baselines from reality. However, experience with nature from the cognitive perspective includes many mental processes that act together to shape people's perceptions. Instead of continuing to treat the mind as a black box, researchers working on nature recovery should investigate these processes.

Drawing on information processing theory (Fig. 3.2), I showed that errors can take place at diverse cognitive stages (sensation, attention, learning, thinking, and memory). Based on my proposed framework of errors of 'omission' and 'commission' (Table 3.3), I argue that it is vital to first understand how misperceptions were generated at a cognitive level, before designing and applying interventions to address SBS that are contextually meaningful and thus potentially effective. For example, different strategies need to be taken for people with little motivation to be exposed to nature than for people with little ecological knowledge, if the aim is to develop their understanding of nature. Further, people exposed to environmental misinformation will need very different interventions to people, young or old, who have failed to recall past environmental conditions.

My results also indicate that people's ability to mentally process changes in different natural features can vary. People in my study found it the most difficult to report change in fish species richness, even incorrectly, probably because they cannot see it. Compared to species richness, the area of greenspace may be more perceivable but may need more time for newcomers to experience geographically-widely enough to form an unbiased understanding. Water quality may be more detectable at the sensation stage in some circumstances, for example, in my context, from polluted, smelly streams to odourless ones, than in other circumstances, for example, the presence of heavy metal ions. To my knowledge this is the first SBS study that compares perceptions of different biodiversity dimensions; there is the potential for much more research on this topic and the application of a plurality of methods including controlled experiments.

Although my results are preliminary, it appeared that some mental processes may help prolong people's understanding of local environmental change and thus mitigate SBS; for example, multi-sensory learning and emotional memory (Kensinger, 2009; Dinh, 1999). This also calls for extensive research input from diverse fields, for example, environmental psychology, sociology, and anthropology.

I recommend future interdisciplinary studies to build understanding around (i) the detailed mechanisms of different processes causing and shaping environmental misperceptions, such as the process of selective attention, (ii) effective approaches to correcting misperceptions based on an understanding of different causes, such as using real-world experience to combat online environmental misinformation, and (iii) ways to improve the accuracy of people's perceptions of environmental change, perhaps through emotion-rich or multi-sensory nature education. Working together to study environmental misperceptions in a more nuanced manner could support interventions to improve the accuracy and vividness of people's perceptions of environmental change. This is one of the key enablers for moving towards a future in which both nature and humanity can thrive.

CHAPTER 4

THE SOCIAL IMPACTS OF NATURE-INCLUSIVE URBAN DEVELOPMENT

Abstract

The new Global Biodiversity Framework has promoted nature-inclusive urban planning as a strategy to contribute to the global goal of halting and reversing biodiversity loss by 2030. However, there is still a lack of discussion on how to implement the strategy to realise the Framework successfully, both ecologically and socially. In particular, integrating nature values and targets into urban planning and development can impact local communities, which requires careful and explicit examinations of the nuances and complexities. In this study, I examine the well-being impacts of a major urbanisation programme of the Qunli New Town in Harbin, China, where urbanisation and expansion were carried out with landscape-level ecological impact mitigation and compensation. Through in-depth interviews with 42 residents and a population-based quantitative survey of 1,018 residents, I found how urban development and associated ecological measures can impact residents' material, relational, subjective well-being. Notably, former agriculturalists, while perceiving no difference in levels of fairness, felt less happy living in the area after the changes compared to non-agriculturalists. Compared to newcomers, long-term residents (who lived in the area before the changes) perceived the economic aspects of the new town as fairer, while viewing the ecological aspects as less fair. My findings provide insights into how social impact assessments can better capture long-term impacts, fostering nature- and people-positive urbanisation and expansion.

4.1 Introduction

As cities expand, natural landscapes such as forests, grasslands, and wetlands are transformed to accommodate the needs of expanding human populations. This transformation of land use for urbanisation has been recognised as a major driver of global biodiversity decline (WWF, 2022; Semenchuk et al., 2022). If these impacts of urbanisation continue to be poorly mitigated globally, it is estimated by 2050, over 30,000 species of native terrestrial vertebrates will be affected, with 855 species directly threatened (Simkin et al., 2022).

For a long time, global biodiversity agreements, such as the now-expired Aichi Biodiversity Targets, have largely overlooked the impact of urbanisation on natural habitats, compared to agriculture and forestry (Simkin et al., 2022). This has now been addressed in the new Global Biodiversity Framework (GBF), agreed upon in 2022, which aims to halt and reverse nature loss by 2030 in a socially fair manner. Specifically, the GBF's Target 12 promotes "*biodiversity-inclusive urban planning*", aiming to "*significantly increase the area and quality, and connectivity of, access to, and benefits from green and blue spaces in urban and densely populated areas sustainably*" (CBD, 2022).

The built-environment design field (e.g., urban planning, architecture) is striving to incorporate nature values into its practices (Birkeland & Knight-Lenihan, 2016; Birkeland, 2017). Architects integrate these values within the building envelope; for example, sustainable building materials, such as reclaimed wood salvaged from historic buildings (e.g., houses and barns), are increasingly used to minimise the depletion of natural forests by reusing wood that would otherwise end up in landfills (Vázquez-López et al., 2023; Abera, 2024). Meanwhile, urban planners have sought to embed nature values into planning processes, guiding the use of urban land, environment, and infrastructure within broader urban boundaries through enhanced

approaches (e.g., increasing natural spaces) to conserve nature, including ecosystems, habitats, and biodiversity (Mattijssen et al., 2023).

In some cases, the goal of urban planning is to achieve 'net-positive design and development', which aims for 'no net loss' (NNL) and ideally a 'net gain' (NG) for biodiversity after urban development, compared to pre-development conditions (Birkeland & Knight-Lenihan, 2016; Birkeland, 2020). In turn, the 'mitigation hierarchy' approach, especially ecological compensation (e.g., biodiversity offsetting), has increasingly become a go-to strategy for urban designers and planners (Birkeland & Knight-Lenihan, 2016; Birkeland et al., 2017; Thomson et al., 2022; Hanson & Olsson, 2023). Blending the mitigation hierarchy into urban planning, which involves sequentially avoiding, minimising, remediating, and offsetting negative ecological impacts within the landscape planned to be converted, can help address the broad impacts of diffuse urban development and conservation activities, helping to identify areas for effective and efficient impact mitigation and nature recovery (Pressey & Bottrill, 2008; Kiesecker et al., 2010; Birkeland & Knight-Lenihan, 2016). Alongside net positive outcomes for nature, urban planners have also long embraced the principle of 'do no harm, and if possible, do good'; that people affected by urban development should be at least no worse off, and preferably better off, after the development than before implementation (Lyles-Chockley, 2008; Vanclay et al., 2013; Baines et al., 2013; Vanclay, 2016; Berglund & Kitson, 2021). The inclusion of nature values and targets into urban planning and development may impact local communities however, requiring explicit and careful examination, as it may not guarantee positive outcomes for everyone (Bidaud et al., 2017; Griffiths et al., 2019b). An effective social impact assessment (SIA) thus should carefully survey how local people are impacted by such an urbanisation programme (Vanclay, 2016), including by the measures taken to meet the nature targets included in the programme. It is crucial for urban planners aiming to mitigate nature losses from urban development in a socially just manner to understand how urban development inclusive of ecological values and targets impacts local well-being and identify strategies to

mitigate any negative effects. This need has been covered by various international and regional agreements, including the GBF.

In the academic literature well-being is typically treated as multi-dimensional, involving three interrelated dimensions: material, relational, and subjective (McGregor & Sumner, 2010; White, 2010; Milner-Gulland et al., 2014; Woodhouse et al., 2015; Jones et al., 2019; Loveridge et al., 2020; Llopis et al., 2023; Wells et al., 2024). The material aspect is concerned with what a person has, the relational aspect with what they can do with what they have, and the subjective aspect with what they think about what they have and can do. The change of a person's resources and states, and the activities a person does, can lead to change in the happiness that they perceive (Anand, 2021). While happiness is a key measure that has been widely used to assess subjective well-being, the perceived fairness of benefit distribution has been recognised as another important indicator (Woodhouse et al., 2015; Brueckner-Irwin et al., 2019). A key difference between the two is that happiness is directly personal, whereas fairness can be perceived in a more detached, analytical manner (Adger et al., 2016; Urbanska et al., 2019; Valcke et al., 2020).

This paper examines Qunli New Town in Harbin, China, a recently urbanised area whose rapid development spanned over a decade, beginning in 2006. The government's urbanisation plan for the town was based on the "*principle of ecological priority*," with the goal of creating a "*ecological garden city*" whose aim is to "*increase the proportion of green space, water surfaces, and park areas, establishing an ecological urban area characterised by a clean and beautiful environment, a sustainable urban ecosystem, and the coordinated development of the environment, economy, and society*" (Qunli Development Office, 2010). Under these ecological values and goals, numerous landscape-level ecological mitigation and compensation measures were implemented to restore existing natural areas and create new green spaces.

Through this case study, this research aims to understand how urbanisation that incorporates nature values and targets such as these may impact local well-being. My

post-hoc monitoring can help identify unintended consequences of such programmes. This understanding, which helps refine methodologies and improve predictive accuracy, can enhance SIAs, support adaptive management, and potentially increase developers' social accountability in programme implementation. This can help countries to meet the global target of promoting nature-inclusive urban planning towards the global 'halt and reverse' nature goal, while ensuring that the benefits and costs of such integration are borne in a socially-equitable manner.

4.2 Materials and Methods

4.2.1 Case Study Site

My analysis focuses on a major urbanisation in Harbin, China, namely the Qunli New Town (see section 1.2). Harbin, the capital and largest city of Heilongjiang Province, is the largest provincial capital by land area in China and serves as a major political, economic, and cultural hub in northeast China. Between 1982 and 2010, Harbin's population expanded from 2.5 million to 10 million. The Qunli New Town, covering 2,733 hectares and designed to support 322,000 residents, has been established on the western outskirts of Harbin. From the early 2000s to the late 2010s, the town took over a decade to be built from scratch.

Local planning documents show that the design for the town's infrastructure developments and associated ecological mitigation were introduced simultaneously at the outset of the planning process. A landscape approach was employed to first avoid and minimise impacts on locally important ecological features (e.g., a degrading marsh wetland that has since been converted into the Qunli National Urban Wetland Park; Fig. 4.1). Subsequently, areas suitable for ecological compensation that can restore ecological connectivity were identified.

Urbanisation and the associated ecological mitigation and compensation have substantially transformed the town's green and blue spaces (Fig. 4.1). Initially, rapid urbanisation caused a decline in local ecological conditions. However, local official

Fig. 4.1: Nature-related features of the urban development of Qunli New Town. a. A fenced-off protected area along the urban river (i.e., Songhua River); b. An educational sign about a local migratory bird, the little ringed plover (*Charadrius dubius*); c. Compensatory afforestation at a housing site; d. A signature park (i.e., Lilac Park, where the Lilac (*Syringa*), the city flower of Harbin, is featured) where a group of young people is exploring the hilly area; e. An urban park with restricted access to mitigate human disturbance on migratory species and ecosystems; f. An urban wetland (part of the "sponge city" scheme) for urban flood control and as a natural habitat.

documents and previous research show a recovery in greenspace, bird species, water quality, and fish populations (see section 1.2), with local surveys reporting new species using urban green spaces compared to recent years. This context can thus be useful in examining the nuanced and complex impacts of urban development implemented in coordination with ecological mitigation and compensation measures on local well-being, offering valuable insights for future urban planning.

4.2.2 Data Collection

I employed a mixed-methods approach that consisted of two stages (see Methods). In stage one, I applied an exploratory case study methodology (Yin, 2009), where 42

semi-structured interviews were carried out using street-by-street sampling. The aim of this inductive stage was to recognise the diverse impacts of nature-inclusive urban development on local well-being. Stage two involved a population-based survey to gain quantitative information on the factors associated with people's well-being, where I used my exploratory study to design questions evaluating residents' perceived benefits and costs of the green elements of the urban development.

1) Qualitative inquiries into environmentally-based well-being. The aim of this stage was to qualitatively document how local people's well-being was affected by urban developments and associated ecological mitigation activities, through in-depth semi-structured interviews coupled with thematic analysis (Braun and Clarke, 2006). In addition, by building knowledge of the local environmental and social situation, stage one played an essential role in designing the large-scale survey at stage two and interpreting its results.

I carried out semi-structured interviews through "semi-randomised" street-by-street sampling within the study area (Igudia et al., 2022; Ackrill et al., 2023). Data were collected from all main roads (including all natural parks) within the new town (Fig. 4.1) and from the west and south edges of the town where residents of the old town have been relocated. I lived in the town from November 2022 to May 2023, and from August to September 2023, allowing for informal conversations with local people, including the local authorities, and extensive field observations in local natural areas. Participants were approached in public areas and asked to participate in the interviews. My sampling therefore targeted residents found outdoors.

I stopped interviewing once data saturation was reached (Glaser et al., 1967; Small, 2009; Gerson & Damaske, 2020; Braun & Clarke; 2021). I recognised that complete saturation is generally not possible as new information can always emerge from more interviews (Wray et al., 2007; O'reilly & Parker, 2013; Low, 2019). I thus aimed to achieve 'depth and richness of analysis' (Small, 2009), and regarded my dataset as saturated once: (i) the responses provided information on how the main dimensions

of well-being (material, relational, and subjective) were impacted by the Qunli urbanisation; and (ii) new participants were no longer providing new understanding about the well-being impacts of local economic development and ecological mitigation activities.

In total, I carried out 42 interviews, lasting from 25 minutes to 1.5 hours. The respondent demographics reflect the age and gender composition in the latest (2020) census of the city. All interviews were carried out in the local language and dialect. They were then transcribed and translated into English. The translated content was re-translated from English back to Chinese (i.e., back translated) with the help of local assistants, to provide an accuracy and quality check (Brislin, 1970 & 1986). A thematic analysis was then performed to analyse data from the interviews, following the six-phase guide of Braun and Clarke (2006). I coded the themes based on a deductive top-down approach, driven by the pre-established human well-being framework.

2) A population-based questionnaire. This questionnaire involved questions to examine people's perceptions of fairness about the distribution of the economic and ecological impacts of the new town. It also included a retrospective comparative survey asking people's perceived changes of well-being elements from the urban developments and associated ecological mitigation, and their happiness change. I took a retrospective approach because there was no initial baseline data for direct comparison in the focal urbanisation programme. There was also a section inquiring about their socio-demographic features. The questionnaire data was collected using *Wenjuanxing* (http://www.wjx.cn/), one of China's biggest online survey platforms, which also provides surveying services. A total of 1,326 responses were collected, of which 312 were removed from the platform due to incomplete answers to key questions or the inclusion of non-local participants, leaving 1,014 for modelling.

I used three models to separately analyse people's perceptions of the fairness regarding the town's economic and ecological outcomes, and perceived change in well-being elements. Ordinal logistic models were used using R programming.

4.2.3 Analysis

I explore the social consequences of the Qunli urbanisation by investigating different dimensions of participants' well-being. I especially aim to provide a more nuanced understanding of subjective well-being by examining how different social groups perceive (i) changes in happiness associated with changes in the urban environment, and (ii) the fairness of the distribution of economic and ecological benefits provided by the newly established town. Additionally, as urbanisation can drive social movement and migration, it is crucial to understand whether people perceived that this has changed with changes in the urban environment.

Using the `clm()` function from the `ordinal` package, I developed ordinal logistic models to explore (i) the relationship between perceived changes in various well-being elements and changes in happiness, while controlling for socio-demographic factors, and (ii) socially-differentiated perceptions of fairness regarding the economic and ecological aspects of Qunli New Town (Table 4.1). The well-being elements selected were directly derived from the qualitative insights in the exploratory interviews (see Section 4.3). In Model 1, I analyse happiness in relation to different well-being elements and socio-demographic factors. Additionally, I constructed two supplementary models which separated well-being and socio-demographic features (see Appendix D). In Models 2 and 3, I examine perceptions of fairness about the economic and ecological impacts respectively, in relation to socio-demographic characteristics. In addition to commonly analysed factors such as age, gender, education, and income, I include 'original resident' status, as this may influence perceptions of environmental changes. Table 4.1 presents the hypotheses to be tested.

4.3 Results

4.3.1 Shifting Societal Baselines

Interviewees in the exploratory study reported changes in various aspects of their well-being as a result of the urban development. Economically, they mentioned

Table 4.1: Variables included in the ordinal logistic models and their expected associations.

Variable	Data type	Statement examined	Reverse coding	Model	Expected association (after reverse coding) with supporting evidence
Dependent variables					
Happiness	Ordinal	"*The economic developments (e.g., housing, malls, jobs, hospitals, schools) and its associated ecological compensation (e.g., urban green spaces and parks, restored or newly created) in the area have made me happier compared to before its land-use was changed.*" (with a figure featuring both local "natural" and "managed" ecosystems are part of the ecological compensation scheme).	No	1	N/A
Fairness (economic aspects)	Ordinal	"*The economic aspects (e.g., housing, malls, jobs, hospitals, schools) of the new town have been fair for residents in the area.*"	No	2	N/A
Fairness (ecological aspects)	Ordinal	"*The ecological aspects (e.g., urban green spaces and parks, restored or newly created) of the new town have been unfair for residents in the area.*"	Yes	3	N/A
Independent variables					
Elements of well-being					
Housing	Ordinal	"*Despite the economic developments in the new town, my housing has not improved compared to before its land-use was changed.*"	Yes	1	Positive association with happiness (Cattaneo et al., 2009; Zhang et al., 2018; Hu et al., 2020).
Markets & malls	Ordinal	"*Due to the economic developments in the new town, I now have improved markets and malls compared to before its land-use was changed.*"	No	1	Positive association with happiness (Potapov et al., 2016; Gbadegesin et al., 2023).
Jobs & income	Ordinal	"*Despite the economic developments in the new town, I have not secured a job or source of income compared to before its land use was changed.*"	Yes	1	Positive association with happiness (Easterlin, 2001; Florida et al., 2013; Dang et al., 2020).
Medical facilities	Ordinal	"*Due to the economic developments in the new town, I now have better medical facilities compared to before its land-use was changed.*"	No	1	Positive association with happiness (Park et al., 2018; Qian et al., 2023).
Educational facilities	Ordinal	"*Despite the economic developments in the new town, I have not received improved educational facilities compared to before the land use was changed.*"	Yes	1	Positive association with happiness (Park et al., 2018; Qian et al., 2023).
Ecosystem goods	Ordinal	"*Due to the ecological compensation in the new town, I now have more natural resources (e.g., food, medicine) harvested from the area, compared to before its land use was changed.*"	No	1	Positive association with happiness (Chaigneau et al., 2019; Wells et al., 2024; Chen et al., 2024).
Social activities in nature	Ordinal	"*Despite the ecological compensation in the new town, I now do fewer social activities in local natural areas, compared to before its land use was changed.*"	Yes	1	Positive association with happiness (van Houwelingen-Snippe et al., 2023; Hakokõngäs & Puhakka; 2023).

Table 4.1 (*continued*)

Variable	Data type	Statement examined	Reverse coding	Model	Expected association (after reverse coding) with supporting evidence
Independent variables					
Elements of well-being					
Beauty of nature	Ordinal	"*Due to the ecological compensation in the new town, I find the area more beautiful, compared to before its land use was changed.*"	No	1	Positive association with happiness (Proyer et al., 2016; Richardson & McEwan, 2018; Møller et al., 2023).
Air quality	Ordinal	"*Despite the ecological compensation in the new town, I find the air quality in the area has not improved, compared to before its land use was changed.*"	Yes	1	Positive association with happiness (Zhang et al., 2017; Clark et al., 2019; Zhang et al., 2022).
Flood control	Ordinal	"*Due to the ecological compensation in the new town, I find the urban flooding events in the area have decreased, compared to before its land use was changed.*"	No	1	Positive association with happiness (Sekulova, & van den Bergh, 2016; Hudson et al., 2019).
Natural knowledge	Ordinal	"*Despite the ecological compensation in the new town, I find I don't know more about local nature (e.g., a bird or habitat type), compared to before its land use was changed.*"	Yes	1	Positive association with happiness (Nisbet et al., 2011; Russell et al., 2013).
Socio-demographics					
Gender	Dummy	0=male, 1=female	N/A	1-3	Uncertain association with fairness (either type) or happiness, but I included this variable out of interest.
Age	Interval	0=18-30, 1=30-45, 2=45-60, 3=>60	N/A	1-3	Uncertain association with fairness (either type); negative association between happiness and age (Kazemi et al., 2021).
Education	Ordinal	0=no education, 1=primary, 2=lower secondary, 3=upper secondary, 4= college diploma, 5=bachelor's degree; 6=master's degree; 7=doctoral degree	N/A	1-3	Positive association with fairness (both types) and happiness (Gurney et al., 2021; Kazemi et al., 2021).
Income (per month)	Interval	0=less than ¥1,000, 1=between ¥1,000 -5,000 2=between ¥5,000-10,000 3=between ¥10,000-20,000 4=More than ¥20,000	N/A	1-3	Positive association with fairness (both types) and happiness.
Agriculturist	Dummy	If respondents were agriculturist before land conversion; 0=non-agriculturist, 1=agriculturist	N/A	1-3	Uncertain association with fairness (either type); negative association with happiness (Wang et al., 2019).
Original resident	Dummy	If respondents were local resident before land conversion; 0=newcomer, 1=original resident.	N/A	2, 3	Uncertain association with fairness (either type).

factors such as changes in their jobs and income, the establishment of markets and malls, and improvements in housing, medical, and educational infrastructure. Ecologically, they noted changes including in urban flooding events, air quality, the beauty of nature, social relations in natural spaces, and knowledge about nature.

Different waves of settlers arriving before and after rapid urban change (initial and later residents) demonstrated different social expectations, standards, and norms. For example, there were many economic benefits that were frequently mentioned by the original, long-term residents - those who had been living in the area before it was developed and urbanised - such as "*nearby groceries and supermarkets*," "*elevators*," and "*heating systems in the flats*." These services were not available in their previous villages and communities:

> "*I prefer living in the flats than the bungalows, because in winters I don't need to buy coals, carry them to my home, and burn them on my own anymore. [Paying energy bills] costs me slightly more money but there's much less trouble now!*" [male, aged 61, former villager]

Long-term residents also mentioned many negative effects of urban development, such as the loss of agricultural land and ecosystem goods that had previously supported their livelihood, identity, and quality of life. For example, one resident highlighted the loss of access to wild products due to the establishment of an urban protected area:

> "*My husband used to go to the [bund] wetland to collect wild duck eggs… The eggs laid by those wild ducks that grew up eating fish from the Songhua River are more delicious than the ordinary eggs laid by ducks raised on feed… The bund area near the Songhua River is now fenced off and protected. Patrol teams drive around several times a day.*" [female, aged 69, cleaner]

However, newcomers to the town, who had not experienced or known the area's past, had different perceptions of how urban development had impacted them compared to original residents. For example, newcomers who moved from Harbin's city centre perceived urban green spaces as "*more accessible*," since the new town had a higher density of parks than the city centre. In contrast, some original residents felt that the urban development "*decreased their ability to explore green areas freely and spontaneously*." For example, one interviewee stated:

> "*My family used to raise cattle, so we always herded cattle within the previous marsh wetland… We have since moved away from that area. The wetland where we used to wander has been partly protected as parks and partly converted into residential areas.*" [male, aged 61, former villager]

4.3.2 Perceived Well-Being

Interviewees in the exploratory study reported changes in diverse elements of their well-being as a result of the urban development; economically, changes included improvements in housing, such as enhanced security systems, social spaces, and building accessibility. New markets and malls also offered better local access to non-local products, including food and clothing. The addition of new schools, hospitals, and clinics increased the availability of vital public services. Furthermore, the development created job opportunities and sources of income, including positions for healthcare workers, teachers, small business owners, delivery personnel, cleaners, and security guards.

Ecologically, urban developments that introduced new green spaces have significantly altered the availability of natural resources. Farmlands that were once collectively owned by villages and used to grow crops, including lilac trees, were acquired for development. Additionally, new parks (e.g., wetland parks) were established with physical barriers. For example, the protected areas, as mentioned earlier, prevented people from harvesting wild products from wetlands. Institutional

changes also impacted the harvesting wild products: residents have faced shifts in regulations governing the use of these ecosystems. Previously, the region operated under more relaxed rules, allowing practices such as "*harvesting birds with mist nets*," which were a primary source of sustenance and integral to the way of life for some residents. Stricter conservation regulations and enforcement measures, including increased park patrols, inhibited them from continuing these harvesting practices.

Yet, ecological compensation measures increased the availability of some natural resources for harvest. As part of the river compensation scheme for the nature-inclusive development, temporary fishing bans, along with restrictions on the mesh sizes of fish nets, led to increased populations and sizes of many kinds of edible fish. Additionally, ecological processes within the parks created new opportunities for harvesting natural resources, such as those used as traditional Chinese medicine:

> "*There are Dandelions (Poh Poh Ding,* Taraxacum officinale*) on the hills in the Lilac Park. They bloom extensively after a heavy rain. I like to go there and get some. I can dig and harvest hundreds of Dandelions each time… It is a popular traditional Chinese medicine that is very effective in clearing heat and detoxifying, treating many diseases in stomaches and lungs such as carbuncle… Many people dig them here not only because they're free to get, but they're naturally grown.*" [female, aged 68, retired factory worker]

Moreover, interviewees highlighted changes in some regulating services that local ecosystems, both 'natural' and 'managed,' provide to support well-being. For instance, many perceived that, under current management, the parks offered emotional and health benefits:

> "*Wetlands and natural parks here are like natural oxygen bars. It's great to visit because the negative ions make the air feel fresh and healthy.*" [male, aged 22, college student]

Additionally, it was noted that the wetland parks functioned as 'sponges' to mitigate urban flooding, with those familiar with the area reporting that local floods were better controlled due to these compensatory measures:

> "*This low-lying area used to flood regularly, submerging the farmlands in the villages. In 1998, we were organised to fight the flood overnight… The town's wetland park can absorb water. Serious flooding is rare.*" [male, aged 74, retired engineer]

Additionally, similar to a recent exploration of the Qunli National Wetland Park (Zhu et al., 2020), I found some residents reported that parks in Qunli increased their knowledge about nature by providing opportunities for activities such as bird-watching and observing ecosystem processes, as well as through educational and informative signs and posters throughout these areas. Some middle-aged individuals (aged 45-65) mentioned passing this natural knowledge down to their children and future generations.

Residents also mentioned the development affected the perceived aesthetic and social values of the town's green areas, where contrasting views were collected. Some perceived increased aesthetic values as they preferred more organised areas to more wild ones, while some disagreed because of they tended to have a sense of connection to the pre-urbanised landscape due to past experiences, such as social activities:

> "*This place wasn't as modern but was very pretty and charming. There were fishponds where I could fish with family and friends, and afterwards, we would cook what we caught and enjoy it together… Those ponds are long gone now. I now live quite far from where one can fish.*" [male, aged 60, former villager]

Based on the qualitative findings, a broad survey of the wider population of Qunli was then performed to offer a before-and-after perspective through retrospective

comparisons, enquiring into how people perceived changes in these aspects of their environment and how these changed had affected their evaluative happiness.

Among the 1,018 residents surveyed, 28.5% were able to perform retrospective comparisons as they had been long-term residents of the area. Most of these residents perceived positive changes of all types of economic and ecological aspects addressed in the survey, compared to the pre-urbanisation era (Fig. 4.2). However, there was less consensus on whether changes in secure jobs and income (with ~51% perceiving an increase), harvesting of ecosystem goods (~52%), social activities with family and friends in local natural areas (~59%), and the beauty of local nature (~58%) had been positive or negative.

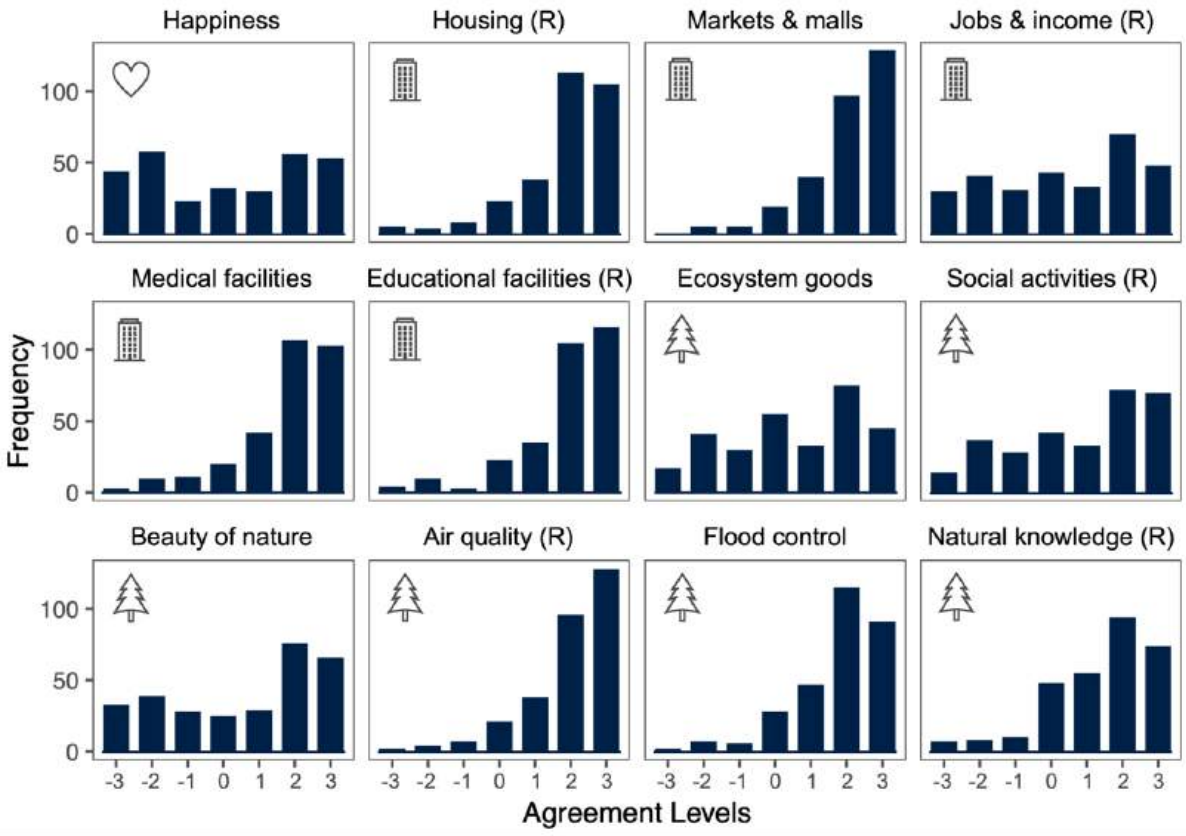


Fig. 4.2: Perceived changes in well-being elements due to land-use change in Qunli New Town (N=289). The subjective element (happiness) is represented by a heart; material elements by a building; and nature-related elements by a tree. Agreement is measured on a -3 to 3 scale, where -3 indicates strong disagreement and 3 indicates strong agreement; R = reverse coding.

Over the period since the town had been built (over a decade), people perceived that housing, markets and malls, and medical and educational infrastructure had changed for the better, but these changes in economic aspects were not significantly associated with increases in their perceived happiness (Fig. 4.3a). In contrast, people who agreed that urbanisation had provided them a job or/and an income source (or had not impacted their previous job or income source) perceived positive changes in their happiness compared to the pre-urbanisation era (odds ratio (OR), 1.22; 95% confidence interval (CI),1.04-1.44; P = 0.014). Ecologically, people who had more social activities in local natural areas (OR, 1.30; 95% CI, 1.08-1.55; P = 0.0049), or who found the urban nature more beautiful, perceived positive changes in their happiness (OR, 1.53; 95% CI, 1.32-1.77; P = 2e-08). Additionally, people who had been agriculturists in the pre-urbanisation era found themselves less happy than non-agriculturists (OR, 0.15; 95% CI, 0.06-0.41; P = 0.00019).

4.3.3 Perceptions of Fairness

Both original residents and later arrivals discussed the subjective theme of perceived fairness. Broadly, their sense of fairness encompassed whether the products and services provided by urban developments and associated ecological mitigation were (i) equally accessible to different stakeholders - "*…fair because everyone can visit the parks without buying tickets…*"; and (ii) equitably distributed to those who need them most - "*…the elderly who need medical services should be treated fairly…*".

What original residents felt was necessary for a good life and what should be accessible to all differed from the views of later settlers. For example, they felt that new regulations preventing residents from harvesting birds in the new town were less fair than new residents. All interviewees affected by these regulations had received no social compensation for their livelihood losses and therefore viewed them as unfair. In contrast, interviewed newcomers regarded them as fair, as they had naturally accepted the 'new normal' without fully realising the shift which had occurred.

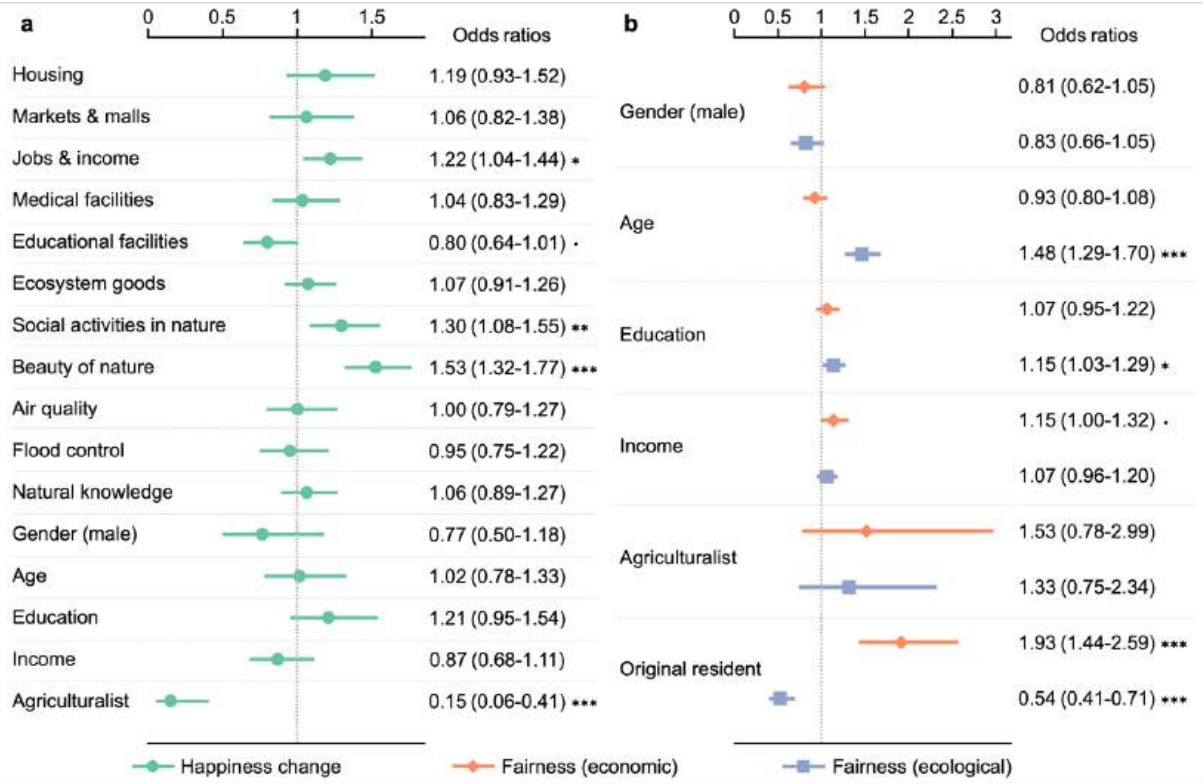


Fig. 4.3: Ordinal logistic regression modelling results. a. A model (N=289) examining the relationship between perceived changes in economic and ecological well-being elements of the new town and perceived change in happiness, with socio-demographic factors controlled; a. two models (N=789 and 959, respectively) examining perceptions of fairness about the economic and ecological consequences of the new town development, in relation to socio-demographic characteristics. (Full models in Appendix D; odds ratios derived from coefficient estimates; significance codes: *** p<0.001, ** p<0.01, * p<0.05, . p<0.1, ns p>0.05).

Furthermore, many ecological mitigation was implemented by the developers as "club goods" (i.e., artificially scarce goods). For example, the onsite plantation and restoration activities within many housing sites were fenced off and made exclusively available to members of the residential complexes. This was especially common in residential developments planned to attract and accommodate newcomers from other parts of the city or other cities, where the overall nature coverage, in terms of both quantity and quality, on the residential sites was higher and better maintained by community management:

> "*The housing developments of [residential complex names] are well-known for their property prices and their green coverage. I've been there*

> *once before. Compared to the resettlement site where I live now, it is much richer [in natural features]: more mature trees, colourful blossoms, and small lakes. It is also under better management. The green areas in my site have already been cleared by my neighbours to grow crops.*" [male, aged 61, former villager]

This bottom-up phenomenon of 'informal ruralisation,' which has been occurring across China (Wang et al., 2024), in my case is characterised by former agriculturalists resuming agricultural activities, a central customary practice of their former communities. They spontaneously ruralised their "club goods" of onsite greening where they "*removed the grass, turned the soil, and sowed vegetable seeds*". According to the agriculturists interviewed, who also reflected on the experiences of their friends and relatives, as well as feedback from a few local planning authorities, many large farmland owners viewed the urban transformation - whether for economic or ecological reasons - as fair. This was because they received generous compensation from the government for their land, which, in some cases, was enough to buy multiple flats and rent them out as a sustainable source of income.

I found both original and later residents considered the economic outcomes of developments as fair for everyone; it appeared that the developments were perceived to have balanced the needs and demands of different social groups, enabling people from diverse socioeconomic backgrounds to secure their basic well-being, though individuals from more advanced socioeconomic backgrounds had more opportunities, freedoms, and choices available to pursue the kind of life they valued:

> "*There are now large shopping centres selling luxury goods. I don't go there… I shop at stores near my place instead. Items there are more affordable.*" [male, aged 30, researcher]

> "*The flats near the Songhua River, where my cousin's family lives, are extremely pricey… We can't afford those. We bought ours just a few*

> *blocks away… still within the town, but at around half the price… We meet [with my cousin's family] and have family dinners in town very often.*" [female, aged 70, retired worker]
>
> "*[If] you want to… get proper treatment, you can go the [hospital name]. But to save money, I only go to the small yet functional clinics. There's one on every street, probably. You can get OK treatment there at a lower cost.*" [male, aged 60, construction engineer]

Among the 1,018 residents surveyed, 789 assessed the fairness regarding the town's economic aspects, while 959 evaluated the fairness about its ecological aspects. Of the 789 respondents, 82.6% reported positively on the fairness related to the economic aspects, and among the 959, 79.8% expressed positive views on the fairness regarding the ecological aspects. Original residents perceived the ecological aspects of the new town as less fair (OR, 0.54; 95% CI, 0.41-0.71; $P = 9.29e\text{-}06$; Fig. 4.3b), while perceiving the economic aspects as fairer (OR, 1.93; 95% CI, 1.44-2.59; $P = 1.22e\text{-}05$). Senior residents (OR, 1.48; 95% CI, 1.29-1.70; $P = 2.83e\text{-}08$), and more educated people (OR, 1.15; 95% CI, 1.03-1.29; $P = 0.013$) perceived the ecological aspects as fairer.

4.4 Discussion

Incorporating nature values into urban planning can lead to changes in both the urban physical environment and institutional settings. In my case, this includes fenced-off protected areas, restricted park routes, improved regulations on bird harvesting, and increased patrol teams for conservation area enforcement. These changes can impact people's well-being across diverse aspects, including material (e.g., natural resources, income), relational (e.g., social relationships), and subjective well-being (e.g., happiness). In particular, 42% of the original residents surveyed felt their lives in the area were less happy than in the pre-urbanisation era. To ensure that the ecological and social benefits of nature-focussed activities within urban

development are achieved in a socially-just manner, it is crucial to understand how different social groups bear the costs and feel the benefits of incorporating nature targets and values.

My retrospective comparative survey found that, as I hypothesised (Table 4.1), respondents' perceptions of changes in jobs and income, the beauty of nature, and social activities in nature significantly correlate with their reported happiness. Therefore, future urbanisation projects in similar contexts (e.g., other cities in China) could allocate more resources towards perceived improvements in these areas to achieve higher levels of reported happiness in the long term. Also, I found that previous agriculturalists were significantly less happy than non-agriculturalists. This may be because, as Wang et al. (2019) revealed, the happiness gains China's agriculturalists obtained from economic developments cannot offset the happiness losses due to their loss of land.

Compared to previous studies that examined the well-being impacts of economic developments aiming for net-neutral or positive nature outcomes (e.g., Bidaud et al., 2017; Griffiths et al., 2020), this work contributes to the literature by (i) employing a larger and more diverse sample, (ii) distinguishing between previous residents and more recent arrivals, and (iii) focusing on an urban development that aims to incorporate nature into its design, rather than a piece of infrastructure with a regulatory offset. I explored how different social groups may perceive varying degrees of fairness regarding local impacts and changes, providing a new subjective lens through which these differences can be understood. For example, former agriculturists were significantly less happy than non-agriculturists as a result of the development but there was no difference in their perceptions of its fairness. This may be because many agriculturalists received sufficient social compensation from the government to feel a sense of fairness, yet they may not have been able to translate this into happiness in the new town (Wang et al., 2019).

Furthermore, original residents and later arrivals showed significantly different levels of perceived fairness. Based on the collected qualitative data, this difference may be due to the occurrence of 'shifting baseline syndrome' related to environmental changes (Chapter 3), where later arrivals develop new expectations and standards for their living environment. Best practice for social impact assessment (SIA) requires baseline comparisons to adhere to the 'do no harm, and if possible, do good' principle (Vanclay et al., 2015). This necessitates well-being assessments across different social groups (e.g., segmented by gender, age, income, occupation) to ensure that diverse voices, particularly those that are underrepresented, are heard equally. From the perspective of shifting baselines, it can be crucial to separately consider different waves of settlers (e.g., initial and later residents). In particular, an urbanisation programme that incorporates nature values and targets may require knowledge and perspectives from long-term residents about the area's natural features and their relationship to their well-being in order to produce more balanced outcomes that benefit both original residents and newcomers.

4.5 Conclusion

As many global agreements, such as the GBF and UN Sustainable Development Goals, promote, incorporating nature values and targets into urban planning can be a crucial measure for conserving biodiversity while pursuing economic development (Mattijssen et al., 2023; Pardo et al., 2023). Socially, it is important to recognise how local people may be affected by the associated activities and interventions, both in urban developments and in ecological mitigation. To meet the best practice principle of 'do no harm, and if possible, do good' in social impact assessments (Vanclay et al., 2015), it is necessary to properly consider the dynamic consequences of these impacts and changes on well-being. More studies are needed from both the Global North and Global South to better understand how an urban development inclusive of nature values and targets may impact local well-being over time, contributing to a socially

just transition towards more ecologically sustainable urban planning and development.

In addition to the perceptions investigated in this study, other mechanisms may also be worth exploring in the context of nature-inclusive urban development. For instance, I found that long-term residents' perceived changes in certain economic and ecological outcomes at my site did not correlate with changes in happiness. This might be because happiness is a multi-dimensional construct, with its determining factors varying across different contexts and potentially changing over time within the same context. Another possible reason could be hedonic adaptation, where people quickly return to a stable level of happiness despite positive or negative changes (Lyubomirsky, 2010; Luhmann & Intelisano, 2018). Understanding these complexities in the evolution of happiness is crucial for improving our ability to predict long-term well-being dynamics resulting from urban developments and associated ecological mitigation, working towards nature- and people-positive urbanisation and expansion.

CHAPTER 5

OPERATIONALISING NATURE AND PEOPLE-POSITIVE INFRASTRUCTURE DEVELOPMENTS

Abstract

It is well-established international good practice for infrastructure development projects to leave nature with net-neutral, and preferably net-positive, outcomes compared to if they were not implemented. The new Kunming-Montreal Global Biodiversity Framework has prompted the pursuit of both nature-positive and people-positive outcomes, given that leaving people worse off after a development project with associated ecological mitigation is not only socially unjust but is recognised as a core barrier for long-term conservation success. Here I review financial institutions' social impact assessment policies and standards worldwide, and critically evaluate their long-standing yet underexplored approach of using the social mitigation hierarchy (SMH). This requires development projects to mitigate their social impacts sequentially through avoidance, minimisation, remediation, and offsetting. Using a case study carried out in Harbin, China, one of the world's largest cities where a major urban expansion has recently been completed, including ecological mitigation, I explore the complexities of implementing the SMH, including selecting well-being indicators, feasibility, compliance, and monitoring. Future studies can contribute to guiding operationalisation of the global nature- and people-positive aspiration, thereby fully unleashing the power of the SMH in managing the diverse well-being impacts of developments.

"*Justice should not only be done, but should manifestly and undoubtedly be seen to be done*."

- Lord Hewart

5.1 Introduction

Countries, businesses and civil society worldwide are taking actions to pursue the mission of halting and reversing biodiversity loss by 2030, as agreed upon in the Kunming-Montreal Global Biodiversity Framework (GBF). The GBF has been recognised as a historic pact foregrounding the need for socially-just nature recovery and equitable benefit-sharing with Indigenous peoples and local communities (IPLCs): IPLCs are mentioned 23 times in the new framework. Placing local people at the heart of the GBF is indispensable (Dinerstein et al., 2020); it is estimated that achieving the framework's area-based targets will potentially impact over 1 billion to 1.8 billion people, mostly in low- and middle-income countries (Schleicher et al., 2019; Allan et al., 2022). The GBF is more likely to be actively successful if it has widespread local acceptance from local people who can fairly access the benefits from recovering nature (Löfqvist et al., 2023).

Impacts associated with under-mitigated infrastructure development have been recognised as a major anthropogenic driver of global nature loss (Maxwell et al., 2016; Newbold et al., 2016; Johnson et al., 2017). Nevertheless, complete cessation of economic development for nature conservation is unfeasible, and prioritising conservation over development can often be unjust or unwarranted (Nilsson et al., 2016; Büscher et al., 2017; Maron et al., 2020). In response, governments, financiers, and businesses worldwide are increasingly requiring that developments achieve no net loss (NNL), and preferably net gain (NG), for nature through following the mitigation hierarchy (Bull & Strange et al., 2018; Bull et al., 2020; Milner-Gulland et al., 2021). To further advance developers' role in the global nature-positive mission, the mitigation hierarchy (MH) should be implemented not only at the level of

individual development projects but throughout entire landscapes, value chains and financial portfolios (Locke et al., 2020; Maron et al., 2024; Booth et al., 2024).

All steps in the ecological MH impact people's well-being (Jones et al., 2019; Díaz et al., 2018). In particular, the step of offsetting can have negative impacts, as shown in Fig. 5.1 (Bidauda et al., 2017; Kalliolevo et al., 2021; Tupala et al., 2022). Though there are instances where the impacts of offsets on people may be positive, studies often show a clash between securing human well-being and conserving biodiversity (Brownlie et al., 2013; Takacs, 2020; Tupala, 2022). This is because, first, under-mitigated development activities can reduce nature-associated values and contributions to people's well-being, and second, the ecological compensation associated with these developments can further threaten people's access to nature-related values through land acquisition and limited access to resources (Jones et al. 2019, Tupala, 2022).

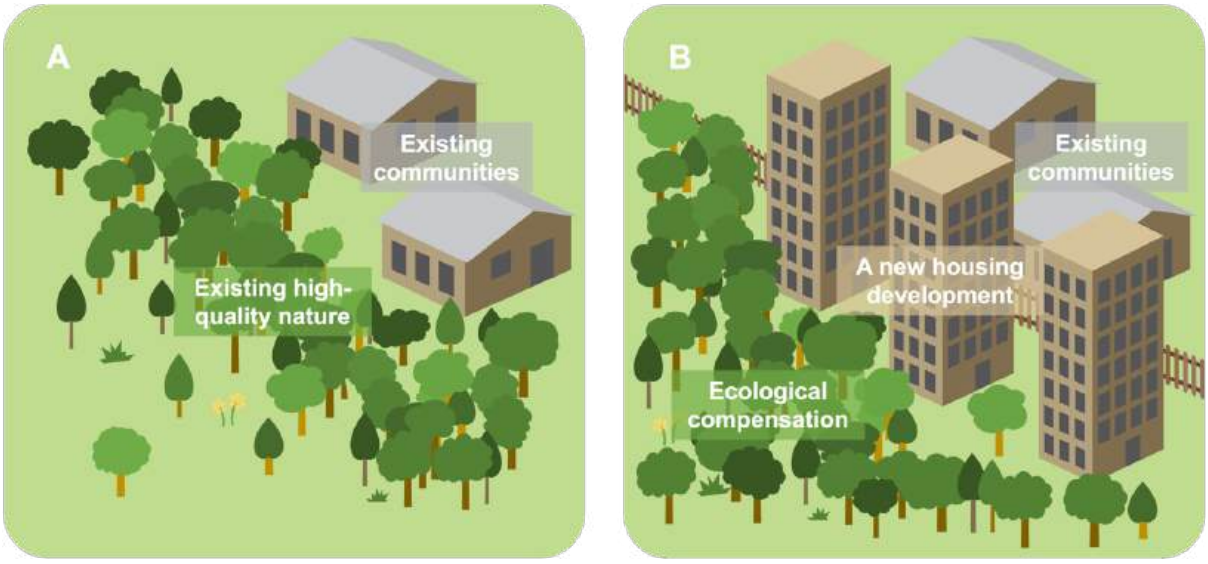


Fig. 5.1: Illustrating how an infrastructure development implementing an NNL/NG target can impact local communities. Panel (A) shows a pre-activity situation where residents of an existing neighbourhood can benefit from an adjacent high-quality natural area. Panel (B) illustrates a new gated housing development with ecological mitigation, which can impact on communities' well-being even if the mitigation area enhances nature.

Evidence from both the Global North and South has emphasised the need to give sufficient attention to changes in nature's contributions to people when

implementing NNL/NG activities (Table 5.1). Thus, developers may need to determine their mitigation actions with local stakeholders through early engagement (e.g., through participatory planning; Bull et al., 2018; Griffiths et al., 2019a; Tupala et al., 2022). As mitigation actions that people find to be acceptable compensation for their well-being loss may not be those that deliver the best biodiversity benefits (Taherzadeh & Howley, 2018), trade-offs are inevitable. To approach outcomes that work for both people and nature, the social impacts of ecological mitigation actions need to be better appreciated (Jones et al. 2019; Tupala et al., 2022). This is important from the moral perspective of environmental justice (Varumo et al., 2023). It is also instrumental in gaining local support towards enhanced and enduring conservation outcomes (Bidauda et al., 2017; Jones et al., 2019; Löfqvist et al., 2023).

The no-worse-off principle for NNL/NG activities was put forward by Griffiths et al. (2019a) and operationalised into Good Practice Principles by Bull et al. (2018). This principle requires that people affected by developments and associated NNL/NG activities perceive their well-being to be at least as good as a result of these activities than if the development and ecological mitigation had not been implemented. Yet, a subsequent scoping study in the UK revealed that, though there was widespread agreement among industry professionals and stakeholders that adverse well-being impacts should be mitigated under the no worse-off principle, it remained unclear how to operationalise such a principle (CIEEM, 2021). Better understanding of operationalisation is vital; as the NNL/NG approach is being implemented around the world (Bull & Strange, 2018; IUCN, 2019), well-being impacts caused by development and associated NNL/NG activities are expected to become increasingly salient.

5.2 Materials and Methods

5.2.1 Social Mitigation Hierarchy

To achieve social outcomes that are desirable to local people while mitigating environmental impacts, reliable social impact assessment (SIA) exercises are

Table 5.1: Global examples of the negative impact of NNL/NG implementation on nature's contributions to people.

Domain	Country	Description	Reference
Access to green areas	Australia	Offsets expanded the area of publicly accessible land area by changing land ownership, generating amenity benefits by enhancing the nature values on public land. However, NNL projects could also contribute to a loss of urban nature, given that offset sites tended to be situated further from urban areas compared to the associated development sites.	Kalliolevo et al. (2023)
Material goods and social relations	Madagascar	The conservation restrictions that prevented local activities (e.g., land clearing for agriculture, gold mining, poaching, livestock grazing, forest product extraction) from taking place in offset sites - though providing certain benefits, such as improved local water supply and air quality - impacted local people's food security, as well as social relations: for example, encouraging people to report forbidden activities introduced new social tensions.	Bidaud et al. (2017)
Human rights	Sweden	Ecological compensation impacted environmentally-based human rights, especially the rights of the Indigenous Sámi people; for example, it impacted local access to recreation, cultural rights and rights over natural resources.	Koh et al. (2017)
Cultural heritage	Uganda	Biodiversity offsetting affected local nature-based cultural values, for example, by impacting people's spiritual beliefs, customary practices, rituals, and ceremonies.	Griffiths et al. (2020)

necessary (CIEEM, 2021). The concept of the social mitigation hierarchy (SMH) originated from João et al. (2011). Financiers at global, regional, and local levels have established SIA policies or standards for the developers which they fund to adhere to. Many of these policies and standards recommend the sequential implementation of the SMH to address projects' local social impacts (Table 5.2). The widespread adoption of SMH in SIA policies and standards over the past decade stems from its endorsement by the International Association for Impact Assessment (IAIA) in the association's SIA guidance (Vanclay et al., 2015).

However, all previous policies and standards assume that the SMH is effective in achieving positive results for people, while no work has attempted to confront and critically evaluate the approach in the academic literature. This lack of scrutiny is particularly concerning given the significant global financial flows being directed toward mitigating and compensating for the social impacts of projects under these policies and standards. For example, for the Philippine Malolos-Clark Railway Project, a USD 2 million grant from the Asian Development Bank, allocated over 2022 and 2023, was used to mitigate social impacts on nearby vulnerable communities (ADB, 2024). Therefore, I use a case study in Harbin, China, to critically evaluate this approach and provide insights into how the SMH could best be operationalised to ensure that both nature-positive and no-worse-off principles can be fulfilled by a development project.

Using the SMH to operationalise people-positive strategies in NNL/NG projects

Though the usage of the term in different policies and standards may vary, the core idea of the SMH is based on the same four steps as the ecological MH, which should be implemented sequentially: (i) avoid, (ii) minimise, (iii) remediate, and (iv) offset (Fig. 5.2). Here, I conceptualise SMH in the context of NNL/NG, a core element towards measurable nature-positive results. I focus particularly on the measures used to mitigate the well-being impacts of losses and gains in nature's contributions to people (e.g., food production, and social and cultural activities within natural

Table 5.2: A global review of financial institutions' SIA policies or standards recommending the use of SMH.

Organisation	Member or recipient	Policy or standard	Document quotations
African Development Bank	54 regional members and 27 non-regional members	Integrated Safeguards System	"*The [Environmental and Social Management Plan] identifies measures and actions, in accordance with the **mitigation hierarchy**, that **avoid and reduce** potentially adverse environmental and social impacts to acceptable levels, and those that maximise positive impacts*."
Asian Development Bank	49 regional member and 19 non-regional members	Environmental and Social Framework	"*These [Environmental and Social Standards] are collectively designed to help borrowers/clients to apply the **mitigation hierarchy** and improve their E&S (environmental and social) performance*."
Eurasian Development Bank	6 countries (Armenia, Belarus, Kazakhstan, Kyrgyzstan, Russia, Tajikistan)	Environmental and Social Responsibility Policy	"*The Bank strives to enhance potential positive and **prevent** or **mitigate** adverse environmental and social effects in planning and implementing investment Projects and to ensure that Bank-funded Projects contribute to sustainable development*."
European Bank for Reconstruction and Development	72 countries from 5 continents	Environmental and Social Policy	"*[A]dopt a **mitigation hierarchy** approach to address environmental and social risks and impacts from project activities on workers, affected communities, and the environment*."
European Investment Bank	27 Member States of the European Union	Environmental and Social Standards	"*Applying the **mitigation hierarchy** through the identification of measures to **avoid, prevent and reduce** any significant adverse effects and, if required, **remedy/compensate** any residual effects on project-affected people, communities and workers, as well as on the environment*."
Inter-American Development Bank	26 borrowing members and 22 non-borrowing members	Environmental and Social Policy Framework	"*Require Borrowers to apply a **mitigation hierarchy** to **anticipate and avoid** adverse impacts on workers, communities, and the environment or, where avoidance is not possible, to **minimize** such impacts. Where residual impacts remain, Borrowers must **compensate/offset** risks and impacts, as appropriate*."
International Finance Corporation	186 countries across the world	Performance Standards on Environmental and Social Sustainability	"*To adopt a **mitigation hierarchy** to **anticipate and avoid**, or where avoidance is not possible, **minimize**, and, where residual impacts remain, **compensate/offset** for risks and impacts to workers, Affected Communities, and the environment*."

Table 5.2 (*continued*)

Organisation	Member or recipient	Policy or standard	Document quotations
Islamic Development Bank	57 member countries	Environmental and Social Safeguards Policy	"*The IsDB reviews the Client's environmental and social assessment and Environmental and Social Documentation in order to determine whether appropriate measures are in place to* ***avoid, minimize, mitigate, offset or compensate for*** *environmental and social risks and impacts of the Project*."
Nordic Development Fund	5 Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden)	Environmental and Social Policy Guidelines	"*NDF recognises that adverse environmental and social impacts cannot be avoided in all projects but must be appropriately* ***reduced, mitigated*** *or* ***compensated for***." "*NDF prefers entering the projects at an early stage as opportunities can be highlighted and encouraged and potential environmental and social problems* ***avoided or minimised*** *with more ease.*"
North American Development Bank	US and Mexico	Environmental, Social and Governance Policy	"*[E]ffective measures will be undertaken by the client to* ***avoid, minimize, mitigate****, or* ***compensate for*** *the adverse E&S (environmental and social) impacts*."
Queensland Government	Queensland	Social Impact Assessment Guideline	"*The SIA must provide management measures for all potentially significant negative impacts, and must demonstrate that* ***the hierarchy of avoid and mitigate*** *has been followed*."
Uganda Development Bank	Uganda	Environmental and Social Management Systems	"*To adopt a* ***mitigation hierarchy*** *to* ***anticipate and avoid****, or where avoidance is not possible,* ***minimize****, and, where residual impacts remain,* ***compensate/offset*** *for risks and impacts to workers, Affected Communities, and the environment*."
US Agency for International Development	Assistance to over 100 countries	Social Impact Assessment Principles	"*The mitigation measures should follow the* ***mitigation hierarchy*** *(from most to least preferred).*"
World Bank (International Bank for Reconstruction and Development & International Development Association)	189 (IBRD) and 174 (IDA) countries	Environmental and Social Standards	"*[I]dentify ways of improving project selection, siting, planning, design and implementation in order to apply the* ***mitigation hierarchy*** *for adverse environmental and social impacts and seek opportunities to enhance the positive impacts of the project*."

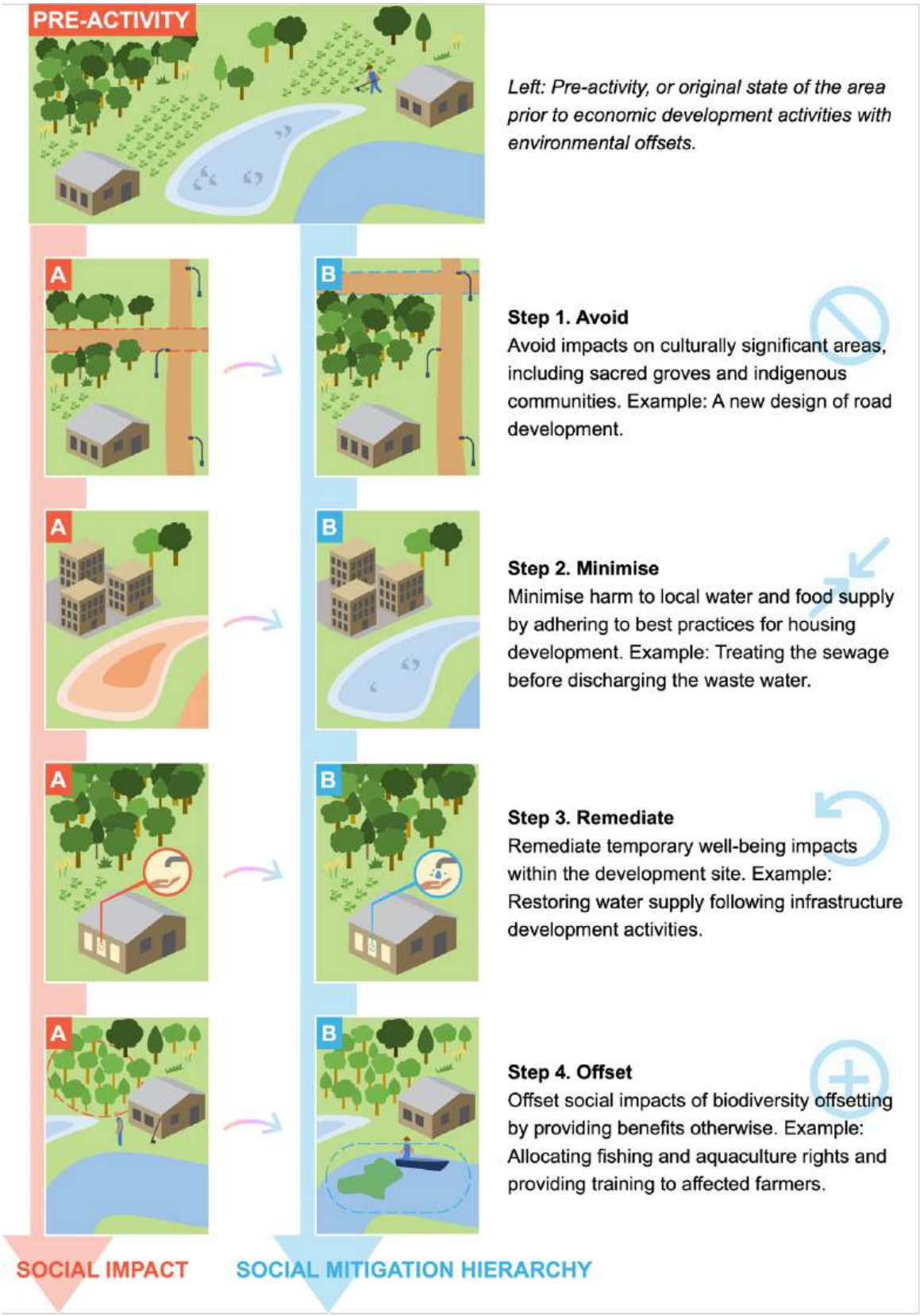


Fig. 5.2: An example of the SMH applied to infrastructure development activities with NNL/NG implementation. The images marked with an (A) represent the types of negative social impacts from development or/and compensation activities, and the corresponding images marked (B) represent ways to mitigate these impacts by undertaking the four steps of the SMH. Steps 1 and 2 are preventative measures, while steps 3 and 4 are compensatory approaches.

landscapes). Though purely social impacts (e.g., involuntary resettlement or new jobs created by the development) are important, addressing these impacts are beyond the scope of this study because I focus on the intersections between ecological and social impacts and their mitigation.

Historically, well-being has commonly been assessed by a single indicator, such as income or health (Well et al., 2024). Yet, there is an academic consensus that well-being is multi-dimensional, involving three interrelated dimensions: material, relational, and subjective (McGregor & Sumner, 2010; White, 2010; Milner-Gulland et al., 2014; Woodhouse et al., 2015; Jones et al., 2019; Loveridge et al., 2020; Llopis et al., 2023; Wells et al., 2024). The material aspect is concerned with what a person has, the subjective aspect with what they think about what they have, and the relational aspect with what they can do with what they have. This multi-dimensional construct means that well-being cannot be adequately assessed solely by objective measures, as this does not reveal the many subjective elements of well-being, such as the extent to which they are satisfied with their overall life or a change in their living environment.

The first step in the SMH involves avoiding impacts on well-being that are impossible or highly difficult to redress later, such as avoiding damage to natural and cultural heritage. Similar to the MH for nature conservation, impact avoidance is considered the most important step in the SMH, as it is the most certain way to tackle adverse well-being impacts (Vanclay et al., 2015; Arlidge et al., 2018). Moreover, impacts on legal rights that identify the minimum levels of civil, cultural, economic, political, and social conditions for people's dignity and basic well-being should be prohibited (Massarani et al., 2007; Hsieh, 2009; Vanclay et al., 2015).

The second step requires that before and during development, impacts are minimised, such as by minimising sewage pollution that can lower local water quality and contaminate food supplies. This can also include minimising impacts on air pollution and accessibility to cultural landscapes, and reducing the height of a dam wall to

reduce the area flooded in order to minimise displacement of communities (Vanclay et al., 2015). Adverse impacts that are not avoidable can be reduced during design, construction, operation, and decommissioning. In both avoidance and minimisation, both permanent and temporary impacts should be considered and prevented as much as possible. Temporary impacts should not be dismissed or disregarded as they may also generate huge well-being impacts (Bidaud et al., 2017; Jones et al., 2019).

The third step of the SMH requires negative impacts on nature's contributions to people and their associated well-being to be remediated within the footprint of the activity (development with NNL/NG implementation), such as recovering air and water quality, restoring water and food supplies, replanting trees, shrubs, and grass, and restoring accessibility (e.g., reopening closed roads) to recreation. Different from offsetting, remediating an impact means to recover it to its original functionality. In some cases, instead of restoring people's situation in a "like for like" way, people may prefer mitigation to enhance other existing well-being factors (whether or not they relate to nature) or they may identify alternative options that are compatible with their new situation (Vanclay, 2017).

The final step requires that any residual social impacts should be offset in a way that is meaningful to the people who are affected by the activity, for example, through the provision of new jobs and recreational opportunities. For example, alternative livelihood projects can be a type of social offset (Wright et al., 2016). Similar to biodiversity offsets, social offsets can also be in-kind or out-of-kind (João et al., 2011; Vanclay, 2015). In-kind offsets are especially required to counterbalance unavoidable impacts on pivotal well-being factors, for example, access to food and income. Out-of-kind offsets can be used when a loss in the well-being factor impacted by the activity can be fully redressed through a gain in another well-being factor.

Temporary offsets are sometimes required to tackle temporary ecological impacts (Moilanen & Kotiaho, 2021). In the social domain, dealing with temporary impacts can be of immense importance, for example, through temporary employment

opportunities, monetary compensation for reduced agricultural production, or provisional water supply from an alternative source. For example, the development activities brought by Ambatovy mine in Madagascar had delayed benefits (e.g., fruit or coffee production); the temporal mismatch between well-being losses and gains forced local people to turn to casual labour to feed their family (Bidaud et al., 2017). This means offsets could be needed earlier than impact remediation, especially for decades-long projects. Offsets can occur before or after some impacts are generated, but remediation can only take place after the impact-generating activity.

5.2.2 Case Study Site

Qunli New Town was a major urbanisation scheme which took over a decade to complete, starting in 2006 (see section 1.2). Many development projects were completed in the town, alongside projects to mitigate and compensate for development impacts. To address the social impacts caused by these land-use changes, multiple mitigation measures were implemented, including monetary compensation for farmland acquisition and for loss in farmers' livelihoods. Yet, some people have raised doubts and disagreements about how the project impacts were mitigated and how the benefits were distributed, according to local media (Heilongjiang Daily. 2006; Xinhuanet Heilongjiang, 2011). The fact that the development aimed to mitigate both ecological and social impacts makes the town suitable to explore the possible benefits of using a SMH in improving social impact mitigation.

5.2.3 Data Collection

Following the guidelines provided by Knott et al. (2022), semi-structured interviews were implemented locally. To investigate how local development and ecological compensation activities generated social impact, I applied the widely-adopted three-dimension framework of human well-being (i.e., material, relational, and subjective) to design my interview protocol (Narayan et al., 2000; Gough & McGregor, 2007;

Milner-Gulland et al., 2014; McGregor & Pouw, 2017; Loveridge et al., 2020); my interviews focussed on how local land-use change activities with social impact mitigation measures affected people in meeting their needs, pursuing goals, and experiencing a satisfactory quality of life.

I recognised that some contextual (political) factors in my study setting can influence the elicitation of people's actual views and perspectives. In response, I framed the interview questions more around environmental change and the impact mitigation activities themselves, focusing less on the politics of these activities (e.g., how and by whom these decisions were made). During data collection, many interviewees voluntarily broached topics related to this sensitive information, demonstrating the trust built by this approach. The fact that I am from the case study area may have helped in ensuring that interviews were conducted in a way that was sensitive to the local context. In total, I conducted 42 interviews, ranging from 25 minutes to 1.5 hours. The demographic characteristics of the respondents mirror the age and gender distribution found in the most recent city census (2020).

I determined when enough interviews had been done, loosely guided by the concept of data saturation (Small, 2009; Gerson & Damaske, 2020). I acknowledge that total saturation is typically unattainable since additional information may continually surface from additional interviews (Wray et al., 2007; O'Reilly & Parker, 2013; Low, 2019). Hence, my aim was to achieve 'depth and richness of analysis' (O'reilly & Parker, 2013). To achieve this target, I employed two main criteria. The first involves capturing information on how material, relational, and subjective well-being are impacted by local environmental change, along with (social impact) mitigation measures. The second entails eliciting views and perspectives, both positive and negative, on local mitigation measures. To identify this information, I carried out a thematic analysis, following the six-phase guide of Braun and Clarke (2006). The aim of this was to develop and interpret different themes regarding the mitigation measures through coding the qualitative information gleaned in the interviews. All

interviews were carried out in the local language and dialect. They were then transcribed and translated into English. The translated content was re-translated from English back to Chinese (i.e., back translated) with the help of local assistants, to provide an accuracy and quality check (Brislin, 1970 & 1986).

5.3 Results

5.3.1 Well-Being Indicators

Residents reported how economic developments with ecological mitigation impacted on many aspects of their well-being. The clearance of land for the new town involved removing villages, farmland and factories, affected residents' jobs, income, social networks, and identities. For example, one interviewee stated:

> "*My family used to plant trees in our farmland, like lilac trees, and then sell them to the government for urban road greening… We no longer own the land.*" [female, aged 69, cleaner]

Additionally, land conversion led to the removal of a public cemetery built on grassland, which was subsequently transformed into a wetland park. This change has affected the emotional and spiritual values of some villagers, who expressed that - though the efforts to mitigate impacts on people's basic (physiological and safety) needs were welcomed - the psychological and spiritual domains of well-being should also be integrated into impact mitigation. The new wetland park provided cultural and recreational values to both villagers and the residents who moved into the new urban developments later. Together with other ecological mitigation measures, such as the restoration of farmlands to wetlands, they provided a range of well-being benefits, including flood control and societal safety. Improved safety was particularly evident in the experiences of some local people:

> "*I fought, in groups, or [committed] other [criminal] acts in the past… then I hid in the coastal area in the [pre-development] Qunli to dodge*

> *[the police]. It's been planned and transformed into a big green park, so there is nowhere to hide now."* [male, aged 49, unemployed]

> *"That place used to be very dark, muddy, unorganised… There was only a narrow lane with no streetlamps. There used to be muggers mugging with knives."* [male, aged 61, former villager]

Stakeholders' opinions reveal multiple aspects they used to define well-being. They generally highlighted the positive and negative effects on a wide range of contributions provided by both 'natural' and 'managed' ecosystems to different people. In addition, different respondents perceived a single change in varied ways, but the key well-being elements felt by people from similar social, economic, or cultural backgrounds were comparable. For example, rural villagers tended to prioritise the impact of NNL practices on their jobs, income, and children's livelihoods and opportunities, while urban residents placed greater emphasis on environmental quality and recreational activities.

5.3.2 Prevention or Compensation?

Residents held differing views on whether preventative or compensatory measures should be used to mitigate a well-being impact. Particularly, avoidance was preferred in cases where few or no alternatives could be found to provide the same type of benefit that was lost. For instance, respondents reported that a designated site of cultural heritage (the *Dianjiantai* Site) was partially damaged by a hydraulic engineering project. As of the date of the interview, the site was undergoing repairs as requested by the authorities. Some proposed that damage to the site should have been avoided in the initial stages because of its uniqueness:

> "*[The developer] shouldn't have started digging in the first place. They should have avoided impacting it… The site is one-of-a-kind and monumental, representing the history of this place.*" [male, aged 61, security guard]

Additionally, residents were more likely to recommend preventative measures when a change could affect the well-being elements upon which their livelihood or quality of life depends. For example, some villagers expressed their reliance on their farmland for their livelihood, identity, and sense of purpose, and therefore suggested that impacts on their farmland should have been avoided. Many urban residents also stressed preventing air and particle pollution that might cause irreversible harm to their bodily and mental functioning.

Another reason villagers expected the avoidance of impact on their farmland was the anticipated future benefits it could provide to their descendants. For example, one interviewee stated:

> "*[Villagers] got [monetary] compensation… The government also provided us with a land-loss pension insurance… We feel that this is not sufficient really, because we sense that we are spending the money intended for our future generations*." [male, aged 61, former villager]

Anticipated high future value was also a reason why people believed the impact on cultural heritage should be avoided. In terms of the *Dianjiantai* site, both villagers and non-villagers interviewed - despite their varied connections to the site - demonstrated a preference for avoidance over compensation because of the cultural value that can be passed down to future generations. Some people advocated avoidance as it was questionable whether the impact was reversible and restorable:

> "*A corner of the* Dianjiantai *collapsed due to the construction work… Some villagers reported the issue to the authority in charge. It's now under repair, but I don't know how much they can fix it*." [male, aged 88, retired engineer]

In contrast, impacts were deemed more reversible when people were confident that certain compensation measures could be effective. In some cases, compensation was considered acceptable but it was felt that it should not take precedence over

prevention. For instance, residents conveyed confidence in the feasibility of effectively restoring local air quality. Thus, although clean air was considered irreplaceable and locally-dependent, many residents could accept compensatory measures. However, they felt that efforts should prioritise minimising this impact initially:

> "*The restored air quality of the town is now the best in the city… In the years of development, the air in the town was quite polluted. Especially during the most intensive construction periods, the sky was often misty. [The developer], in a rush to build and complete projects quickly, did not handle the pollution problem very well.*" [male, aged 30, junior researcher]

In cases where people expected that their well-being outcomes could clearly improve through offsetting, they expressed a preference for offsetting over prevention. For example, many younger villagers reported their willingness to trade their farmland for money because they found farming work to be "*neither respected nor profitable*." Consequently, they preferred to recruit workers from remote areas to farm their land, while they themselves sought jobs in urban areas.

Though not my primary focus, I found some non-ecological impacts also presented similar features. For example, villagers in the town whose houses were cleared received compensation in the form of new, higher-quality flats of similar or larger size. One reason why many villagers desired to exchange their houses for new flats was for a better living environment, for example, due to improved energy and heating services:

> "*I prefer living in the flats than the bungalows, because in winters I don't need to buy coals, carry them to my home, and burn them on my own anymore. [Paying energy bills] costs me slightly more money but there's much less trouble now!*" [male, aged 61, former villager]

Besides, villagers who owned larger houses exchanged them for multiple flats, living in one while renting out the others to generate sustainable income, resulting in a significant improvement in their living standards.

5.3.3 Just Transition Processes

People emphasised the importance of making the transition processes fairer and more engaging, both for the development and ecological mitigation efforts. Some respondents expressed their discontent with the approach that was taken regarding the replacement of the cemetery with a wetland, and with the inadequacy of the consultation and negotiation processes. For example, some felt they were not provided with sufficient time to relocate graves:

> "*[The compensation provider] cleared that area for a large wetland without providing any compensation… The process was so rapid that many villagers couldn't relocate the graves in time. I went to see it when they were clearing the cemetery, and the whole place was filled with skulls and bones, very frightening.*" [female, aged 83, retired]

Some tenant farmers (who rent farmland from landowners) and farm workers (who were employed to farm) also found it unfair that the entire compensation fees went to the landowners, while they themselves received no compensation. They didn't know whether it was a lack of compensation allocated to them by the developer and government, or if their landowners had embezzled their compensation fees. They expressed the need for the process to be more respectful, transparent, and accessible.

Similar fairness issues were also identified in the context of resettlement. Some villagers faced forced evictions from their homes due to disagreements over the allocated compensation fees; they expressed their emotional and material loss in the process, but also a loss of trust in the developer and the government. Others revealed that a lack of information disclosure prevented them from developing informed opinions on many major decisions they needed to make for their and their families'

lives. For example, some pointed out that crucial information about the relocation flats, such as their location and floor numbers, was not disclosed to them:

> "*[The government] only gave us several minutes to choose our relocation flats. Lots of information was unclear and not provided in advance.*" [female, aged 69, cleaner]

5.3.4 Adaptation to Change

As an offset for the well-being impacts of the developments, lump sums were transferred to the villagers whose land rights were acquired for the developments and associated ecological mitigation. The local government, responsible for overseeing local mitigation measures, played a key role in mitigating these impacts. However, a local planning authority official indicated that how compensation fees were spent by residents was beyond their responsibility:

> "*[Villagers] could use the money to do whatever they want and lead the kind of lives they want. They can invest or start businesses. We've done all we need to do; money is transferred, case is closed.*" [male, aged 55, government official]

Yet, some villagers revealed a failure of such transfers, which assumed they have full agency to decide and act to benefit their own well-being. For example:

> "*Some of our villagers took the money and went gambling, losing everything… They don't have the ability to open shops or start companies, [though] they've thought about that*." [male, aged 61, security guard]

The loss of farmland also generated long-term well-being problems due to people's failure to adapt to the new situation, which has even affected ecological outcomes. For example, some older villagers who relocated into the new housing area still regarded farming as an integral part of their way of life, considering it a central customary practice of their former communities. Some said they were not aware of

farming being a meaningful part of their lives before physically moving into the urban area. Thus, they resumed their previous agricultural activities and began cultivating vegetables by "ruralising" the natural areas developed for ecological compensation on the housing site; it is reported that these former villagers "*removed the grass, turned the soil, and sowed vegetable seeds*". In fact, this bottom-up phenomenon of 'informal ruralisation' has been occurring across China (Wang et al., 2024).

There were also non-ecological impacts on long-term well-being caused by relocation, which also needed better measures to support people's adaptation. For example, housing certificates are a key document for school enrolment of young kids, as one interviewee stated:

> "*Our flat(s) took a long time to get their housing certificate(s). It delayed the enrolment of our (grand)children in schools!*" [female, aged 70, retired worker]

Generally, respondents argued that the social offsetting measures which were implemented were oversimplified and failed to effectively help them adapt to their new environment. Further, those who were already precarious and vulnerable were more likely to suffer from having to adapt to their new environment on their own.

5.3.5 Compliance and Monitoring

In addition, terms of the impact on local cultural heritage, one main reason why the impact failed to be avoided properly, as documented in local reports (e.g., Life Daily, 2020), was insufficient regulatory and political enforcement; developers started converting the cultural site before being permitted to do so by the local heritage department. Some respondents suggested "*severe penalties*" should be applied as a deterrent against such an impact. In terms of severity, some gave some numbers from "*three times*" to "*ten times*" the cost imposed on local people by the loss of their cultural heritage, but they were unsure about the right multipliers to apply.

In my post-hoc evaluation, some villagers suggested that monetary compensation had failed to fully offset the well-being losses caused by land clearance, and they indicated that some other actions might be needed to cover the long-term, intergenerational well-being impacts, including the knock-on effects of past changes. Many of these impacts only emerged in the long run, and were not fully predictable for local people at the stage of land acquisition, or, potentially, for the developer. Some villagers also disclosed that their perceptions of their diminished ability to care for their children had intensified over time.

5.4 Key Lessons for SMH Implementation

The case study shows the many components and complexities involved in operationalising the 'local people should be no worse off and preferably better off' principle while pursuing ecological NNL/NG goals (Table 5.3). Despite the mitigation hierarchy prioritising prevention of impacts, my case study demonstrated that impact prevention is not always better than impact compensation. Thus, to implement a SMH, it is essential to decide with local stakeholders whether an impact is reversible, or a well-being element should be prioritised, as this determines whether the impact should be prevented in the first place or could be compensated. I present a conceptual framework to assist decision-making (Fig. 5.3); it proposes that for every change that could impact how nature contributes to people's well-being, it is at least required to determine to what extent these contributions are locally dependent, replaceable by accessible alternatives, ongoing, and remediable/offsetable within the local context.

I found that people sometimes desire improvements to previously enacted mitigation measures or the enactment of additional measures to address long-term intra-generational and inter-generational effects that emerge several years after an economic development project. One main reason why many of these impacts were not anticipated during the initial planning stages is because they were not fully apparent. As people's responses to an activity (e.g., land-use change for ecological

Table 5.3: Approaches to addressing the challenges of applying the SMH, based on work on social interventions and lessons from the mitigation hierarchy for nature conservation (based on Bull et al. 2013, 2019; Arlidge et al., 2018; Jones et al., 2019).

Challenge	Description	Current project-level best practice recommendations
Additionality	Whether an intervention has an effect, when compared to a counterfactual	Only well-being gains that are additional to a counterfactual "no development/mitigation" scenario count as valid social offsets.
Compliance and monitoring	Noncompliance with SMH; insufficient compensation for well-being losses	Relevant authorities should follow up with monitoring to ensure compliance; social offsets should be enhanced and expanded if well-being impacts turn out to be more extensive or different to originally anticipated.
Equivalence	Demonstrating equivalence between well-being losses and gains	'In-kind' (e.g., land-for-land) or 'out-of-kind' (e.g., cash-for-land) trading can be both feasible if the measure is locally accepted as good enough to fully compensate for local well-being loss.
Feasibility	The practical complexities of engaging local people with the SMH.	Social targets (e.g., no worse off) are defined and assessed at the appropriate level of aggregation that is feasible for the relevant authority/implementer but captures relevant groupings in a population.
Justice	Ensuring 'just means' and 'just ends' in SMH implementation	Views and knowledge systems of different local stakeholders, especially those from minority and marginalised groups, are well recognised and involved in decision-making processes; participatory approaches are applied to design and implement social mitigation measures, to evaluate the well-being benefits of measures, and to monitor the effectiveness of measures through time.
Longevity	The length that a social offset scheme should endure	Well-being enhancements should last the length of the negative impacts at a minimum; social offsets should be adaptively managed in the light of ongoing internal and external change (e.g. impacts on the next generations)
Multipliers	A factor that increases the amount of well-being gains required by an offset	For quantitative indicators (e.g., economic assets that compare compensation fees with farmland losses), calculation of a multiplier is based on various factors, including the discount rate for future well-being gains and uncertainty in definition and well-being measurement. Multipliers are unfeasible for less quantifiable aspects.
Reference scenario	Defining a well-being baseline to compare against	To ensure that well-being is at least non-declining, a static baseline should be used unless local well-being is expected to increase in the absence of the development.

Table 5.3 (*continued*)

Challenge	Description	Current project-level best practice recommendations
Reversibility	Defining if certain well-being impacts can be offset	Irreversible impacts are generally recognised as impacts that cause long-lasting effects; are difficult to undo/have high revoking costs; and lead to the loss of substances or processes that are difficult to compensate for. These impacts should be prevented.
Time lag	Deciding whether to permit a temporal gap between well-being losses and gains	Time lags in mitigating local well-being impacts should be avoided; temporary compensation can be implemented to ensure well-being improvement during the transitional period.
Well-being indicators	How well-being impacts is assessed or measured	Using a multi-dimensional system with indicators that are both conceptually and contextually valid. They should include 'global' elements that are recognised as important to every individual's well-being. They should also involve 'local' elements that local communities value or have reasons to value.
Prioritisation	Well-being components that should be prioritised	Well-being elements that are felt to be important by the project-affected people should be prioritised, along with globally recognised key components of well-being even if not highlighted by local stakeholders (e.g., rights).

compensation) or a social mitigation measure (e.g., financial compensation for farmland acquisition) can evolve over time, it is imperative to monitor how they impact local well-being over time, both so that impact mitigation can be adjusted, and to help inform decision-makers about some of the likely issues which will affect future interventions towards people-positive outcomes. It may be that an ongoing social impact mitigation fund associated with a development should be established to ensure that capacity exists to tackle any unanticipated impacts.

Successful implementation of the SMH requires early involvement of multiple stakeholders in the planning process, rather than retrofitting mitigation to accommodate their views and concerns after major decisions have already been made. Inequitable stakeholder engagement can lead to suboptimal, or even unethical, outcomes (Sayer et al., 2013; Loveridge et al., 2020). Adequate engagement that well integrates local interests and concerns and make local communities feel they are well heard and respected can promote the public acceptability of the project (Ross et al.,

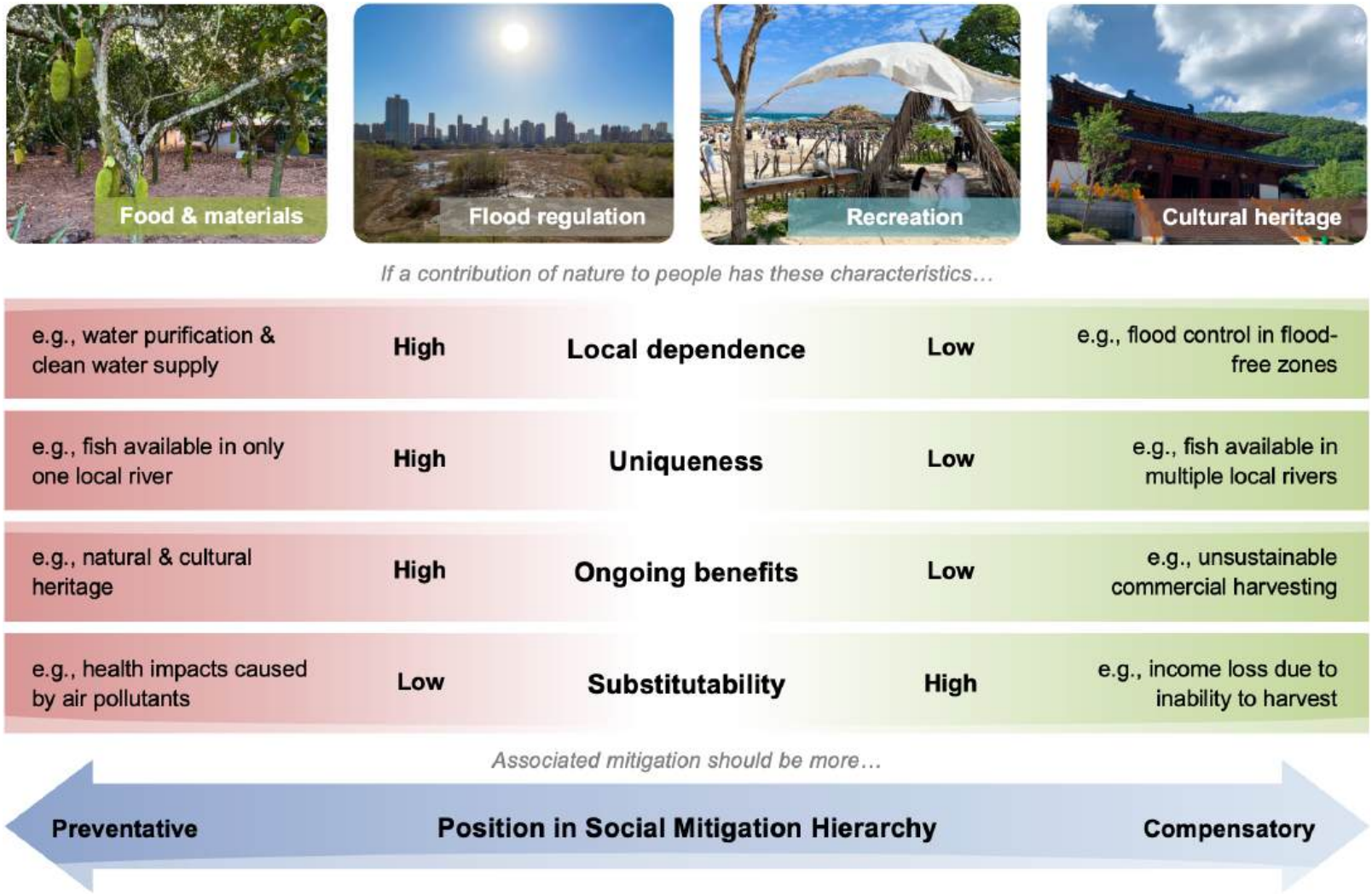


Fig. 5.3: A conceptual framework for determining if preventative or compensatory measures should be used. Preventive measures are more likely to be needed if a contribution that nature makes to people, which will be impacted by the development is locally dependent, lacks alternatives, provides significant ongoing benefits, and is unlikely to be effectively compensated within the local context.

2014; Metcalf et al., 2015; Walker & Baxter, 2017), especially when local people were asked to impact major decisions regarding a change in their environment (Liu et al., 2019 & 2020).

5.5 Moving Forward

Infrastructure developments which aim to be nature-positive must adhere to the ecological mitigation hierarchy (Maron et al., 2024). Yet, implementing nature-positive developments, even at the project level, can generate high social impacts (Jones et al., 2019). These impacts will also be felt when the MH is applied throughout entire value chains and financial portfolios in order to contribute to the global nature-positive mission (Maron et al., 2024). Social impacts need to be properly addressed to ensure that nature-positive actions are socially just, for true sustainable development that benefits both people and nature (CIEEM, 2021; Obura et al., 2023; Doncaster & Bullock, 2024).

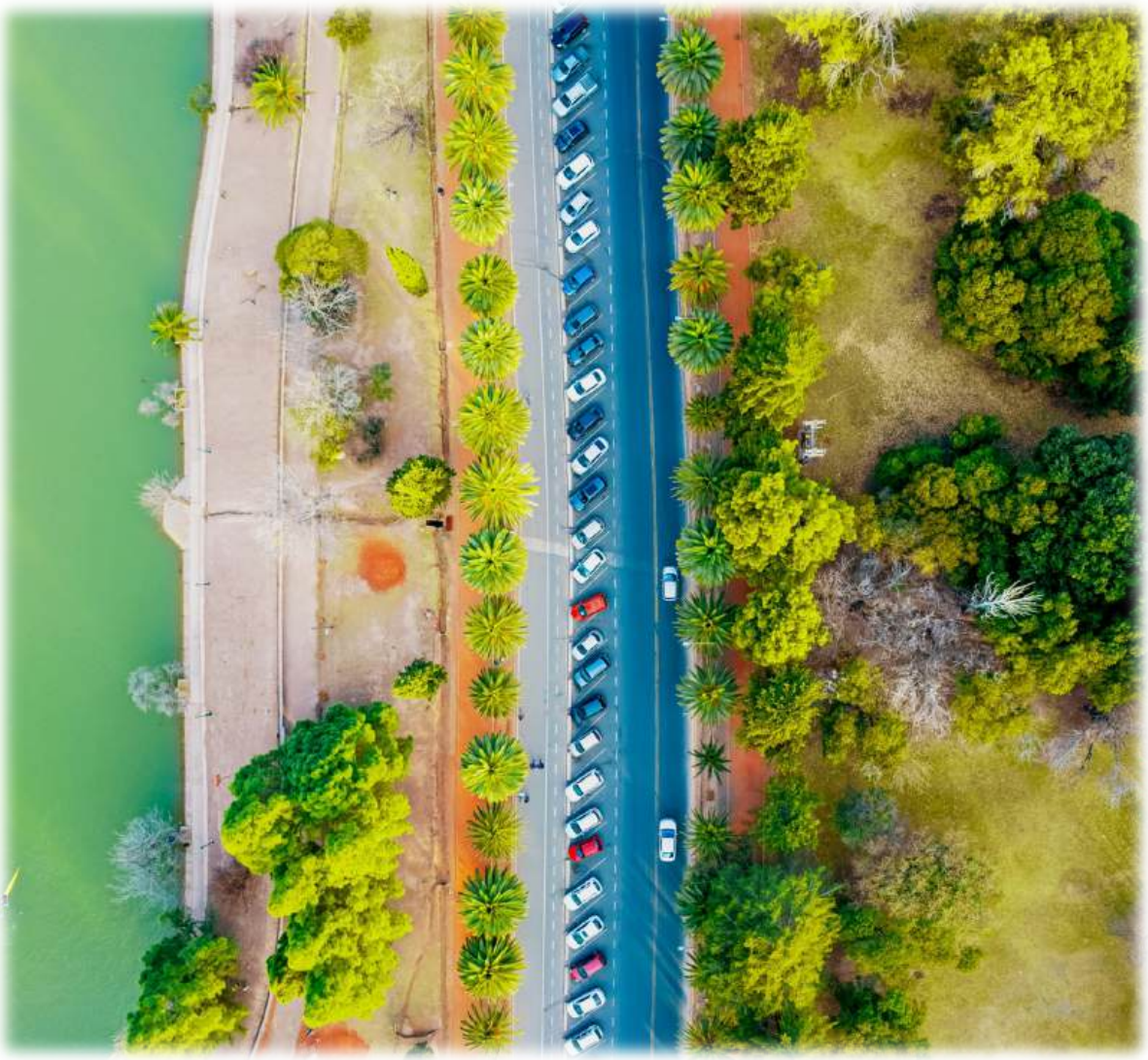
Through a global review of financiers' SIA policies and standards, I found frequent recommendations to follow the Social Mitigation Hierarchy to counterbalance a project's social impacts. My case study demonstrates that this approach has the potential to structure decision-making in order better to account for different well-being impacts of both developments and the associated ecological compensation. For example, the direct impacts of construction and compensation on cultural sites, the effects of air and particle pollution on people outside the immediate development site, and intergenerational livelihood impacts could be accounted for within the same framework, enabling coherent and integrated strategies for apparently disparate mitigation efforts to be developed. However, the complexities of using the SMH in practice have not been confronted and critically discussed enough. My case study illuminates a set of issues that should be considered when using the SMH to address well-being impacts, including understanding and addressing long-term and unanticipated impacts, and ensuring procedural equity in the design and implementation of ecological compensation.

There remain numerous questions that future studies need to address to fully unleash the power of the SMH. For example, regarding stakeholder engagement, future work needs to explore ways to address situations where people have conflicting views or needs, or where there are individuals for whom no compensation will ever be enough. Questions also persist regarding how the SMH can be implemented in different contexts and its effectiveness in achieving desired social outcomes in real-world settings. Furthermore, while my case study focuses on mitigating the well-being impacts of ecological losses and gains, it may be worthwhile to explore its applicability for non-ecological impacts. All these questions call for broad discussion and examination of the impacts of ongoing economic development and associated nature-positive aspirations across diverse disciplines, both conceptually and empirically. Additionally, my conceptualisation will need to be discussed, debated, clarified, and further refined. I hope that I have at least been able to argue that mitigation measures for social impacts need to be better designed and implemented through early and ongoing stakeholder participation.

Lastly, the SMH approach reviewed and analysed in this article exemplifies the critical need to integrate various existing social policies and measures that promote human well-being within the context of NNL/NG, or more recent nature-positive commitments that include systemic changes (Booth et al., 2024). Future research should further investigate how these established approaches can be harmonised, to ensure that biodiversity losses are mitigated and reversed while simultaneously pursuing positive outcomes for people.

CHAPTER 6

DISCUSSION



Urban greening can benefit both nature and people. Rafael Hoyos Weht/Unsplash

"*What is the use of a house if you haven't got*
a tolerable planet to put it on?"
- Henry David Thoreau

6.1 Research Summary

Developers aiming to contribute to the global nature-positive aspiration need to follow the mitigation hierarchy (MH) to achieve 'no net loss' (NNL) or 'net gain' (NG) for nature (Chapters 1 & 2). Previous research has demonstrated how economic developments, along with their associated ecological mitigation, can impact the well-being of local communities (e.g., Bidaud et al., 2017; Koh et al., 2017; Griffiths et al., 2020). Consequently, the 'no worse off' principle has been proposed to ensure that people are not worse off - and preferably better off - in terms of their perceived well-being after these activities than they were before (Griffiths et al., 2019a). However, human well-being is a dynamic and evolving concept (Gough & McGregor, 2007; Ng & Fisher, 2013; Schreckenberg et al., 2018), and the dynamic impacts of developments and their associated ecological mitigation on well-being are currently underexplored in the literature. Therefore, a central theme throughout this thesis is to explore how to recognise, capture, and adequately mitigate the dynamic impacts of developments and associated ecological mitigation activities on human well-being.

Chapter 2 analysed China's ecological compensation to address a significant research gap in the conservation field (Bull & Strange, 2018). I identified several key issues within the approach and proposed recommendations based on international best practice standards. Additionally, I highlighted features of China's compensation system from which other countries could learn. For instance, paying upfront restoration fees might encourage developers elsewhere to avoid and minimise their ecological impacts at the early stages of their projects. Moreover, levying fees from

developers to be spent by local governments on projects to enhance both nature and people's well-being in a strategic way could serve as a useful model for ecological compensation elsewhere.

Chapter 2 also helped to contextualise the Chinese study system that this thesis focuses on, leading to an examination of the Qunli New Town project to study the dynamic effects of its past urban developments and associated ecological mitigation on local well-being. Chapter 3 delved into the complexities of 'shifting baseline syndrome' within the social-ecological system, particularly in relation to different waves of settlers in the focal town. The chapter revealed that individuals with personal experience had more accurate perceptions of environmental change, while cognitive errors, including omission and commission, impacted perception through processes such as sensation, attention, learning, thinking, and memory.

Building on Chapter 3, Chapter 4 investigated how original residents perceive the impacts of local environmental changes on their well-being through a retrospective comparative survey, given the absence of an initial baseline for direct comparison. The main findings showed that development with ecological mitigation measures impacted residents' well-being in varied ways. Notably, former agriculturalists felt less happy after the changes compared to non-agriculturalists, though both groups perceived similar levels of fairness. Long-term residents viewed the economic aspects as fairer but saw the ecological aspects as less fair compared to newcomers.

To more effectively address the negative well-being impacts of economic development and its associated ecological mitigation measures, Chapter 5 further discussed the under-mitigated social impacts resulting from the Qunli project. I proposed guidance for more effective social impact mitigation alongside ecological impact mitigation. After reviewing financial institutions' social impact assessment policies and standards worldwide, I critically evaluated the long-standing but underexplored 'social mitigation hierarchy' (SMH). Based on the Qunli case in Harbin,

China, I highlighted the complexities of applying the SMH, such as selecting appropriate well-being indicators and ensuring effective compliance and monitoring.

6.2 Cross-Cutting Themes

6.2.1 Implementing Ecological Compensation

It is often recognised as good practice to implement ecological compensation (e.g., biodiversity offsets) in a quantitative manner, typically through the use of a unified measurement framework, such as biodiversity metrics (Maron et al., 2016; Bull et al., 2013 & 2016; Baker et al., 2019). However, to date, ecological compensation in China has not relied on any unified measurement framework to quantify ecological losses on the development sites and gains on the compensation sites (Chapter 2). This has resulted in issues such as a lack of consistency and comparability, and potentially a lack of clarity and transparency, due to the absence of a common framework for communication between stakeholders, including policymakers, developers, and conservationists. Therefore, a step forward for countries, including China, that have not yet adopted a common approach to measuring biodiversity losses and gains would be for them to develop their own biodiversity measurement frameworks, drawing from existing models (e.g., England's biodiversity metric tool). Such frameworks can help inform decision-making, track progress, set actionable goals, and ensure accountability in both conservation and development initiatives (Brown & Williams, 2016).

However, in the academic literature, a unified measurement framework is often regarded as a reductionist approach (Apostolopoulou & Adams, 2017; Marshall et al., 2020), which may not always be effective in capturing ecological impacts in varying contexts (Cristescu et al., 2013; Moreno-Mateos et al., 2015; Kujala et al., 2015; Hanford et al., 2017). There have been concerns about placing excessive emphasis on pre-determined quantitative metrics, as over-reliance on them risks promoting a

tick-box approach rather than fostering a genuine commitment to nature conservation (Hunter et al., 2021; Cox et al., 2023).

In turn, the absence of a common framework in China's compensation policy design may reflect an intention to avoid a one-size-fits-all model that may overlook local specificities. This can be observed in the distinct compensation practices, for instance, when comparing tree plantation programs in Yangqu County, Shanxi Province, and Dongsheng District, Inner Mongolia (Chapter 2), with the creation of ecological features in Qunli New Town, Harbin (Chapters 3–5). The flexibility in China's ecological compensation system has allowed for a more nuanced consideration of context-specific variability, not only in ecological terms but also in relation to the social, economic, and cultural dimensions of ecosystems that are crucial to local communities. For example, a compensation project in Longhui County, Hunan Province, involved establishing a production base for pepper, tea, and oranges to support local rural livelihoods (Chapter 2).

The Qunli case demonstrates the potential for aligning ecological compensation with broader biodiversity and non-biodiversity environmental objectives - something that a metrics-based approach, which focuses predominantly on quantifiable gains, could overlook. According to the local government's development plans, the Qunli urbanisation project prioritised long-term, holistic environmental benefits. In this context, ecological mitigation and compensation measures were implemented at the landscape level, aimed at enhancing the health and integrity of the entire urban ecosystem. The holistic approach adopted by the urbanisation project aimed not only to achieve biodiversity gains but also to improve key ecosystem services by restoring and enhancing the existing wetlands and creating new green spaces. For instance, the restoration of an urban swamp wetland with native species aimed not only to restore local biodiversity but also to build resilience by mitigating flood risks in the face of climate change, while promoting cultural benefits such as opportunities for ecological education (Chapter 4).

Nevertheless, the absence of biodiversity measurement tools posed challenges in accurately assessing the Qunli project's impact. This lack of proper monitoring of both initial and current biodiversity levels made it difficult to determine whether, or to what extent, biodiversity had improved or declined due to urbanisation. As a result, the ecological compensation projects could not be effectively integrated into a strategic biodiversity conservation plan.

One model currently in practice for incorporating quantitative biodiversity metrics into broader strategic conservation goals is England's Biodiversity Net Gain (BNG) policy, which is integrated into its new Local Nature Recovery Network (LNRN) framework (Smith et al., 2022; Smith et al., 2023; Rampling et al., 2024). While BNG allows for measurable outcomes, the LNRN provides a landscape-scale approach that identifies priority areas for habitat restoration and creation, offering a strategic guide for where BNG efforts should focus to maximise ecological benefits. South Africa has also implemented a similar systematic conservation planning method for such identification and prioritisation (Knight et al., 2006; Smith et al., 2006; Reyers et al., 2007; Botts et al., 2019). However, the effectiveness of these approaches still requires further investigation, and how quantitative biodiversity metrics can be effectively incorporated into broader strategic goals remains an unresolved issue.

6.2.2 Sustainable Urban Development: A Dynamic Perspective

Based on the 'positive development' theory, which argues that the responsibility of developments should extend beyond mere remediation, the 'net-positive design' approach promotes sustainable urban development that not only reduces the impacts of developments, but also creates net both ecological and social gains compared to a no-development scenario (Birkeland & Knight-Lenihan, 2016; Birkeland, 2017 & 2020). To operationalise net-positive design for ecological gains, the ecological 'mitigation hierarchy', particularly ecological compensation, is often used as a foundation by designers and planners (Birkeland & Knight-Lenihan, 2016; Birkeland et al., 2017; Thomson et al., 2022; Hanson & Olsson, 2023). The 'net-positive design'

also involves a social standard that requires a development to leave the affected communities in a better state than before the development was implemented (Birkeland & Knight-Lenihan, 2016; Birkeland et al., 2017). Therefore, it is vital to understand how pursuing nature-positive outcomes may generate negative social impacts, as well as how to address them effectively. This typically requires experts from diverse fields, including ecologists and sociologists, to work with designers and planners to develop urban programmes (Neuman & Zonneveld, 2018; Brenner, 2019; Neuman et al., 2022).

The case study of the Qunli urbanisation in Chapters 4 and 5 shows that blending ecological compensation into an urban development that incorporates nature-related goals can generate extensive social impacts on the well-being of local communities. Some key themes have emerged with the Qunli case. First, the social impacts from implementing a development's nature-related goals resulted from both physical changes and modifications to the institutional framework. Physically, the Qunli development included measures such as establishing fenced-off protected areas and restricting park routes to conserve migratory bird species, habitat quality, and essential ecological processes. These physical changes were complemented by enhanced environmental regulations, such as stricter controls on bird harvesting and the establishment of increased patrol teams within urban green areas to enforce these regulations. While taking such an integrated approach may increase the likelihood of achieving the established nature-related goals, it is vital to consider the social implications of both tangible and intangible changes introduced towards achieving these goals, so as to ensure that the costs of conservation borne by the local population are acknowledged and addressed.

In addition, the social impacts of urban development that integrates nature goals may not always be fully predictable at the outset and may become apparent only over time. These impacts can arise from both the ecological and non-ecological aspects of the development. For example, in the Qunli project, former agriculturists experienced

significant changes in their social identity and a loss of traditional practices, such as farming, which were unforeseen during the planning stages. Furthermore, some social impacts can be intergenerational, taking even longer to emerge. For instance, former agriculturists whose lands were acquired for the project's ecological mitigation and compensation - such as the creation of a large urban bund wetland designed to ensure ecological connectivity - faced immediate economic effects, which the government had anticipated and compensated for. However, over time, concerns arose among some of these agriculturists about the future livelihoods and opportunities for their children. From a non-ecological perspective, the delay in obtaining residence documentation, which is required for school enrolment, disrupted some children's education, highlighting another emerging intergenerational issue. These examples from the context of urban developments with ecological compensation, consistent with a range of prior research uncovering the long-term and intergenerational consequences for displaced agriculturists (e.g., Ablo & Asamoah, 2018; Nguyen et al., 2019; Jiang et al., 2020), underscore the need for ongoing monitoring, not only throughout the lifecycle of the development project but also after its completion, to track and address emerging social impacts.

Moreover, social impacts may also need to be managed before a project begins, as well as throughout and after its implementation. The Harbin government is currently working with developers to expand Qunli New Town westward, with plans for improved infrastructure and housing, and increased ecological features as compensatory measures in the urban area. Interviews with former agriculturalists in the existing town have revealed that farmers in the villages to the west have already been affected by the tentative plans, even though the expansion has yet to occur - and may not happen at all. It must be acknowledged that social impacts can begin with rumours. In addition to causing anxieties, former agriculturists reported that recurring rumours about the timing of land acquisitions and the compensation levels for different types of farmland (e.g., arable land versus orchards) have been significantly influencing the behaviours of farmers in these villages. For instance, it

is reported that some have altered their land use in anticipation of higher compensation for land acquisition. In line with prior studies (e.g., Marx, 2002; De Feyter, 2015; Braun, 2020; Edelstein & Vanclay, 2024), this research, which examined a major urbanisation programme with associated ecological compensation measures, demonstrates that managing the social impacts - including both psychological and behavioural effects on local communities - before any physical work begins can be just as important as managing those caused by the work itself.

The social impacts, of varying characteristics, generated by the Qunli development highlight the need for future studies to examine and analyse these impacts more carefully and across different contexts. This would help deepen our understanding of how to effectively manage social impacts in the pursuit of socially-sustainable urban development, while striving for ecological sustainability. For instance, it is important for future studies to understand whether designing social impact mitigation actions through participatory scenario planning (e.g., following the social mitigation hierarchy) can effectively address emergent and intergenerational social impacts, and to what extent addressing these long-term impacts requires top-down, expert-based approaches. If major decisions must be made by experts to minimise biases - such as myopia, as in the case of a highway cutting through ecologically sensitive habitats (Ascher, 1992) - further investigation may be required into how such top-down approaches can be implemented in a way that ensures certain levels of legitimacy. It is also essential to explore who these experts should involve and how they should be consulted; procedural and recognition equity are as important as distributive equity, yet they are often overlooked aspects of achieving fairness.

6.2.3 Methods for Indicating 'No Worse Off'

The 'no worse off' principle requires that developments with ecological mitigation activities address their impacts on local communities, ensuring that people are no worse off, and preferably better off, in terms of their perceived well-being after these activities than they were before (Bull et al., 2018; Griffiths et al., 2019a). Evaluating

whether a development with associated social mitigations meet the ‘no worse off’ principle involves several methodological approaches (Table 6.1; Stern, 2015, Woodhouse et al., 2016). In light of the absence of existing datasets that capture the impact of the focal Qunli development on local communities, this thesis adopts an engaged, consultative approach to evaluate its local social impacts. The approach includes pairing a retrospective comparison survey with semi-structured interviews, local observations, and informal conversations. While this approach aligns closely with the ‘participatory’ type of evaluation described in Table 2, the limited timeframe of this project made a fully participatory study - characterised by deeper levels of participant involvement and empowerment – unfeasible.

Given the scope of this thesis, the examination of residents’ well-being focuses on ‘stepwise dynamics’ by analysing changes at two specific points: before and after the urban development. This contrasts with the assessment of ‘continuous dynamics,’ which involves tracking gradual changes in well-being throughout the entire period. To assess these ‘stepwise dynamics’, retrospective comparative surveys can be one practical strategy that conducts ex-post net-outcome assessments, particularly in the absence of historical social baseline information. However, this retrospective approach has its limitations and may not be the most effective way for assessing local impacts. For instance, retrospective comparative surveys at the personal level (as discussed in Chapter 3) can introduce recall bias, where recent experiences may distort memories, leading to less reliable assessments.

Therefore, as the retrospective comparative approach is still underdiscussed in the literature, future research could improve the approach by, for example, exploring how to design and implement it more effectively and determining the level of reliability needed for retrospective data to indicate a ‘no worse off’ situation. For instance, some interviewees who lived in the area before the Qunli project could not accurately recall when the development began. This might consequently dilute the comparisons they made between their current well-being and the state prior to the development.

Table 6.1: Different approaches to exploring whether an intervention has left people "no worse off" (based on Stern, 2015, Woodhouse et al., 2016).

Type	"No worse off" indication	Enabling conditions	Examples
Experimental	'Counterfactual': comparing the change in the well-being indicators at the project site with what would have happened in the absence of the project and associated impact mitigation measures	Valid control with baselines	Randomised controlled trials; quasi-experimental designs (Before- After-Control-Intervention)
Statistical	Correlations between outcome indicator and input indicator, controlling for confounding factors	A large-sample, longitudinal data, and data on confounding factors	Regression modelling
Theory-based	Identifying mechanisms that explain changes in well-being outcomes, and providing empirical evidence	Strong theory of change (pre-existing or developed)	Process tracing
Case-based	Comparing outcomes of project (and associated impact mitigation measures) across and within cases under various causal factors	Strong theory; several different cases are needed for comparison.	Qualitative comparative analysis
Participatory	Perceived well-being dynamics from the people affected by the project and associated impact mitigation measures	Skilled facilitators	Reflexive counterfactuals; ranking and scoring

Furthermore, even when best practices for social impact assessment (SIA) are followed, with initial well-being states collected, comparing results from retrospective comparisons with those from conventional baseline comparisons can provide valuable insights into social dynamics throughout the project (e.g., which well-being losses have been accepted or adapted to by local communities and which have not). This calls for future studies to examine how these dynamics manifest across various contexts and social groups.

6.2.4 Bridging the Social and Ecological Silos

Global impact assessment policies and standards require a development project to address its negative social and ecological impacts - and if possible, bring benefits - though often the two aspects are considered in isolation (Dumitru et al., 2020; Therivel & González, 2021). Many previous studies have called for integrating social and ecological considerations into a holistic approach, which recognises that social and ecological issues are interlinked (Morrison-Saunders et al., 2014; Olagunju et al., 2016; Therivel & González, 2021). Without such an integrated approach, a development project may address ecological and social impacts separately, failing to account for how one set of impacts can exacerbate or mitigate the other. For example, in the Qunli case, it has been observed that the impacts of reduced social activities in nature caused by establishing urban protected areas were insufficiently addressed (Chapter 4). Moreover, an integrated approach can uncover synergies where solutions for one issue also address another. This can also be found in the Qunli case, where developing an urban wetland park with native species for improved biodiversity values also enhanced societal resilience by reducing the frequency and severity of urban flooding events.

Integrating the social and ecological mitigation hierarchies into a hybrid approach can help bridge the gaps between social and ecological considerations in managing a development project. This approach allows project planners to develop a more comprehensive understanding of how a social mitigation measure might impact

nature and ecosystems, and vice versa. For example, in the Qunli case, converting farmlands to wetlands displaced local agriculturalists and affected their livelihoods and cultural practices as farmers. In response, they spontaneously converted the compensated grassland on the resettlement housing site back to cropland to resume their traditional practices (Chapters 4-5).

To achieve effective integration, the complexities involved must be addressed with care, necessitating more detailed discussions in future studies. A significant challenge in operationalising an integrated mitigation hierarchy is engaging a diverse range of stakeholders. Consequently, future research could explore how to design and implement effective stakeholder engagement processes that balance these conflicting interests and ensure that all perspectives are considered in the integration of social and ecological mitigation measures. Existing approaches, such as multi-criteria decision-making, which evaluates and prioritises multiple conflicting criteria in decision-making situations (Yeo et al., 2010; Bahadorestani et al., 2020; Kharanagh et al., 2020; Fasth et al., 2020), have proven useful in managing conflicting stakeholder interests across various contexts and could be tested in relation to implementing an integrated mitigation hierarchy.

6.2.5 Policy Suggestions for China's Ecological Compensation

There are several ways in which China's government defines 'ecological compensation' (Table 2.1 in Chapter 2). Existing policies and studies regarding China's ecological compensation mostly focus on the second measure (proactively compensating for previous ecological impacts) and the third measure (payment for ecosystem services), with little attention paid to investigating the first approach (reactively compensating for contemporary development impacts), despite its potentially enormous scale in China (Chapter 2).

This study explores this underexplored first approach, which focuses on reactive, disincentive-based compensation for contemporary ecological impacts caused by

development activities. This approach is most similar to the 'compensation' or 'offsetting' mechanisms implemented elsewhere, such as Australia's 'biodiversity offset', the US's 'compensatory mitigation', and Canada's 'conservation offset'. What's worrying about the predominance of studies and policies in China using the second and third measures to represent 'ecological compensation' is that it may create a false impression that ecological compensation has been thoroughly studied and implemented, thereby bypassing a careful examination of an entire approach.

In recent years, China's central government has proposed numerous national targets to improve its ecological compensation approach for biodiversity conservation. For example, in the *National Biodiversity Conservation Strategy and Action Plan (2023-2030)*, introduced by China's Ministry of Ecology and Environment (MEE) for advancing China's implementation of the GBF, Priority Action 2 commits to '*establishing a robust regulatory compensation system for the occupation of various natural habitats*,' with the goal of '*improving ecological compensation for conserving forests, grasslands, and wetlands*'.

To meet the new national target, Chapter 2 highlights the need to better apply established international best practices to guide China's ecological compensation and NNL efforts. This includes: (i) increasing the fee levels that many provincial governments currently charge developers; (ii) implementing a standardised indicator framework for measuring biodiversity impacts and, if feasible, making its use mandatory for all development projects; and (iii) improving publicly available information on how governments spend their compensation fees, as well as on ex-ante biodiversity assessments and ex-post compensation implementation and outcomes, to enable a comprehensive assessment of biodiversity losses and gains.

This thesis also examined Qunli New Town, exploring how ecological compensation can impact local communities' well-being (Chapters 4 and 5). The Qunli case demonstrates that ecological compensation in China often involves transforming land previously used for agriculture, industry, residential purposes, and culturally

significant sites (e.g., the Qunli public cemetery) into green spaces such as forests, grasslands, and wetlands. These transformations can have wide-reaching implications for various aspects of local well-being, including access to natural resources, job and income security, and perceptions of happiness and fairness. Furthermore, as these green spaces were created with more flexible standards compared to those developed through the restoration and enhancement of existing habitats, there may be concerns. These spaces, which may include non-native species, might be created to appeal to certain people, but they could also displace native wildlife and long-term residents.

It is crucial to improve China's SIA policies to better assess how these environmental changes impact different social groups, particularly in terms of who bears the most risks and responsibilities versus who reaps the benefits of compensation. For example, in Chapter 4, exploring people's perceptions of fairness in Qunli revealed heterogeneity among socio-demographic groups. Long-term residents, in particular, viewed local ecological compensation as less fair compared to newer settlers. This underscores the importance of understanding the social system as well as its dynamics when identifying the socio-demographic factors that should define groups in SIAs. By enhancing China's SIA system to more accurately capture the social impacts experienced by different social groups, SIAs can better gauge the true social impacts of ecological compensation and ensure that representative - if not all - voices are considered in the process.

6.3 Gaps, Limitations, and Future Research

Much of the theoretical knowledge generated by this research - though guided by established theories and frameworks - comes from a single case study in Qunli New Town, China. As a result, some of this knowledge may not be fully transferable to other development contexts, especially those outside China. To gain a more nuanced understanding of the dynamic impacts of development and associated ecological mitigation on well-being, as well as the mechanisms (e.g., shifting baseline syndrome)

driving these dynamics, further research is needed in diverse settings (e.g., the Global North and Global South) and across a broader range of development projects (e.g., urbanisation at different scales and with varying ecological mitigation measures) to generate more comparative perspectives.

Chapter 3 advocates for a cognitive approach to exploring people's (mis)perceptions of the natural environment. However, the mixed-method approach I employed may not have been the most effective for studying cognitive processes. For instance, the absence of experimental design in my study limits the external validity of some results. Therefore, I call for interdisciplinary research to deepen the understanding of how various cognitive processes shape these perceptions. For example, in the process of attention, key questions include why some individuals pay more attention on specific changes of the natural environment than others, how certain distractions prevent others from noticing these changes, and what influences these differences. In terms of learning and thinking processes, important questions revolve around how various cognitive biases might hinder accurate perceptions of local ecological characteristics. Overall, understanding human experience at the cognitive level can yield more refined insights into managing human-nature relationships.

In Chapter 4, I explored the social impacts of nature-inclusive urban planning. Ideally, an initial social baseline should be established for comparison with later situations. Due to the absence of such a dataset, a retrospective comparative survey was conducted, asking participants to compare their current well-being with their previous states. However, to minimise biases and obtain objectively accurate and reliable social information, several improvements could be made by integrating more sociological and anthropological techniques. For example, the survey could benefit from incorporating recall aids, such as visual materials like photographs, and landmark events, to remind respondents of key events in the project (van der Vaart & Glasner, 2011; Drasch & Matthes, 2013; Glasner et al., 2015; Müggenburg, 2021). This could help trigger memories and enable respondents to more accurately recall and

compare their current situations with the past. Additionally, including cross-check questions - those that ask similar questions in different ways or at different points in the survey - can help identify inconsistencies in responses (Calvert et al., 1997; Roumelioti & Leotsinidis, 2009; Bauer et al., 2020).

Lastly, the social mitigation hierarchy (SMH) approach evaluated in Chapter 5 warrants further assessment and discussion. To my knowledge, no existing case study has explicitly and systematically applied this approach to mitigate a project's social impacts, despite its long-standing regulation and recommendation in global SIA policies and standards. Therefore, case studies are needed to fully operationalise the SMH, providing evidence-based recommendations on how this approach can be implemented to achieve net neutral or, preferably, positive outcomes for people, as envisaged by the 'no worse off' principle.

6.4 Conclusion

Contributing to the global nature-positive aspiration, the implementation of ecological compensation to counterbalance development impacts towards NNL/NG for nature presents significant challenges. These challenges arise from various technical, ethical, governance, and social perspectives (Chapter 1). Addressing the dynamic social impacts associated with ecological compensation adds further complexity. However, this thesis does not aim to complicate ecological compensation, but rather uses an in-depth case study to emphasise the importance of considering and addressing these long-term impacts, ensuring that local communities are genuinely left 'no worse off', as required by both existing research and international best practice standards for developments involving ecological compensation. Further research is needed to explore how well-being impacts from these activities evolve over time, the factors driving these changes, and how these impacts can be effectively managed. If a social mitigation hierarchy is to be adopted, future studies should investigate how such an approach can be successfully implemented to meet the 'no worse off' requirement.

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APPENDICES

Appendix A: Supplementary Information for Chapter 1

A.1: Official Evidence of Local Environmental Trends (in Chinese)

新浪 新闻中心 新浪首页 > 新闻中心 > 国内新闻 > 正文

污染水位低使松花江鱼类锐减 十网九空江开无鱼

http://www.sina.com.cn 2005年04月17日10:26 东北新闻网

到了吃开江鱼的时候，可连日来，一些打鱼者纷纷反映，松花江里难觅鱼踪，有的时候甚至一整天都打不到一斤鱼。据哈尔滨市农委渔政处负责人介绍，松花江水连年被污染及今年水位偏低，是导致鱼量减少的主要原因。

12日9时许，记者在哈尔滨市松花江北岸"马家船口"附近看到，只有二三艘长约10米的小渔船在江边缓慢地划行，其他20几艘小渔船都停靠在江岸上。正在划行的每艘打渔船上都站着两个人，其中一个人划船，一个人拿着鱼网忙着捕鱼。可是，每次他们收网时几乎都没有收获。其中，一位40余岁的男子上岸后告诉记者，前几天，来这里捕鱼的人还很多，但由于江里的鱼少，几乎捕不到鱼，所以许多捕者这几天都没有下江。

Photo not available

家住哈尔滨市松浦镇的老赵今年44岁，多年来靠种地为生，每年开江的时候，他都到松花江打鱼来贴补家用。据老赵讲，10年前他在这里每天都可以打到10多斤鱼，而且鱼的种类很多。可这两年来，他明显感觉到江里的鱼越来越少，捕鱼越来越难。常常是"十网九空"。今年开江以来，他已经连续打七八天鱼了，最多一天，他也就打了不到2斤"嘎牙子"。

据哈尔滨市农委渔政处相关负责人薛军介绍，据记载，松花江里最早共有79种鱼。但在1990年，哈尔滨市环境监测中心站和哈尔滨市水产资源管理站的科研人员在松花江却里只采集到56种鱼。而研究人员在2000年开江期到当年8月中旬的采集研究中发现，松花江里鱼的种类又下降到了34种，到目前种类可能更少。基本可以确定，目前在松花江里，甲鱼、日本七鳃鳗、大白鱼，以及鳊花已经绝迹了，鳌花、狗鱼、青鱼、雅罗、乌苏里白鲑等保护鱼类也基本绝迹。薛军说，导致鱼量锐减的主要原因是，松花江哈尔滨段每天要承载上游和哈尔滨的污水580吨，其中近百吨是未经处理的污水，而且连续十几年松花江开江时水位偏低。

目前，哈尔滨市渔政部门正采用限量发放捕鱼证、组织人工增殖放流鱼苗、减少江水污染等方法，希望近早恢复松花江的鱼量。(新华网)[编辑：龙秋秀]（来源：东北新闻网）

换一种方式"吃水"

哈尔滨：重新"发现"松花江

本报记者 吕博雄 实习生 王茜 通讯员 李兵 《中国青年报》（2011年06月06日 04版）

哈尔滨市道外区民主乡村民王月梅一直守着松花江打渔，"一年到头也赚不到啥钱。"她根本没想到，随着松花江湿地的开发，自己家门口最近也变成了风景区。现在，一起打渔的邻居都在忙着适应新职业——有的改行当了导游；有的筹备渔具，开展垂钓旅游服务。据说，同乡胜利村小七队的59户村民，抓住湿地旅游开发的机会，干脆整村搬进由"小别墅"群组成的现代都市村庄，干起了"农家乐"。

这种改变，也发生在哈尔滨市松花江沿岸的千家万户当中。哈尔滨市下辖的137个乡镇中，濒临松花江的41个，占全市乡镇总数的30%。随着近几年当地湿地旅游建设的推进，沿岸农民也正在实现自身角色的转变。

南方许多大城市江河被渠化的今天，松花江沿哈尔滨绵延120公里，依然保持着蜿蜒曲折的原生状态，实在是一笔天赐的资源。"横向对比，哈尔滨近年来的经济总量已落后于兄弟城市，唯有找准方向，才能迎头赶上。"黑龙江省委常委、哈尔滨市委书记盖如垠在接受中国青年报记者独家专访时说，要培育建设周期较长的新经济增长点，更要利用城市自身优势，发展旅游是绝佳选择——以旅游来惠民生，以旅游来调结构，以旅游来促进环境保护，"我们决定，不拘泥于GDP指数，也不搞'形象工程'、'政绩工程'，而是实实在在地让老百姓过上看得见、摸得着、用得上的好日子。"

最新调研证明，时至今日，在哈尔滨，松花江流域内形成的湿地面积达468平方公里，仅自然形成湿地就占全市土地面积的5.4%，是哈尔滨恢复松花江水生态与城乡一体化、老工业基地经济结构调整之间的最佳契合点。靠山吃山，靠水吃水，百年哈尔滨如今决定换一种方式"吃水"，使这个城市与松花江一同迈入人水和谐的时代。

源于发现的"水经济"

上个世纪八九十年代，歌曲《太阳岛上》风靡全国，曾勾起人们对哈尔滨太阳岛风景区的无限想往。可大多数人不知道，太阳岛风景区只是哈尔滨市已开发及正在开发的11处类似湿地之一。而风景独特的金河湾湿地、阳明滩湿地等景区资源，一直不为人知。3年前，很多湿地景区甚至人迹罕至。去年，全年湿地游的游客也仅有56万人。目前，哈尔滨对水资源的利用率在20%左右，远低于欧洲滨水城市60%的标准。

这是遗憾，也是机会。研究了这些问题之后，去年8月，履新不久的哈尔滨市委书记盖如垠在探察松江湿地的船上，即兴抒怀七律一首，以"辽阔松江何许言，滨城得景靓其间"的诗句，表达了对哈尔滨湿地资源新发现的惊喜。他提出，努力打造中国最大原生态多样性城市湿地景观，使"湿地旅游"成为哈尔滨市继"冰雪节"之后的第二张城市名片。

这发现，也得到外界的认可。前不久，哈尔滨荣获了由亚太旅游联合会颁发的“大美湿地城市”称号。

“水”字与“冰”字，笔画只差两点儿。但作为一个城市的发展思路来讲，两种定位，市民完全是两重感受。以往，人们熟悉“冰城”哈尔滨，浪漫、激情，旅游主要局限于以冰雪节为主打产品的冬季，只有几个月的活跃期，相关就业、经济发展同时受到局限；现在，哈尔滨要打造“冰城夏都”，把水的四季样态，逐一呈现在全国游客面前。已经开通的15条湿地旅游线路，将使哈尔滨旅游季延长至八九个月。

哈尔滨市旅游局局长杨杰说，从全国看，很少有其他城市，特别是北方城市，具有如此独特、鲜明的内涵型水生态资源——大大小小滩岛20余个，总面积超过245平方公里。大小滩岛形成了全国最大的城中原生态多样化湿地。

《松花江哈尔滨城区段百里生态长廊总体规划》编制人员黄利群、许士国等曾对哈市的湿地生态环境进行过详尽的调查统计。结果显示，城市湿地主要植被群系有十余种植物，其中国家级保护植物就有3种。湿地已查明的鱼类有37种，占黑龙江全省鱼类总数的35%。

如今这个城市正以“旅游即城市，城市即旅游”的气魄和紧迫感，在丰富自己的新发现。投资2.54亿元的五项沿江湿地路网工程年内就将建成，到时候游客驱车从主城区抵达湿地景区，将从1小时缩短为20分钟；总投资100余亿元的松花江避暑城也已开建。在全市宾馆接待能力不足的现状下，这个城市已开始动员大小招待所提高规模、层次，甚至新办家庭旅馆可以暂时免税经营。

“一江居中、两岸繁荣”

提及儿时的松花江，曾在环保部门工作十余年的原哈尔滨市环保局副局长李贵友不胜唏嘘。上世纪50年代，江水清澈、水产丰富，他和伙伴常常到江边游泳、垂钓。随着上世纪50年代及改革开放后沿江工业的建设，松花江变了。

“在上世纪70年代，松花江主体水质能够达到三类水；80年代末期，只能达到四类水了；到90年代中期，基本上就不能游泳了。”李贵友说。哈市农委渔政处提供的数据显示，1988年的渔业产量，只有1959年的五分之一。也就是说，松花江鱼类资源量，30年间减少了80%。

这些，刺痛了2009年刚刚上任的哈尔滨市委书记盖如垠。市委连续召开了七、八、九次全会，用科学发展的思路和目标统一思想。

哈尔滨拥有松花江、呼兰河等众多大小河流、湖泊，水资源丰富。由于历史原因，江北一直是洪涝灾害多发区，水资源开发利用程度低，而且松花江干流和支流污染、滩涂无序开发、河道占用等问题日益严重。

如何做好“水”文章？2009年，盖如垠首次提出了“以水定城”理念，即城市发展以水系网络为骨架，以松花江沿岸产业带开发、呼兰河以及肇兰新河综合治理为重点，道路、水电等基础设施随水系湖泊建设、整治构建，形成“北国水城”新格局——计划利用松花江天然丰富的水资源，向北引水，通过水生态环境修复和综合整治、污染控制与水系连通，建设人工水系湖泊、沿岸绿化、河湖连通的河网体系，并建设8座铁路桥、78座公路桥和68座步行桥，完成水城的主干骨骼建设。

松花江北岸堤防和堤顶路工程将同步启动。总投资超过70亿元，涉及河道111公里，集防洪、交通、景观、岸线整治、生态修复于一体，堤防防洪能力全部达到百年一遇标准，成为哈尔滨“水城”战略的重要安全屏障。

经过几年的建设，松花江水质重回三类水标准，江边又有了垂钓者。从2009年起，哈尔滨完成了松花江流域污染防治规划24个项目，总投资近28亿元，松花江哈尔滨段的排污主力“三沟一河”得到有效治理。仅去年一年，松花江干流出境水质主要污染指标就累计降低12.9％。

松花江的水质经历了从清澈到污染，又逐渐好转的过程，松花江湿地也经历了由退化到修复的过程。而这个转变过程，也被认为是哈尔滨发展思路的转变。哈尔滨市长林铎在前不久的一次环境会议上就强调，环境保护要与转方式、调结构，以及惠民生、促和谐结合起来。

生态的改善，使哈尔滨增添了开发利用松花江及其湿地的信心。在哈尔滨“一江居中、两岸繁荣”的发展战略中，松花江第一次被赋予重要的意义。

具体产业规划“一横一纵一园”中的“一纵”，就是以松花江为依托的旅游产业带。松花江及流域湿地的开发寄托了哈尔滨太多的期待，以湿地旅游为主打的旅游业被定位为战略性支柱产业之一，被视为经济结构调整的新增长点。

“因地制宜发展旅游业，上符合国家经济结构调整战略，下可提高居民收入。”盖如垠说。按照哈尔滨的旅游发展规划，未来3～5年，哈尔滨计划建设松花江湿地十景、松花江十景、太阳岛十景，形成湿地景观链以及包括旅游、休闲度假、房地产等在内的沿江产业带。

开发与不开发之间

“冰城夏都”的定位，掀起了当地人对松花江开发建设的热情。但怎么建设，市委、市政府一直在开发与不开发，甚至多种开发方案中权衡。

湿地因其对环境保护的特殊意义，在生态学上通常被誉为“地球之肾”。哈尔滨的干部们都知道，对湿地旅游资源的开发，保护是前提——只在邻近城市的滩岛进行小部分的开发，且核心区域是不能进入的。最大限度保护湿地原生态才能实现可持续发展。

在松花江湿地开发进程中，哈尔滨坊间曾流传这样的段子：在长岭湖湿地及月亮湖湿地的规划中，有关部门曾费尽周折引进了多家开发商共同开发，方案报给市领导时，却被全盘推翻。得到的答复是，“开发不好，不如先养鱼”。

黑龙江省环保厅总工程师赵宴滨介绍，湿地在抵御洪水、调节径流、蓄洪防旱、净化水源等方面都有其它系统不可替代的作用。但由于区域气候的变化、水资源过度开发、工农业生产活动的持续干扰等因素，在哈尔滨人对湿地的概念和功用不甚明了的年代，松花江湿地曾一度呈现出中度甚至重度退化。就在去年，还有企业向松花江成吨排放工业废水。就在今年5月初，松江江流域的一片200亩的湿地还被毁湿开荒。

如今开发湿地是否意味着更大程度破坏？如何在开发的同时，保护湿地、“收复”湿地？

在开发与不开发之间，哈尔滨有自己的权衡。

狗岛是松花江泛洪区自然形成的梭形岛，目前正在开发建设，而其生态恢复工程总投资就达2.4亿元，包含水系开挖、护岸、进出口水闸、环岛路等。开发旅游项目计划投资却只有1.13亿元，主要建设湿地高尔夫球场、马术俱乐部、驿站广场等。

在这个城市，去年曾产生一年之内4次改版哈尔滨地图的“城建速度”，在“奋起追赶，努力晋位”的新一届市委班子的口号下，哈尔滨以整个城市的名义提出“城市即旅游，旅游即城市”的理念以加快建设。但这个城市并没有急躁和忽视自然规律。盖如垠说，相比于多数国内城市河流渠化、硬化，原生态是松江湿地的最大特色，不能拿出最佳的规划方案，不如搁置开发，着力改善生态。

为此，急性子的哈尔滨人干出了一些慢性子的事。虽然松江湿地旅游开发非常紧迫，哈尔滨市水务局对于被破坏湿地的治理方针仍以自然恢复为主。湿地修复是一个系统工程，加之哈尔滨周围的湿地由于前期破坏比较严重，植物群落经过演变、生息，到产生最适合湿地生长的物种，一般来说，需要10余年的时间才能逐渐恢复。

粗犷的哈尔滨人也学会了在湿地开发前精心地约法三章。最近出台的《松花江湿地旅游管理办法》，开宗明义就强调了湿地保护优先的原则。此外，还有诸如滨江湿地风景区“六不准”等管理框架，沿岸农民也被要求必须以村集体为单位成立旅游公司，杜绝小规模的零散开发。

开发与不开发，都体现了城市科学发展的要义。不久前，第二届“冰城夏都号——哈尔滨市民宣传哈尔滨旅游大篷车”已经驶向全国，哈尔滨人藉此希望，让全世界的游客共同来感受人水和谐的新哈尔滨。

本报哈尔滨6月5日电

松花江休养生息再现生机 久违珍稀鱼种重新出现

2012年04月19日 13:52 来源：中国环境报 参与互动(0)

在哈尔滨九站码头，一位渔民兴奋地向记者展示刚刚捕到的大江鲤，竟然有18斤4两重。 中国环境报记者 吴殿峰 摄

开江鱼来了。

这几天在刚刚开江的松花江哈尔滨江段，渔民们正忙着捕捞开江鱼。

“今年开江可是遇上了开门红，一网下去，能捕到近百斤的开江鱼。”一位渔民兴奋地告诉记者。

在哈尔滨松花江滨洲铁路桥段的江面，渔民王顺开根本没想到，在渔网中来回跳跃的，竟是鲫花鱼和鳌花。

这些一度在松花江内消失的珍稀鱼类再次出现，令王顺开兴奋不已。

又见开江鱼

“现在松花江水质好，可以放心吃”

记者来到松花江哈尔滨九站码头，这里人头攒动，岸边的一个个大水槽子里分别装着鲶鱼、鲫鱼、鲤鱼等。围观的市民说，好多年没见到这么大的江鲤了。

卖鱼的渔民告诉记者，这都是今早刚打上来的开江鱼，其中一尾江鲤重达18斤4两，这是他近几年来捕到的最大的开江鱼。

他说:“这是松花江土生土长的开江鱼，现在松花江水质好，可以放心吃。”

松花江是黑龙江人民的母亲河，早在一千年前，春季开江就已经成为民俗中的一件盛事。每年这个时候，在松花江边生活的居民都盼着能品尝到鲜美的开江鱼。

住在松花江江边的老一辈都知道，那时候，在江边“小九站”经常有不少穿着“水衩”的打鱼人。沿着江边有好多渔村，江里有乌苏里白鲑、鲟鱼、鳖花、黑斑狗鱼……但从上世纪60年代中后期开始，沿松花江中上游建设的大型重化工业相继投产，沿江的城镇快速膨胀，污染日益严重，松花江里的江鲤、江鲫以及鲫花、鳊花、胡罗等市民常说的“三花五罗十八子”，有的难觅踪影，有的濒临绝迹。

而如今，随着松花江流域治污力度的不断加大，一些久违的鱼种又能见到。

生机重现松花江

鱼类大量出现，是松花江水环境变好的最有力佐证

在哈尔滨防洪纪念塔广场的开江祈福现场秀上，渔民和赫哲族人正在用松花江开江水洗手，两口百印大锅摆在红砖搭起的炉灶上，锅内雪白的鱼肉冒着腾腾热气，一派赫哲族渔家生活场景。

热闹的场景下，还有许多市民和志愿者在清理母亲河畔的垃圾，他们将杂物一一收进垃圾袋内。人们在欢庆的时刻，并没有忘记更好地保护母亲河。

以“生机重现”4个字来概括今天的松花江再恰当不过。

黑龙江省环境监测中心站对松花江流域内55个河流断面监测的结果显示，2011年流域内水质达标率比2008年提高了21.8个百分点，松花江干流的溶解氧上升显著，鱼类种类和产量相应增加。

哈尔滨市环境监测中心站水质监测曲线图清楚地记录着近几年松花江水质改善的过程:2006年、2007年、2008年，松花江哈尔滨段Ⅲ类水质的达标监测断面仅为20%；从2009年开始，Ⅲ类水质的达标断面开始增至60%，2010年达到80%；2011年，这一数据提升至100%，松花江哈尔滨段5个监测断面水质均为Ⅲ类。

中国水产科学研究院黑龙江水产研究所研究员姜作发介绍说，这些年，通过污染治理，松花江珍稀鱼类已经开始重现，且其种群数量还在不断增加。

2010年，姜作发在进行松花江干流调查时，采集的鱼类种类已经达到64种。

鱼类大量出现，是松花江水环境变好的最有力佐证。

休养生息带来水清鱼跃

“江水越来越清澈，我的心也越来越敞亮”

在江畔住了几十年的许大爷每年开江时都会守在江边:“这些年，看到城市迅速发展，日子越过越好，江水越来越清澈，我的心也越来越敞亮。”

“十一五”以来，沿松花江流域的吉林省、黑龙江省全面实施松花江流域水污染防治规划，给予松花江充分的人文关怀，不断减轻其污染负荷，恢复生态系统的活力，使松花江再现盎然生机。

除了中央财政投入外，黑龙江省级财政近几年累计投入奖补资金14.4亿元，大力支持松花江流域水污染防治项目建设，流域环境得到了有效改善。

环境保护部部长周生贤多次视察黑龙江省松花江流域水污染防治工作，提出要使松花江成为全国江河湖泊休养生息的样板和探索环保新道路的示范区，促进全流域的可持续发展与和谐稳定。黑龙江省省长王宪魁提出，“十二五”期间要继续推进松花江流域水污染治理，全面改善支流水环境质量，不断提高干流断面水质达标率。

“十二五”期间，黑龙江省计划总投资约150亿元，重点解决面源污染问题。到“十三五”结束时，松花江全流域的环境质量将基本恢复到三四十年前水平。（记者 吴殿峰）

水质改善鱼类增多江风清新 记忆里的松花江又回来了

新浪黑龙江
09月01日 14:36

关注

摘要： 这几年，松花江哈尔滨段能吸引那么多人前来游玩，主要与水质的改善有关。记者从环保、渔政等部门了解到，通过对松花江流域风险企业进行搬迁和关闭，管控进入松花江的污染源，并进行投放鱼苗、延长禁渔期等生态修复，松花江的水质越来越好，鱼类种类数量也得到恢复，没有了腥臭，江风清新，游人如织。

原标题：水质改善鱼类增多江风清新

记忆里的松花江又回来了

来源：生活报

生活报讯（记者张立王萌）本报8月31日刊发“冰城最美沿江全景图步步倾心”的报道后，引起了广泛关注。记者走访发现，这几年，松花江哈尔滨段能吸引那么多人前来游玩，主要与水质的改善有关。记者从环保、渔政等部门了解到，通过对松花江流域风险企业进行搬迁和关闭，管控进入松花江的污染源，并进行投放鱼苗、延长禁渔期等生态修复，松花江的水质越来越好，鱼类种类数量也得到恢复，没有了腥臭，江风清新，游人如织。

20年游泳爱好者

讲述松花江水质变化

8月31日，宽阔的松花江从哈尔滨市区流过，岸边是成排的垂钓者，台阶上坐着很多人，看着荡漾的江水、吹着江风，非常惬意。

“10年前，我有一次出差来过哈尔滨，在当地朋友的带领下去了防洪纪念塔，那时松花江没有现在宽，江水有股腥臭味，不好闻。”来自贵州的高先生告诉记者，他现在退休了，又带着老伴来哈尔滨避暑，这次来到江边，江风卷来一阵江水的味道，像刚割过的草地，鲜甜鲜甜的。

除了游客，在松花江游了20多年泳的市民米长珍，对松花江的水质更有感触。今年67岁的米长珍，2016年曾获得第十六届哈尔滨国际冬泳邀请赛女子老年组冠军，她告诉记者，这几年松花江的水

质好多了，游泳后简单冲洗一下就行。“前些年冬天，江上有清沟，不结冰，都是各河沟流进的污水。夏天也能在江面上看到一条污水带顺江而下，‘泾渭分明’。”米长珍说，她们游泳虽然避开污水带，但是水质也不行，有一股味儿，难闻，尤其是靠近江南的水，她们都去江北一带游泳。“这几年在哪游泳都行了，水质都很清澈，随便畅游。”今年，她们几个游泳爱好者已经多次横渡

松花江，还从十四道街码头游到了港务局码头。

多举措修复松花江鱼类增多

踏访中，市民张大爷介绍：“我和几个老伙伴儿每天都要来江边垂钓，只

要往江边一坐，手杆一支，什么烦恼都没了。现在还有渔政部门修护治理，不仅水质环境得到大幅度提升，小鱼小虾等品种也更加丰富，儿时记忆里的松花江又回来了。”

记者从省农业农村厅渔政管理局获悉，据初步统计，今年已经增殖放流各种鱼类苗种8646万尾，其中包括施氏鲟、达氏鳇、哲罗鲑、细鳞鲑、大麻哈鱼等。从2019年起，松花江禁渔期为5月16日至7月31日，首次延长30天。与此同时，2020年初以来，我省组织开展“渔政亮剑2020”系列专项执法行动，环保志愿者也加入其中，收缴违禁网具12.6万延长米，收缴地笼等违禁渔具5918（张顶、套）。

通过这一系列行动，松花江生态逐渐恢复。黑龙江水产研究所调查发现，近年来，哲罗鱼、苏里白鲑、黑斑狗鱼、七鳃鳗等7种珍稀冷水鱼在松花江不同江段频频出现，对水生态环境要求苛刻的冷水鱼重新回归松花江，表明水质已得到明显改善，水生态环境得到初步恢复。来自省环境监测中心站的鱼类分析显示，松花江流域鱼体污染残留较少，鱼类生存状态较好，食用相对安全。

松花江干流哈尔滨江段水质全优

近些年，有关部门对沿线城市松花江流域风险企业进行了搬迁和关闭，目前沿江的化工、制药、焦化等企业大多已经撤出。记者从省环保厅获悉，我省深入实施水污染防治行动计划，目前已成功消除阿什河、倭肯河、梧桐河劣V类水体。2019年的环保公报显示，松花江水系水质与2018年相比，I~III类水质比例升高6.4个百分点，劣五类比例降低1.3个百分点。

今年一季度，哈市13个国考断面优良（I~III类）比例69.23%，超过国家考核要求7.7个百分点，国考断面全面消除劣V类。据了解，2008年松花江哈尔滨段三类水质的达标监测断面仅为20%，2011年这一数据提升至100%并一直持续，2019年1至9月份，松花江干流水质持续为优。

更多区域喝上干净的松花江水

据专家介绍，松花江干流水质达到三类，即可作为集中式生活饮用水地表水源地二级保护区。2013年，哈市水务局组织哈工大市政环境工程学院和哈供水集团多次检测结果显示，哈尔滨松花江水源地原水水质达到国家三类地表水水体条件，109项指标均在正常范围之内，符合饮用水供水条件。

根据哈市水源规划，哈市2014年11月份启动了松花江水源工程建设。根据当时的计划，哈南、哈西、松北、呼兰区等区域将饮用松花江水。2018年，12万松北居民已喝上优质松花江水。今年7月，松花江水源供水工程（净水管线）开始施工，竣工后万宝大道、利民一带的居民也有望告别地下水，喝上松花江水。目前，哈市已将松花江水源地取水口上移项目列入计划。上移后，取水口远离城区，水质将会有所提高。

A.2: Research Ethics Approval Letter for the Project

MEDICAL SCIENCES INTERDIVISIONAL RESEARCH ETHICS COMMITTEE
Research Services, Boundary Brook House, Churchill Drive, Headington, Oxford, OX3 7GB
Tel: +44(0)1865 616575
ethics@medsci.ox.ac.uk

CONFIDENTIAL

Professor E.J. Milner-Gulland & Shuo Gao
Department of Biology
University of Oxford
11a Mansfield Road
Oxford

6 January 2023

Dear Professor Milner-Gulland and Shuo,

Research Ethics Approval - CUREC 1

Ethics Approval Reference: R84176/RE001

Study title: Dynamic Consequences of Environmental Change for Well-being

The above application has been considered on behalf of the Medical Sciences Interdivisional Research Ethics Committee (MS IDREC) in accordance with the University's procedures for ethical approval of all research involving human participants.

I am pleased to inform you that, on the basis of the information provided to the IDREC, the proposed research has been judged as meeting appropriate ethical standards, and approval has been granted for a period of **18 months**, commencing on **6th January 2023.**

Amendments

Should there be any subsequent changes to the study, you should submit details to the MS IDREC for consideration and approval. Details of changes must be listed on an amendment form.

Yours Sincerely

DocuSigned by:
Leah Butts
9F14889D2BC549A...

Mrs Leah Butts
Research Ethics Administrator

for
Dr Helen Barnby-Porritt
Research Ethics Manager

Appendix B: Supplementary Information for Chapter 2

B.1: Supplementary Materials

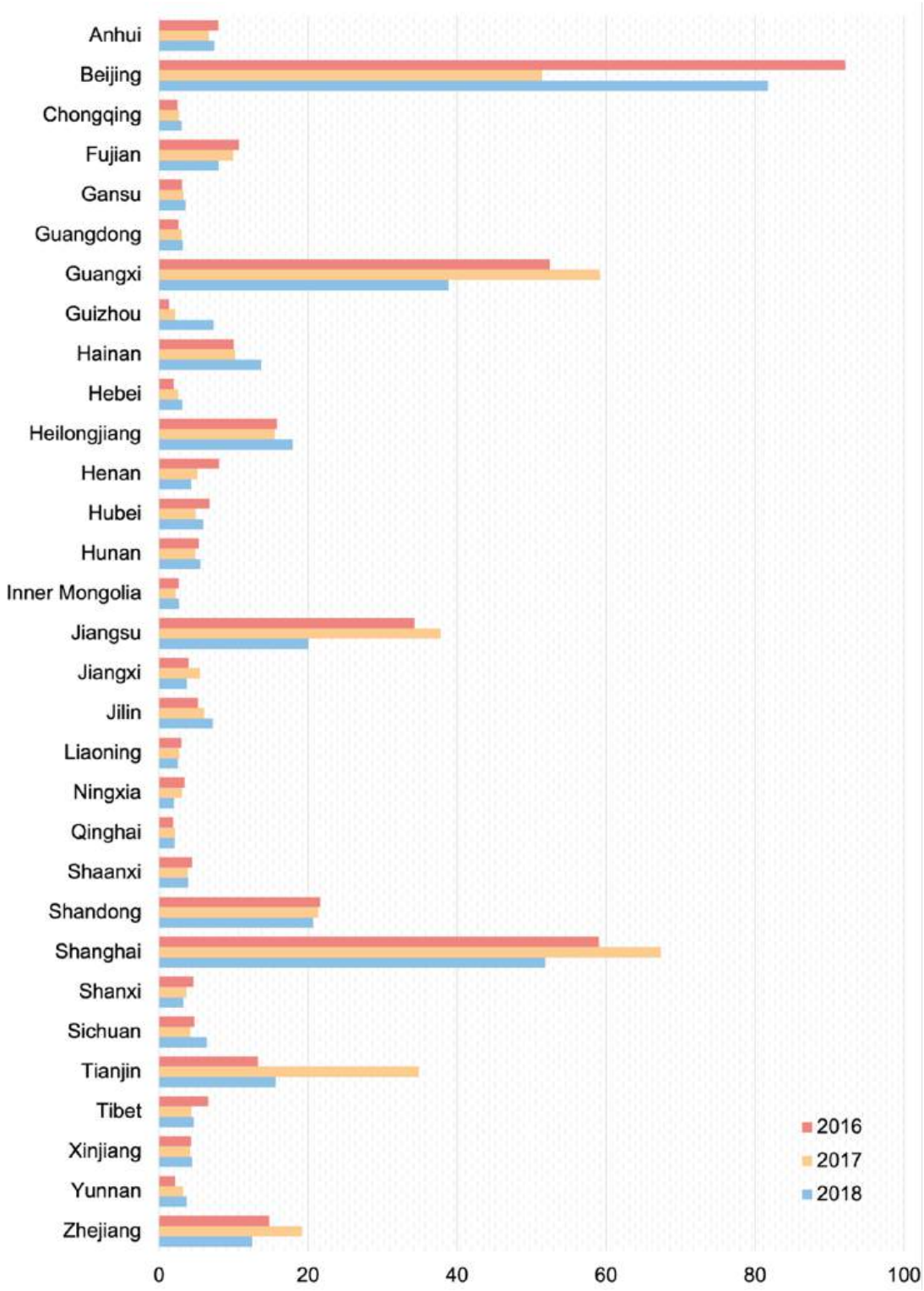


Fig. B.1: Total afforestation costs in China's 31 provincial-level administrative units (in CNY).

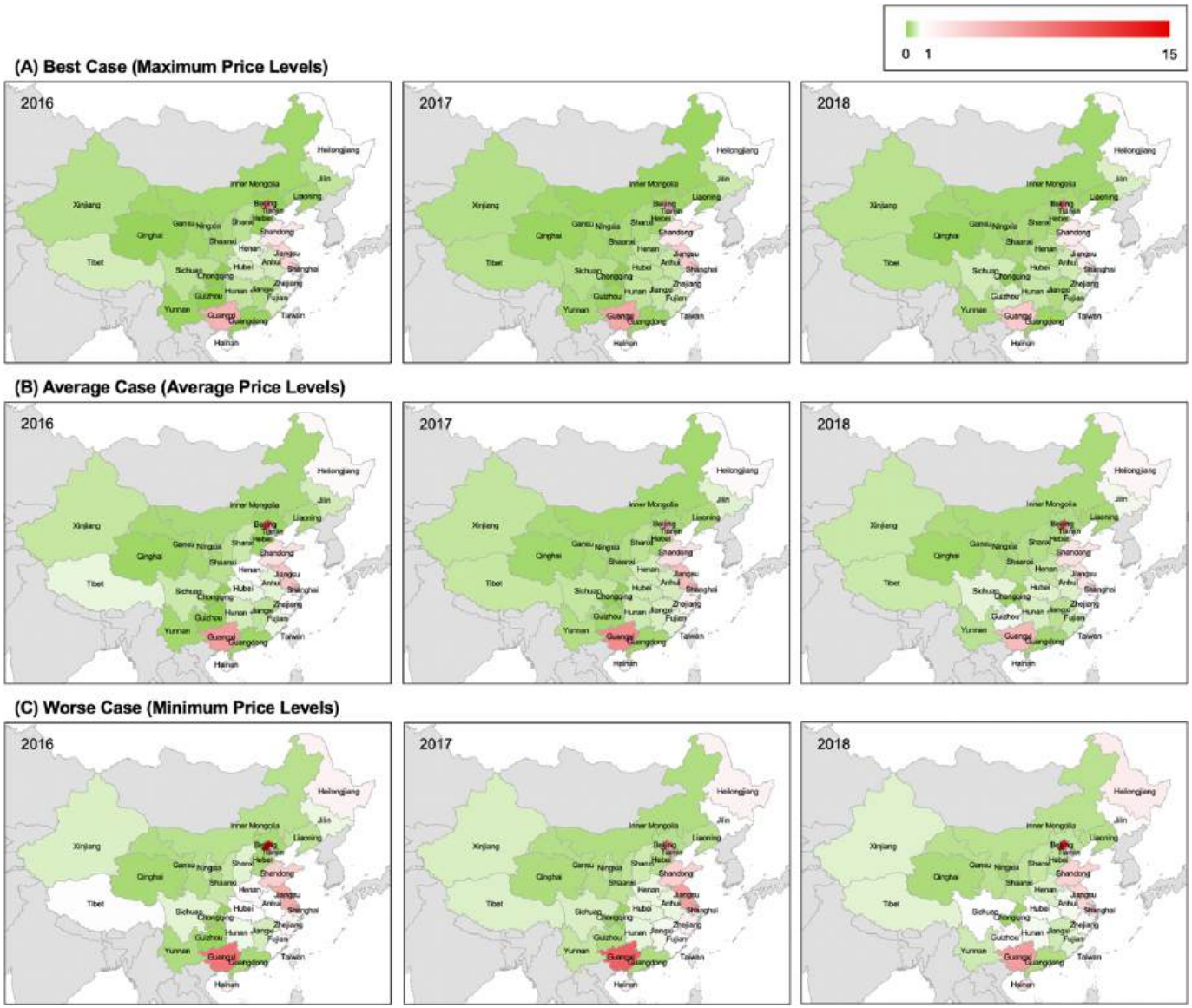


Fig. B.2: Cost-price ratios across three years. The ratio of the total provincial government spending on forest development in each region to the price levels applied in China's FVRF from 2016 to 2018 across China's 31 province-level administrative units. A sensitivity analysis is conducted considering best, average and worse-case scenarios, since China does not report how much of each type of forest land is delivered each year. The highest forest restoration price levels (i.e. prices for arbour forest lands) and lowest forest restoration price levels (i.e., prices for young afforested lands) are used to develop the best and worst scenarios respectively. The current price levels renewed in 2015 were less than the cost of compensation - which includes, if any, government corruption and misappropriation - in some regions including Beijing, Shanghai, Guangxi, Jiangsu, Shandong, and Tianjin. The average scenario is constructed using a mean of all six prices for forest restoration. Suitable lands for forest (Table 2.2) is not considered in this analysis.

Table B.1: Biodiversity measurements for developments and proposed compensatory actions based on their EIAs.

Name of development	Region	Year	Land-use area (hectare)	Protected species/habitats	Biodiversity indicators	Compensatory actions	Source
Jiasajiang Level 1 Hydropower Station	Yunnan	2014	66720.76	Identified	Forest patch indexes; habitat area; primary productivity; biomass loss; species phenology & morphology; species abundance	Fish fry releasing of 10 affected species; fish ladder development; onsite forest restoration; onsite farmland reclamation; offsite tree plantation; offsite farmland improvement	http://www.doc88.com/p-0992324394228.html
Ningdu Oucheng Community Development	Sichuan	2014	3.6341	Not identified	Not applied	Real estate area greening	https://www.doc88.com/p-6854560313100.html
Huyayuan Construction Project	Chongqing	2015	1.369238	Not identified	Not applied	Real estate area greening	https://www.doc88.com/p-7778968764679.html
Shujie Highway Double House Connection Line	Fujian	2015	3.6029	Not identified	Affected family/genus/species names; biomass loss	Road greening	https://www.doc88.com/p-0197694102174.html
Qiaocheng Haijingwan Community Project	Fujian	2015	1.1701	Not identified	Affected family/genus/species names	Real estate area greening	https://www.doc88.com/p-8049746923859.html
Xiyu Haijing Community Project	Liaoning	2015	17.0335	Not identified	Not applied	Real estate area greening	https://www.doc88.com/p-2754529549645.html
Nanming Road Park Middle Road Construction Project	Guizhou	2015	14.79	Not identified	Affected family/genus/species names	Road greening	https://www.doc88.com/p-7022824902488.html
Shengfeng Bridge Construction Development	Fujian	2015	0.1313	Not identified	Not applied	Onsite vegetation plantation (buddhist pine and pinwheel flower)	https://www.doc88.com/p-6065229017497.html
Shanghai Hongqiao Hospital	Shanghai	2015	0.218669	Not identified	Affected family/genus/species names	Not mentioned	https://www.doc88.com/p-7794493334547.html
Qianjin Huayuan Community	Jiangsu	2015	17.28067	Not identified	Not applied	Real estate area greening	https://www.doc88.com/p-5498958011516.html
Jian Liren Hospital Development	Jiangxi	2015	0.401681	Identified	Affected family/genus/species names	Not mentioned	https://www.doc88.com/p-2512372781367.html

Table B.1 (*continued*)

Name of development	Region	Year	Land-use area (hectare)	Protected species/habitats	Biodiversity indicators	Compensatory actions	Source
Chenjiadu Middle School Development Project	Hunan	2015	4.3975	Not identified	Affected family/genus/species names	Development site greening	https://www.doc88.com/p-2701542840764.html
346 Provincial Highway (Lianshui Section) Project	Jiangsu	2015	46.33	Not identified	Affected family/genus/species names; habitat area	Road greening	https://www.doc88.com/p-9166962054596.html
China-Korea Square Development	Sichuan	2015	6.63022	Not identified	Affected family/genus/species names	Development site greening	https://www.doc88.com/p-6038998529886.html
Dongfang Lanhai Community Development	Anhui	2015	12.585009	Not identified	Not applied	Real estate area greening	https://www.doc88.com/p-9982180023691.html
Wuhu Jinfuyuan Community Development	Anhui	2015	1.9541	Not identified	Not applied	Real estate area greening	https://www.doc88.com/p-3187689361202.html
Linquan Guojian Hospital Development Project	Anhui	2016	0.8	Not identified	Affected family/genus/species names	Not mentioned	https://www.doc88.com/p-6476926058760.html
Aositing Meigui Town Project	Shandong	2016	39.666865	Not identified	Affected family/genus/species names	Real estate area greening	https://www.doc88.com/p-1952873124185.html
Ruibeika Xingtianxia Real Estate Project	Henan	2016	16.1643	Not identified	Not applied	Real estate area greening	https://www.doc88.com/p-1893539523896.html
353 Provincial Highway (Yangzhou East Section) Project	Jiangsu	2016	405	Identified	Affected family/genus/species names; species abundance and traits; biomass loss; community diversity	Onsite grassland (medicago and white clover) restoration for future farmland restoration; fish pond restoration and development; offsite 1035.5-mu (about 69.03-hectare) tree plantation	https://www.doc88.com/p-1671589332993.html
Xingyue Hongqiao Center (North) Project	Shanghai	2016	3.25045	Not identified	Not applied	Development site greening	https://www.doc88.com/p-7476958737373.html

Table B.1 (*continued*)

Name of development	Region	Year	Land-use area (hectare)	Protected species/habitats	Biodiversity indicators	Compensatory actions	Source
Yancheng-Nantong Railway	Jiangsu	2016	696.94	Identified	Habitat area; species abundance; community composition; vegetation height; biomass; net primary productivity; forest patch indexes	Tree plantation beside railway	https://www.doc88.com/p-5791520461603.html
Nanjing No.7 Line Underground Development	Jiangsu	2016	81.82	Not identified	Not applied	Not mentioned	https://www.doc88.com/p-6189756597384.html
403 Provincial Highway (Haian Section) Project	Jiangsu	2016	216	Not identified	Affected family/genus/species names; biomass loss	Road greening	https://www.doc88.com/p-4042344782006.html
Shanghai Heersen Rehabilitation Hospital	Shanghai	2016	1.3245	Not identified	Not applied	Development site greening	https://www.doc88.com/p-2082365694576.html
Shanghai Yikang Traditional Chinese Medicine Hospital	Shanghai	2016	1.96687	Not identified	Affected family/genus/species names	Not mentioned	https://www.doc88.com/p-7952360888283.html
G356 State Road (Jinyangbingdi - Tugou Section) Project	Sichuan	2016	0.8199	Not identified	Community composition; vegetation species traits and distribution; affected animals species	Tree planation	https://www.doc88.com/p-98561827578515.html
Liming North Road (North Section) Project	Chongqing	2016	0.006970554	Not identified	Not applied	Road greening	https://www.doc88.com/p-1127436253865.html
Qiaolu Tongde Hospital Development	Zhejiang	2017	0.002	Not identified	Not applied	Not mentioned	https://www.doc88.com/p-7334977243610.html
Danzhou Tiyubei Road Construction Project	Hainan	2020	0.0428604	Not identified	Not applied	Road greening	https://www.doc88.com/p-04287171271262.html
Changsha Nanhai Hospital Construction Project	Hunan	2021	0.00296172	Not identified	Affected family/genus/species names	Not mentioned	https://www.doc88.com/p-59416023791764.html

Appendix C: Supplementary Information for Chapter 3

C.1: Perceptions of Environmental Change Survey

Introduction & Consent

- Hello, my name is Shuo Gao. I am an independent doctoral researcher at the University of Oxford in the UK. Thank you for taking the time to answer this questionnaire.
- My research seeks to explore your understanding of environmental changes in Qunli, including those related to the Songhua River.
- We are surveying people who are residents over the age of 18 and currently living in Qunli New Town, Harbin, China.

How this questionnaire will work

- This survey will take around 15-20 minutes to complete.
- If you choose to participate, all your responses will be kept confidential and anonymous. We will not collect any information that can be used to identify you. No third parties, including governmental or non-governmental organisations, will have access to the information you share with us.
- You do not have to answer any question you are uncomfortable with, and you can choose to withdraw at any time.
- The collected information will be stored in a secure database, accessible only by password. The information collected is for academic use only. I will analyse the information, and the results will be presented as part of my doctoral thesis. Some results may also be published internationally in academic papers, at conferences, and on online blogs.
- In accordance with the University of Oxford's procedures for ethical approval of research involving human participants, this study has been reviewed and has received ethical clearance through a subcommittee of the University's Central University Research Ethics Committee (Ethics Approval Reference: R84176/RE001).

If you have any questions

- If you have any concerns or questions about the research, please get in touch with me, and I will do my best to assist.
- If you remain dissatisfied or wish to make a formal complaint, I can provide you with the contact details of the Research Ethics Committee at the University of Oxford.

0. Are you happy to take part in this survey?

○ Yes
○ No

Section A: Environmental Changes in Qunli & the Songhua River

The first part of this questionnaire asks about environmental changes in the natural areas of Qunli New Town, including the Songhua River, in Harbin, China. Please answer based on what you already know—no need to search for information, as that could affect the validity of the results. This survey is anonymous, so it's perfectly fine if you don't know the answers to some questions. Just give your best answer if you're unsure.

1. What was Qunli New Town mostly converted from? You can tick more than one answer.

○ I don't know
○ A cleared flat plain
○ Some communities, bungalows, and factories
○ A big marsh with farmland and fishponds
○ A natural woodland with a protected national wetland park
○ A large mall with extensive parking areas

○ Other, please specify: _____

2. Around which year did the Qunli Bund Wetland restoration project begin?

○ I don't know
○ 2007
○ 2010
○ 2013
○ 2016
○ 2019

3. In which year did you first become aware of the local situation in the Qunli area (either because you moved here or were old enough to notice changes in your surroundings)? _____

4. Starting from the year you first became aware of the local situation and thinking up until now, how has the area of natural habitats (figure below) within the Qunli area changed?

○ Increasing
○ Decreasing
○ First decreasing, then increasing
○ First increasing, then decreasing
○ Unchanged
○ Other, please specify: _____
○ I don't know

A natural habitat provides space for plants or animals to live in. It can be naturally occurring (left) or artificially created following proper procedures (right).

5. In which year did you first start to get to know about the situation in Songhua River (Harbin Section) (either because you moved to places nearby, or you were old enough to notice changes in your surroundings)? _____

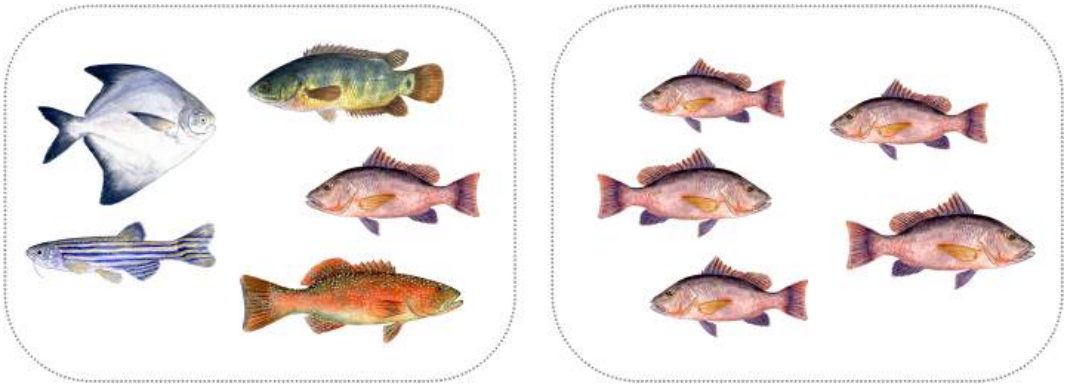
6. Compared to the year you first became aware of the local situation, how has the water quality of the Songhua River changed up to the present?

○ Improving
○ Declining
○ First declining, then improving
○ First improving, then declining
○ Unchanged
○ Other, please specify: _____
○ I don't know

7. Compared to the year you first became aware of the local situation, how has the number of fish kinds (figure below) in the Songhua River changed up to the present?

○ Increasing
○ Decreasing
○ First decreasing, then increasing
○ First increasing, then decreasing
○ Unchanged

○ Other, please specify: _____
○ I don't know



The number of fish kinds is different from the number of fish. Both panels above have 5 fish, while there are 5 kinds of bird in the left but only 1 kind in the right.

8. Which of the plants listed below were planted during the development of Qunli New Town?

○ Yes ○ No ○ I don't know	○ Yes ○ No ○ I don't know	○ Yes ○ No ○ I don't know
		
Lotus	Siberian apricot	Lilac
○ Yes ○ No ○ I don't know	○ Yes ○ No ○ I don't know	○ Yes ○ No ○ I don't know
		
Lavender	Sunflower	Gardenia
○ Yes ○ No ○ I don't know	○ Yes ○ No ○ I don't know	○ Yes ○ No ○ I don't know
		
Forsythia	Reed flower	Sage

9. How confident are you in your answers to these questions?
○ Very confident
○ Somewhat confident
○ Not very confident
○ Not confident at all

10. Please explain the reasons for your answers to this question.
○ I know a lot about this place.
○ I don't know much about this place.
11. If you don't know much about this place, please indicate the reasons (you can select more than one).
○ I have no interest to visit or learn knowledge about local natural environment.
○ I am unable to know local nature a lot because I am new to the town.
○ I am too busy to fully appreciate the local nature, even though I am around it.
○ I have paid little attention to the natural environment during my visits.
○ I lack sources of knowledge to learn about the local environmental situation.
○ I do not have sufficient ecological or scientific knowledge to identify or distinguish natural elements.
○ I used to have some environmental knowledge, but I can't remember it now.
○I feel uncertain about the environmental knowledge I previously acquired from media, other people, or various information sources.
12. How do you know about the environmental conditions in Qunli? You can select more than one option.
○ My own experience
○ Relatives or friends
○ Print media (e.g., newspapers)
○ Television
○ Official pages (government websites or official social media accounts)
○ Non-official pages (personal websites or unofficial social media accounts)
○ I don't have any knowledge of the local environmental conditions in Qunli
○ Other, please specify: _____
13. How often have you visited the natural areas in Qunli over the last 12 months?
○ Never
○ Less than three times in total
○ Less than once a month
○ About once a fortnight
○ About once a week
○ Most days
14. For each visit, how much time do you usually spend in the natural areas (including the Songhua River) in Qunli?
○ Never been there
○ Less than 30 minutes
○ Around 30 minutes to an hour
○ Over an hour
15. How interested are you in visiting the natural areas in Qunli?
○ Very low
○ Low
○ Neutral
○ High
○ Very high
16. How do you interact with the natural environment and features in Qunli (including the Songhua River)? You can select more than one option.
○ I look at them from a distance (e.g., through the windows of my flat, car, or bus).
○ I interact with nature directly by being within it, so I can touch, smell, and see it.
○ I don't really interact with nature at all in this area.

17. Before the development of Qunli New Town began (around 2006), how often did you visit the old Qunli area?

○ I have never been to the old Qunli area before the development began.
○ I visited onone or a few times in total before the development began.
○ I visited from time to time before the development began.
○ I visited very often before the development began.
○ I lived in the old Qunli Area before the development began.
○ I can't remember.

Section B: Socio-demographic information

In this section, I would like to gather some information about you. These questions will help us understand how different backgrounds might influence perceptions of environmental changes in Qunli. Your responses will remain confidential and will only be used for research purposes.

18. What is your gender?

○ Male
○ Female
○ Other
○ Prefer not to say

19. How old are you?

○ 18-30
○ 31-45
○ 46-60
○ Over 60
○ Prefer not to say

20. What is the highest level of education you have completed?

○ No education
○ Primary
○ Lower secondary
○ Upper secondary
○ College diploma
○ Bachelor's degree
○ Master's degree
○ Doctoral degree
○ Prefer not to say

21. What is your current sector of work?

○ Department, organisation, or enterprise head
○ Technician or professional
○ Clerk
○ Business or social service worker
○ Agriculturalist
○ Manufacturing worker
○ Other, please specify: _____
○ Prefer not to say

22. Did you have to change your job because of the development of Qunli New Town?

○ Yes
○ No
○ Not sure
○ Prefer not to say

23. If yes or not sure, what was your previous sector of work before the development of Qunli New Town?

○ Department, organisation, or enterprise head
○ Technician or professional
○ Clerk
○ Business or social service worker
○ Agriculturalist
○ Manufacturing worker
○ Other, please specify: _____
○ Prefer not to say

24. During the last year, what was your approximate average monthly income?

○ Less than ¥1,000
○ ¥1,000 - ¥5,000
○ ¥5,000 - ¥10,000
○ ¥10,000 - ¥20,000
○ More than ¥20,000
○ Prefer not to say

25. During the last year, how long in total did you spend outside Qunli New Town, whether for work or personal reasons?

○ Never or no more than 1 month
○ 1-3 months
○ 3-6 months
○ Over 6 months

26. Which of the following religions do you identify with?

○ I don't have a religion
○ Buddhism
○ Taoism
○ Christianity
○ Islam
○ Other, please specify: _____
○ Prefer not to say

27. What is your ethnicity?

○ Han
○ Manchu
○ Korean
○ Hui
○ Other, please specify: _____
○ Prefer not to say

Thank You

- Thank you for taking the time to participate in this survey. Your input will provide valuable insights into how different residents perceive local environmental changes.
- If you have any concerns about any aspect of this study, please don't hesitate to contact me at shuo.gao@st-hildas.ox.ac.uk. You can expect an acknowledgment of your concern within 7 working days.
- If you remain dissatisfied or wish to make a formal complaint, please contact the Chair of the Medical Sciences Interdivisional Research Ethics Committee at the University of Oxford. You can reach them via email at ethics@medsci.ox.ac.uk.

C.2: Supplementary Materials

Table C.1: Model comparison results for determining Minimum Adequate Models (MEMs). AICc: Corrected Akaike Information Criterion; RVI: Relative Variable Importance; Delta: Delta AICc.

	(Int)	Age	Baseline	Direct	Edu	Freq	Freq_pre	Friends	Interest	Official	Out	Printed	Local	Time	TV	Unofficial	AICc	Delta
(1) Overall knowledge																		
14559	35.4502	*NA*	-0.0170	0.0645	0.0626	0.0200	*NA*	0.0386	0.0614	*NA*	*NA*	*NA*	-0.0447	0.0547	-0.0557	*NA*	4483.2140	0.0000
14495	35.4977	*NA*	-0.0170	0.0641	0.0661	0.0209	*NA*	*NA*	0.0621	*NA*	*NA*	*NA*	-0.0473	0.0566	-0.0523	*NA*	4483.3930	0.1796
12495	35.4692	*NA*	-0.0170	0.0696	0.0642	*NA*	*NA*	0.0425	0.0656	*NA*	*NA*	*NA*	*NA*	0.0608	-0.0585	*NA*	4483.4450	0.2316
12511	34.6345	*NA*	-0.0166	0.0645	0.0649	0.0148	*NA*	0.0412	0.0605	*NA*	*NA*	*NA*	*NA*	0.0570	-0.0598	*NA*	4483.8140	0.5999
14543	36.2741	*NA*	-0.0174	0.0709	0.0624	*NA*	*NA*	0.0409	0.0675	*NA*	*NA*	*NA*	-0.0323	0.0601	-0.0553	*NA*	4483.9970	0.7835
14591	36.9168	*NA*	-0.0177	0.0647	0.0638	0.0212	-0.0125	0.0389	0.0620	*NA*	*NA*	*NA*	-0.0449	0.0553	-0.0563	*NA*	4484.1110	0.8967
12431	35.5076	*NA*	-0.0170	0.0693	0.0683	*NA*	*NA*	*NA*	0.0667	*NA*	*NA*	*NA*	*NA*	0.0633	-0.0549	*NA*	4484.1270	0.9134
12447	34.6274	*NA*	-0.0166	0.0640	0.0689	0.0155	*NA*	*NA*	0.0613	*NA*	*NA*	*NA*	*NA*	0.0591	-0.0563	*NA*	4484.3220	1.1084
14527	36.9447	*NA*	-0.0177	0.0643	0.0674	0.0221	-0.0123	*NA*	0.0627	*NA*	*NA*	*NA*	-0.0475	0.0572	-0.0528	*NA*	4484.3240	1.1101
14496	36.0213	-0.0156	-0.0172	0.0619	0.0594	0.0215	*NA*	*NA*	0.0625	*NA*	*NA*	*NA*	-0.0435	0.0569	-0.0504	*NA*	4484.3320	1.1177
14815	35.1091	*NA*	-0.0168	0.0674	0.0648	0.0210	*NA*	0.0411	0.0624	-0.0262	*NA*	*NA*	-0.0446	0.0544	-0.0531	*NA*	4484.3790	1.1647
14479	36.3706	*NA*	-0.0174	0.0707	0.0661	*NA*	*NA*	*NA*	0.0687	*NA*	*NA*	*NA*	-0.0344	0.0624	-0.0516	*NA*	4484.4680	1.2540
14528	38.1231	-0.0208	-0.0183	0.0614	0.0588	0.0232	-0.0164	*NA*	0.0634	*NA*	*NA*	*NA*	-0.0426	0.0578	-0.0504	*NA*	4484.5220	1.3085
14555	35.7814	*NA*	-0.0171	*NA*	0.0626	0.0223	*NA*	0.0382	0.0653	*NA*	*NA*	*NA*	-0.0446	0.0639	-0.0542	*NA*	4484.5480	1.3342
14560	35.8664	-0.0122	-0.0172	0.0628	0.0577	0.0205	*NA*	0.0350	0.0617	*NA*	*NA*	*NA*	-0.0420	0.0551	-0.0539	*NA*	4484.6060	1.3917
12527	36.7993	*NA*	-0.0176	0.0701	0.0653	*NA*	-0.0108	0.0429	0.0664	*NA*	*NA*	*NA*	*NA*	0.0616	-0.0589	*NA*	4484.6150	1.4013
Null	1.8780	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	4766.8000	283.5860
Full	37.3559	-0.0190	-0.0179	0.0650	0.0588	0.0231	-0.0142	0.0361	0.0636	-0.0234	-0.0077	0.0020	-0.0415	0.0549	-0.0529	0.0043	4491.4000	8.1860
RVI		0.43	1	0.68	1	0.6	0.39	0.52	1	0.33	0.3	0.27	0.53	0.99	0.74	0.27		
(2) Pre-turning point knowledge																		
10412	47.7506	-0.0380	-0.0236	*NA*	0.0988	*NA*	0.0338	*NA*	0.1021	*NA*	*NA*	*NA*	-0.0719	*NA*	-0.0864	*NA*	3453.7340	0.0000
10475	45.3698	*NA*	-0.0224	*NA*	0.1080	*NA*	0.0403	0.0627	0.0982	*NA*	*NA*	*NA*	-0.0781	*NA*	-0.0954	*NA*	3453.8230	0.0895
14508	47.0414	-0.0391	-0.0232	*NA*	0.0964	*NA*	0.0324	*NA*	0.0917	*NA*	*NA*	*NA*	-0.0700	0.0366	-0.0815	*NA*	3453.9740	0.2407
10411	45.5599	*NA*	-0.0225	*NA*	0.1140	*NA*	0.0407	*NA*	0.1006	*NA*	*NA*	*NA*	-0.0815	*NA*	-0.0901	*NA*	3454.0100	0.2766
10476	47.2985	-0.0329	-0.0234	*NA*	0.0958	*NA*	0.0344	0.0538	0.0998	*NA*	*NA*	*NA*	-0.0702	*NA*	-0.0915	*NA*	3454.1790	0.4454
8364	46.2865	-0.0439	-0.0229	*NA*	0.1007	*NA*	0.0322	*NA*	0.0984	*NA*	*NA*	*NA*	*NA*	*NA*	-0.0933	*NA*	3454.3630	0.6294
14507	44.8019	*NA*	-0.0222	*NA*	0.1122	*NA*	0.0396	*NA*	0.0904	*NA*	*NA*	*NA*	-0.0800	0.0353	-0.0855	*NA*	3454.3740	0.6399

Table C.1 (*continued*)

	(Int)	Age	Baseline	Direct	Edu	Freq	Freq_pre	Friends	Interest	Official	Out	Printed	Local	Time	TV	Unofficial	AICc	Delta
(2) Pre-turning point knowledge																		
12460	45.5879	-0.0449	-0.0225	*NA*	0.0982	*NA*	0.0308	*NA*	0.0877	*NA*	*NA*	*NA*	*NA*	0.0381	-0.0878	*NA*	3454.4590	0.7248
14571	44.6989	*NA*	-0.0221	*NA*	0.1068	*NA*	0.0393	0.0586	0.0890	*NA*	*NA*	*NA*	-0.0769	0.0322	-0.0909	*NA*	3454.4850	0.7510
10416	47.1597	-0.0370	-0.0233	0.0577	0.0989	*NA*	0.0335	*NA*	0.0953	*NA*	*NA*	*NA*	-0.0732	*NA*	-0.0868	*NA*	3454.6420	0.9078
10479	44.8246	*NA*	-0.0222	0.0597	0.1078	*NA*	0.0398	0.0620	0.0912	*NA*	*NA*	*NA*	-0.0792	*NA*	-0.0957	*NA*	3454.6530	0.9196
8428	45.8813	-0.0384	-0.0227	*NA*	0.0975	*NA*	0.0328	0.0559	0.0961	*NA*	*NA*	*NA*	*NA*	*NA*	-0.0985	*NA*	3454.6810	0.9476
14572	46.6883	-0.0344	-0.0231	*NA*	0.0938	*NA*	0.0331	0.0492	0.0903	*NA*	*NA*	*NA*	-0.0686	0.0339	-0.0865	*NA*	3454.6970	0.9630
10415	44.9889	*NA*	-0.0223	0.0610	0.1137	*NA*	0.0402	*NA*	0.0934	*NA*	*NA*	*NA*	-0.0826	*NA*	-0.0904	*NA*	3454.7800	1.0467
14476	51.2562	-0.0493	-0.0253	*NA*	0.0950	*NA*	*NA*	*NA*	0.0945	*NA*	*NA*	*NA*	-0.0660	0.0393	-0.0813	*NA*	3454.8580	1.1246
10380	52.2013	-0.0486	-0.0258	*NA*	0.0975	*NA*	*NA*	*NA*	0.1058	*NA*	*NA*	*NA*	-0.0678	*NA*	-0.0867	*NA*	3454.8960	1.1620
Null	0.8936	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	3629.0000	175.2660
Full	46.2845	-0.0326	-0.0229	0.0383	0.0957	0.0025	0.0329	0.0487	0.0871	-0.0009	0.0088	-0.0076	-0.0705	0.0289	-0.0808	-0.0281	3465.4000	11.6660
RVI		0.6	1	0.35	1	0.28	0.68	0.45	1	0.27	0.3	0.28	0.61	0.46	0.75	0.3		
(3) Current conditions knowledge																		
4287	31.6176	*NA*	-0.0153	0.0772	0.0433	0.0300	-0.0441	*NA*	0.0475	*NA*	*NA*	*NA*	*NA*	0.0796	*NA*	*NA*	3871.2110	0.0000
4799	31.1144	*NA*	-0.0150	0.0784	0.0448	0.0297	-0.0426	*NA*	0.0479	*NA*	-0.0160	*NA*	*NA*	0.0782	*NA*	*NA*	3871.9620	0.7509
12479	31.1792	*NA*	-0.0150	0.0785	0.0441	0.0307	-0.0444	*NA*	0.0484	*NA*	*NA*	*NA*	*NA*	0.0771	-0.0358	*NA*	3872.0440	0.8330
4283	31.9956	*NA*	-0.0154	*NA*	0.0434	0.0328	-0.0439	*NA*	0.0523	*NA*	*NA*	*NA*	*NA*	0.0902	*NA*	*NA*	3872.2250	1.0144
4543	30.8658	*NA*	-0.0149	0.0808	0.0464	0.0313	-0.0419	*NA*	0.0489	-0.0344	*NA*	*NA*	*NA*	0.0789	*NA*	*NA*	3872.2990	1.0883
6335	32.1385	*NA*	-0.0155	0.0773	0.0415	0.0337	-0.0442	*NA*	0.0481	*NA*	*NA*	*NA*	-0.0313	0.0777	*NA*	*NA*	3872.4210	1.2103
4351	31.6592	*NA*	-0.0153	0.0773	0.0409	0.0296	-0.0443	0.0257	0.0469	*NA*	*NA*	*NA*	*NA*	0.0784	*NA*	*NA*	3872.6220	1.4115
4288	32.4992	-0.0149	-0.0157	0.0754	0.0369	0.0314	-0.0471	*NA*	0.0481	*NA*	*NA*	*NA*	*NA*	0.0796	*NA*	*NA*	3872.6410	1.4300
12991	30.6404	*NA*	-0.0148	0.0798	0.0456	0.0303	-0.0429	*NA*	0.0489	*NA*	-0.0167	*NA*	*NA*	0.0757	-0.0373	*NA*	3872.6980	1.4871
4795	31.5191	*NA*	-0.0152	*NA*	0.0448	0.0324	-0.0425	*NA*	0.0528	*NA*	-0.0155	*NA*	*NA*	0.0890	*NA*	*NA*	3873.0650	1.8547
6847	31.6444	*NA*	-0.0153	0.0785	0.0429	0.0336	-0.0427	*NA*	0.0486	*NA*	-0.0167	*NA*	-0.0331	0.0762	*NA*	*NA*	3873.0760	1.8651
4800	32.1277	-0.0180	-0.0155	0.0763	0.0372	0.0312	-0.0462	*NA*	0.0487	*NA*	-0.0178	*NA*	*NA*	0.0781	*NA*	*NA*	3873.1260	1.9158
20671	31.7164	*NA*	-0.0153	0.0774	0.0425	0.0302	-0.0444	*NA*	0.0471	*NA*	*NA*	*NA*	*NA*	0.0792	*NA*	0.0127	3873.1410	1.9304
5055	30.4183	*NA*	-0.0147	0.0818	0.0476	0.0309	-0.0406	*NA*	0.0493	-0.0328	-0.0155	*NA*	*NA*	0.0777	*NA*	*NA*	3873.1430	1.9326
12475	31.5781	*NA*	-0.0152	*NA*	0.0441	0.0335	-0.0442	*NA*	0.0533	*NA*	*NA*	*NA*	*NA*	0.0880	-0.0342	*NA*	3873.1550	1.9447
5311	31.4898	*NA*	-0.0152	0.0777	0.0432	0.0302	-0.0441	*NA*	0.0477	*NA*	*NA*	-0.0074	*NA*	0.0795	*NA*	*NA*	3873.2030	1.9920
Null	1.4102	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	4006.1000	134.8890
Full	31.3327	-0.0121	-0.0151	0.0821	0.0381	0.0355	-0.0440	0.0286	0.0500	-0.0357	-0.0180	0.0074	-0.0257	0.0714	-0.0372	0.0237	3881.4000	10.1890
RVI		0.34	1	0.67	0.96	0.82	0.95	0.34	0.91	0.35	0.42	0.27	0.33	0.99	0.38	0.29		

Appendix D: Supplementary Information for Chapter 4

D.1: Environmentally-Based Well-Being Survey

Introduction & Consent

- Hello, my name is Shuo Gao. I am an independent doctoral researcher at the University of Oxford in the UK. Thank you for taking the time to answer this questionnaire.
- My research seeks to explore how environmental changes in Qunli affect you and your life.
- We are surveying people who are residents over the age of 18 and currently living in Qunli New Town, Harbin, China.

How this questionnaire will work

- This survey will take around 15-20 minutes to complete.
- If you choose to participate, all your responses will be kept confidential and anonymous. We will not collect any information that can be used to identify you. No third parties, including governmental or non-governmental organisations, will have access to the information you share with us.
- You do not have to answer any question you are uncomfortable with, and you can choose to withdraw at any time.
- The collected information will be stored in a secure database, accessible only by password. The information collected is for academic use only. I will analyse the information, and the results will be presented as part of my doctoral thesis. Some results may also be published internationally in academic papers, at conferences, and on online blogs.
- In accordance with the University of Oxford's procedures for ethical approval of research involving human participants, this study has been reviewed and has received ethical clearance through a subcommittee of the University's Centra
- l University Research Ethics Committee (Ethics Approval Reference: R84176/RE001).

If you have any questions

- If you have any concerns or questions about the research, please get in touch with me, and I will do my best to assist.
- If you remain dissatisfied or wish to make a formal complaint, I can provide you with the contact details of the Research Ethics Committee at the University of Oxford.

0. Are you happy to take part in this survey?

○ Yes
○ No

Section A: Environmentally-Based Well-being

In this section, we aim to gain an understanding of how the economic developments and associated ecological compensation activities (figure below) in Qunli affect your daily life and well-being. Rest assured, your responses will remain completely anonymous. Please select the option that best captures your experience.

Ecological compensation can be applied to restore a naturally occurring habitat (left) or to create an artificial one following proper procedures (right).

1. Did you live in the Qunli area around 2006?
○ Yes
○ No
○ Not sure

2. If yes, how have the environmental changes in the Qunli area and the Songhua River affected you? Please evaluate the following statements by comparing your current feelings to those you had before the major changes in Qunli. If you did not live in this area around 2006, you do not need to answer these questions.	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
The economic developments (e.g., housing, malls, jobs, hospitals, schools) and its associated ecological compensation (e.g., urban green spaces and parks, restored or newly created) in the area has made me happier compared to before its land-use was changed.							
Despite the economic developments in the new town, my housing has not improved compared to before its land-use was changed.							
Due to the economic developments in the new town, I now have improved markets and malls compared to before its land-use was changed.							
Despite the economic developments in the new town, I have not secured a job or source of income compared to before its land use was changed.							
Due to the economic developments in the new town, I now have better medical facilities compared to before its land-use was changed.							
Despite the economic developments in the new town, I have not received improved educational facilities compared to before the land use was changed.							
Due to the ecological compensation in the new town, I now have more natural resources (e.g., food, medicine) harvested from the area, compared to before its land use was changed.							

Despite the ecological compensation in the new town, I now do fewer social activities in local natural areas, compared to before its land use was changed.							
Due to the ecological compensation in the new town, I find the area more beautiful, compared to before its land use was changed.							
Despite the ecological compensation in the new town, I find the air quality in the area has not improved, compared to before its land use was changed.							
Due to the ecological compensation in the new town, I find the urban flooding events in the area have decreased, compared to before its land use was changed.							
Despite the ecological compensation in the new town, I find I haven't known more about local nature (e.g., a bird or habitat type), compared to before its land use was changed.							

3. To what extent do you think the past environmental changes in Qunli were fair to residents? Please evaluate the following statements. You don't need to answer these questions if you feel unable to do so.	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
The process of land acquisition and clearance for the new town was fair to residents affected by it.							
Allocated social compensation for land acquisition and clearance was unfair to residents affected by it.							
The economic aspects (e.g., housing, malls, jobs, hospitals, schools) of the new town have been fair to residents in the area.							
The ecological aspects (e.g., urban green spaces and parks, restored or newly created) of the new town have been unfair for residents in the area.							

Section B: Socio-demographic information

In this section, I would like to gather some information about you. These questions will help us understand how different backgrounds might influence your perceived well-being in Qunli. Your responses will remain confidential and will only be used for research purposes.

4. What is your gender?

○ Male
○ Female
○ Other
○ Prefer not to say

5. How old are you?

○ 18-30
○ 31-45
○ 46-60
○ Over 60

○ Prefer not to say

6. What is the highest level of education you have completed?

○ No education
○ Primary
○ Lower secondary
○ Upper secondary
○ College diploma
○ Bachelor's degree
○ Master's degree
○ Doctoral degree
○ Prefer not to say

7. What is your current sector of work?

○ Department, organisation, or enterprise head
○ Technician or professional
○ Clerk
○ Business or social service worker
○ Agriculturalist
○ Manufacturing worker
○ Other, please specify: _____
○ Prefer not to say

8. Did you have to change your job because of the development of Qunli New Town?

○ Yes
○ No
○ Not sure
○ Prefer not to say

9. If yes or not sure, what was your previous sector of work before the development of Qunli New Town?

○ Department, organisation, or enterprise head
○ Technician or professional
○ Clerk
○ Business or social service worker
○ Agriculturalist
○ Manufacturing worker
○ Other, please specify: _____
○ Prefer not to say

10. During the last year, what was your approximate average monthly income?

○ Less than ¥1,000
○ ¥1,000 - ¥5,000
○ ¥5,000 - ¥10,000
○ ¥10,000 - ¥20,000
○ More than ¥20,000
○ Prefer not to say

11. During the last year, how long in total did you spend outside Qunli New Town, whether for work or personal reasons?

○ Never or no more than 1 month
○ 1-3 months
○ 3-6 months

○ Over 6 months

12. Which of the following religions do you identify with?

○ I don't have a religion
○ Buddhism
○ Taoism
○ Christianity
○ Islam
○ Other, please specify: _____
○ Prefer not to say

13. What is your ethnicity?

○ Han
○ Manchu
○ Korean
○ Hui
○ Other, please specify: _____
○ Prefer not to say

Thank You

- Thank you for taking the time to participate in this survey. Your input will provide valuable insights into how different residents are affected by the environmental changes in Qunli.
- If you have any concerns about any aspect of this study, please don't hesitate to contact me at shuo.gao@st-hildas.ox.ac.uk. You can expect an acknowledgment of your concern within 7 working days.
- If you remain dissatisfied or wish to make a formal complaint, please contact the Chair of the Medical Sciences Interdivisional Research Ethics Committee at the University of Oxford. You can reach them via email at ethics@medsci.ox.ac.uk.

D.2: Supplementary Materials

Table D.1: Results of ordinal regression analysis on socio-demographic characteristics associated with perceived changes in happiness.

Term	Estimate	Std. Error	z value	Pr(>|z|)
-3 | -2	-1.38743	0.529978	-2.61791	0.008847
-2 | -1	-0.20654	0.520213	-0.39703	0.691347
-1 | 0	0.145943	0.521201	0.280012	0.779468
0 | 1	0.6092	0.525293	1.159735	0.246157
1 | 2	1.041093	0.528076	1.971484	0.048669
2 | 3	2.051267	0.535531	3.830342	0.000128
Gender (male)	-0.4686	0.211516	-2.21545	0.026729
Age	0.078181	0.129898	0.601866	0.547263
Education	0.211475	0.113842	1.857616	0.063224
Income	-0.10188	0.116688	-0.8731	0.382607
Agriculturist	-1.45569	0.442131	-3.29244	0.000993

Table D.2: Results of ordinal regression analysis on well-being factors associated with perceived changes in happiness.

Term	Estimate	Std. Error	z value	Pr(>|z|)
-3 | -2	1.820242	0.815468	2.232145	0.025605
-2 | -1	3.238684	0.804106	4.027684	5.63E-05
-1 | 0	3.704081	0.806555	4.592471	4.38E-06
0 | 1	4.431756	0.822212	5.390037	7.04E-08
1 | 2	5.158515	0.844847	6.105858	1.02E-09
2 | 3	6.619488	0.894362	7.401354	1.35E-13
Housing	0.131775	0.117064	1.12566	0.26031
Markets & malls	0.045733	0.131352	0.348174	0.72771
Jobs & income	0.158562	0.078663	2.015726	0.043829
Medical facilities	-0.00801	0.10821	-0.07404	0.940979
Educational facilities	-0.17345	0.113929	-1.52242	0.127904
Ecosystem goods	0.063484	0.079316	0.800383	0.423489
Social activities in nature	0.205142	0.089509	2.291874	0.021913
Beauty of nature	0.498828	0.074289	6.71473	1.88E-11
Air quality	0.039774	0.119458	0.332958	0.739166
Flood control	-0.11278	0.121342	-0.9294	0.352682
Natural knowledge	0.111861	0.08845	1.264684	0.205985

Table D.3: Results of ordinal regression analysis on well-being factors and socio-demographic characteristics associated with perceived changes in happiness.

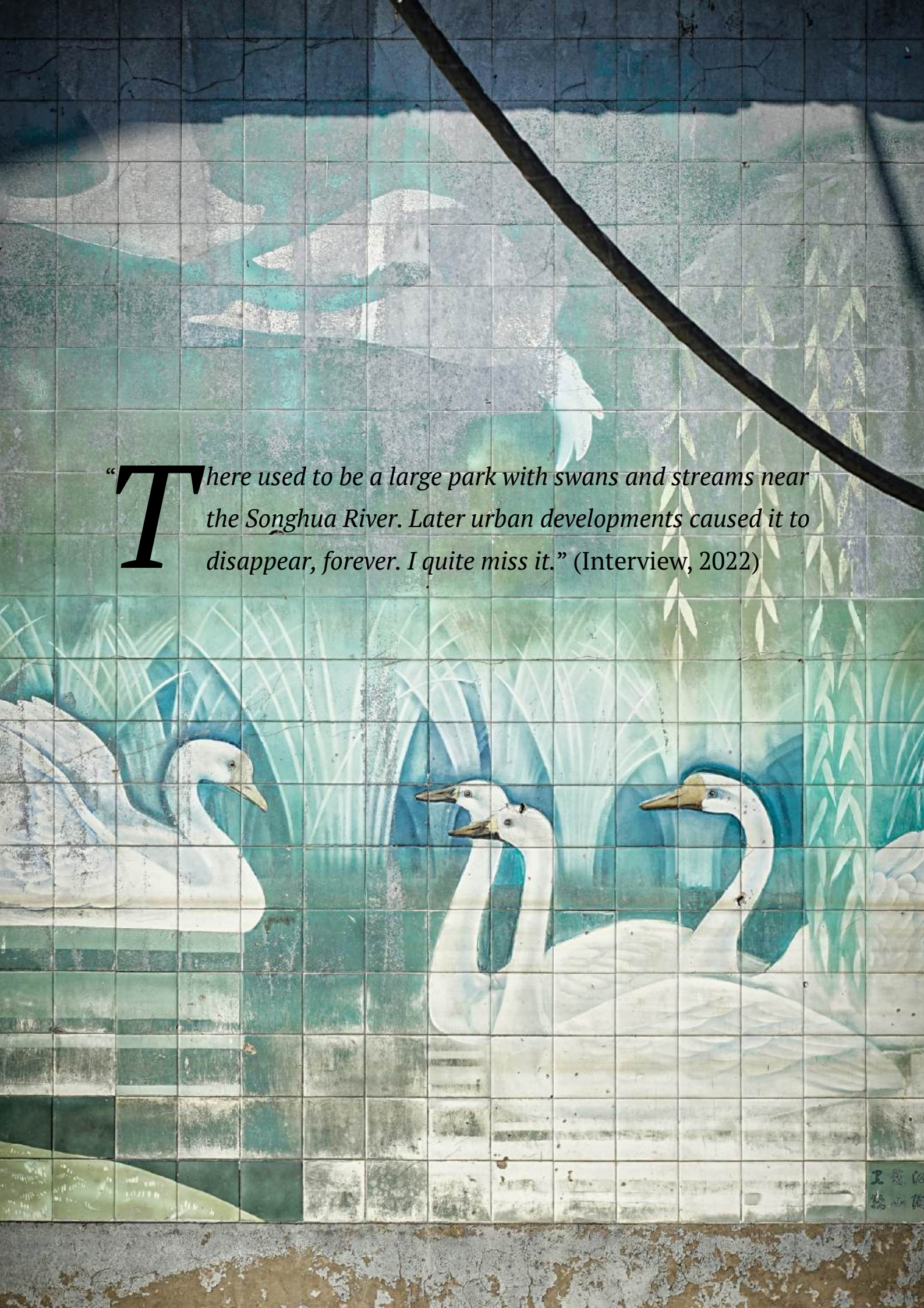
Term	Estimate	Std. Error	z value	Pr(>|z|)
-3 | -2	2.370469	0.981088	2.416165	0.015685
-2 | -1	3.827041	0.973223	3.932337	8.41E-05
-1 | 0	4.334289	0.977676	4.433257	9.28E-06
0 | 1	5.118105	0.997426	5.131314	2.88E-07
1 | 2	5.884378	1.020102	5.768418	8E-09
2 | 3	7.404408	1.062202	6.970807	3.15E-12
Housing	0.173021	0.126617	1.366495	0.171784
Markets & malls	0.060884	0.134403	0.452992	0.650555
Jobs & income	0.201332	0.082117	2.451759	0.014216
Medical facilities	0.035885	0.111171	0.322788	0.746856
Educational facilities	-0.22111	0.116778	-1.89344	0.0583
Ecosystem goods	0.071234	0.082505	0.863384	0.387926
Social activities in nature	0.260019	0.092373	2.814888	0.004879
Beauty of nature	0.423253	0.075417	5.612203	2E-08
Air quality	0.004597	0.120631	0.038104	0.969605
Flood control	-0.04864	0.124239	-0.39154	0.695402
Natural knowledge	0.062542	0.091521	0.683365	0.494376
Gender (male)	-0.26477	0.220403	-1.20128	0.229643
Age	0.017275	0.136056	0.12697	0.898964
Education	0.191653	0.123141	1.556373	0.119619
Income	-0.13769	0.125526	-1.09694	0.272666
Agriculturist	-1.86868	0.50008	-3.73676	0.000186

Table D.4: Results of ordinal regression analysis on socio-demographic characteristics associated with perceptions of fairness (economic aspects).

Term	Estimate	Std. Error	z value	Pr(>|z|)
-3 | -2	-3.3449	0.394531	-8.47818	2.29E-17
-2 | -1	-2.56273	0.352889	-7.26215	3.81E-13
-1 | 0	-1.90658	0.334877	-5.69339	1.25E-08
0 | 1	-1.04628	0.324986	-3.21946	0.001284
1 | 2	-0.27532	0.322846	-0.85279	0.393775
2 | 3	1.089386	0.324729	3.354754	0.000794
Gender (male)	-0.20999	0.132855	-1.58059	0.113971
Age	-0.07144	0.077085	-0.92671	0.354077
Education	0.07191	0.064789	1.109914	0.267036
Income	0.138744	0.072651	1.909723	0.056169
Agriculturist	0.424363	0.343077	1.236934	0.216112
Original resident	0.656925	0.150218	4.373145	1.22E-05

Table D.5: Results of ordinal regression analysis on socio-demographic characteristics associated with perceptions of fairness (ecological aspects).

Term	Estimate	Std. Error	z value	Pr(>|z|)
-3 | -2	-2.00715	0.322717	-6.21953	4.99E-10
-2 | -1	-1.35631	0.309729	-4.37903	1.19E-05
-1 | 0	-0.79067	0.303874	-2.60198	0.009269
0 | 1	-0.41697	0.30199	-1.38073	0.167361
1 | 2	0.45518	0.301686	1.508789	0.131353
2 | 3	1.974199	0.308006	6.409619	1.46E-10
Gender (male)	-0.18696	0.118081	-1.58333	0.113345
Age	0.390567	0.070351	5.551711	2.83E-08
Education	0.141821	0.057362	2.472404	0.013421
Income	0.068631	0.05789	1.185551	0.2358
Agriculturist	0.282557	0.289659	0.975484	0.32932
Original resident	-0.62076	0.140026	-4.43313	9.29E-06



"*There used to be a large park with swans and streams near the Songhua River. Later urban developments caused it to disappear, forever. I quite miss it.*" (Interview, 2022)