TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Engaging the unengaged

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Engaging the unengaged: Exploring citizen participation in nature-based solutions in China

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Li Dai
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DEPARTMENT OF THE BUILT ENVIRONMENT

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

The pressing unsolved environmental issues such as super-storms, floods, droughts, and heatwaves have become a critical challenge in many Chinese cities, including metropolises like Beijing and Guangzhou. The severe climate-related risks result in economic losses and threaten citizens' life safety, decreasing urban resilience, sustainability, and liveability.
The recurring urban disasters have raised considerable concerns and reflections over current urban development strategies, and a "low-impact development" strategy is highly advocated by experts and researchers. Against this backdrop, nature-based solutions, a vital component of the urban low-impact development method, have received extensive attention to address increasing socio-environmental challenges.
However, efforts to adopt, implement and diffuse nature-based solutions can confront various barriers and fail to achieve the expected results. One of the dominant barriers is a lack of public awareness and engagement. Upscaling nature-based solutions projects require integrated, coordinated, and multifaceted strategies involving a wide range of citizens to co-design and co-create at the neighbourhood level. The externalities caused by these projects, such as visual landscape degradation, land acquisition, and inconvenience, often incite public opposition and protest, threatening project success and social stability. Although making citizens' voices heard has become legally indispensable in China, citizen participation in the decision-making process of nature-based solutions is still "in its fancy."
Therefore, this thesis aims to deepen the understanding of citizen participation in the nature-based solutions decision-making process within the Chinese context and contribute to future participatory design and planning suggestions.

DEPARTMENT OF THE BUILT ENVIRONMENT

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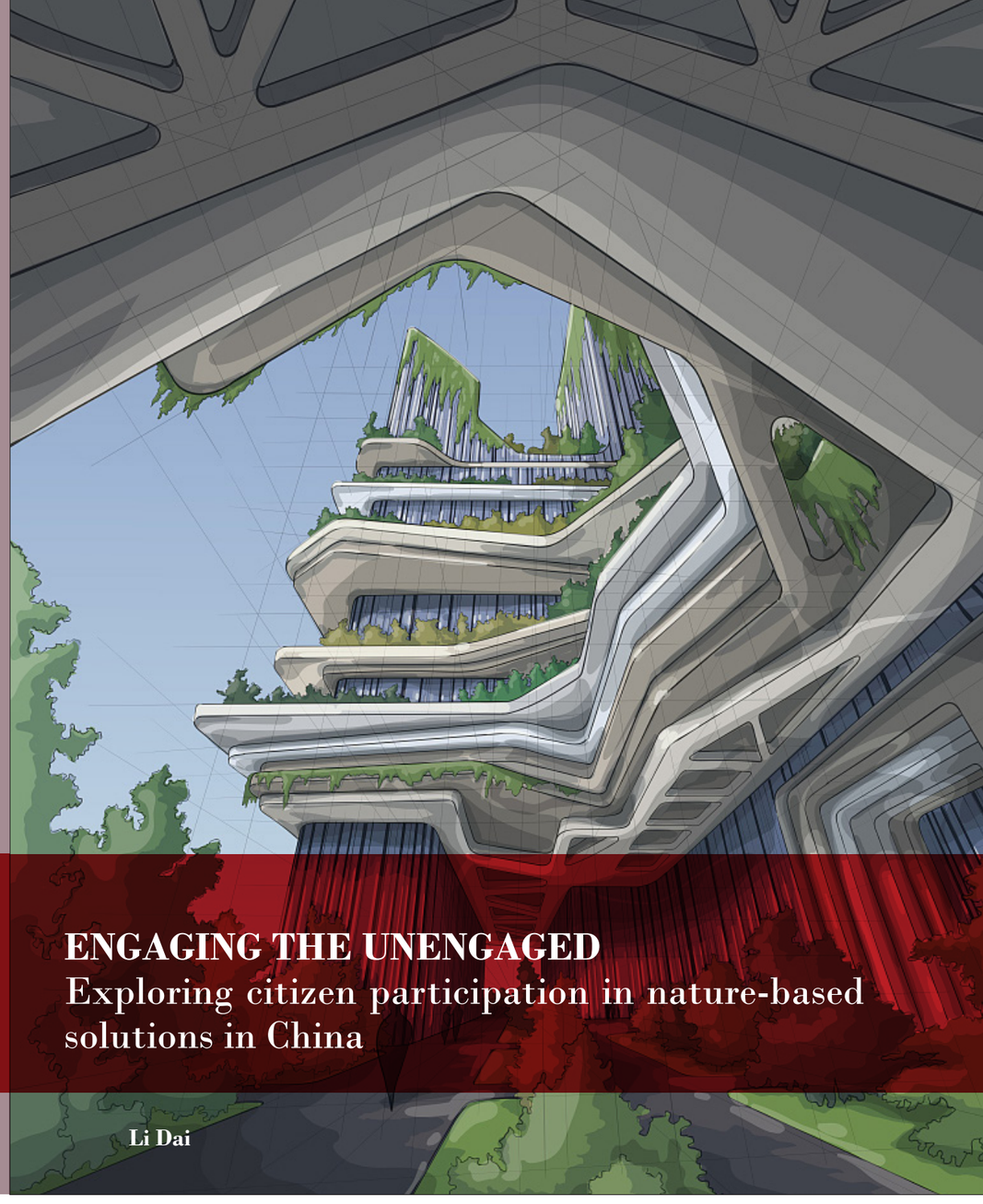

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Eindhoven, October 2022

Summary

The pressing unsolved environmental issues such as super-storms, floods, droughts, and heatwaves have become a critical challenge in many Chinese cities, including metropolises like Beijing and Guangzhou. The severe climate-related risks result in economic losses and threaten citizens' life safety, decreasing urban resilience, sustainability, and liveability. The recurring urban disasters have raised considerable concerns and reflections over current urban development strategies, and a "low-impact development" strategy is highly advocated by experts and researchers. Against this backdrop, nature-based solutions (NBS), a vital component of the urban low-impact development method, have received extensive attention to address increasing socio-environmental challenges. However, efforts to adopt, implement and diffuse NBS can confront various barriers and fail to achieve the expected results. One of the dominant barriers is a lack of public awareness and engagement. Upscaling NBS projects require integrated, coordinated, and multifaceted strategies involving a wide range of citizens to co-design and co-create at the neighbourhood level. The externalities caused by these projects, such as visual landscape degradation, land acquisition, and inconvenience, often incite public opposition and protest, threatening project success and social stability.

Although making citizens' voices heard has become legally indispensable in China, citizen participation in the decision-making process of NBS is still "in its fancy." It was observed that the lack of citizen participation could be exclusively attributed to the local government's predominant or even exclusive role in the decision-making process. However, for citizen participation to happen, citizens' response is largely overlooked. How do citizens respond to the uptake and implementation of NBS in their neighbourhoods? If participation is so rewarding and effective, why does not everyone participate? What factors affect citizens' participation in the decision-making process, and how? These questions remain unheeded and unsolved. Therefore, this thesis aims to deepen the understanding of citizen participation in the NBS decision-making process within the Chinese context and contribute to future participatory design and planning suggestions.

The PhD research began by exploring how citizens react to the uptake and implementation of NBS in their neighbourhood and what factors affect their acceptance. An assessment framework is built to examine key determinants for NBS community acceptance of citizens. There are three vital perspectives to be understood in the framework: the public, government, and project management perspectives. The project-related variables refer to the features associated with the NBS project, including the function, site selection, and proposed project design. These factors represent the proposed project's details from different aspects, which could significantly affect citizens' perceptions and attitudes. The government's dominant position in the NBS implementation makes it impossible to ignore the government's actions. In this framework, the government-related variables are expected to measure practitioners' activities in planning and implementing the new NBS. Community acceptance is significantly affected by different personal characteristics. The public-related variables mainly refer to citizens' preferences and attitudes toward NBS based on their knowledge and belief. The assessment provided an overview of the state of the practice of NBS projects in China. It identified that government- and project-related factors are more likely to influence community acceptance of NBS. These factors include the availability of feedback and information from the government perspective and project design and location from the project management perspective. Only one public-related factor is identified to influence community acceptance significantly, namely, personal experiences. In addition, this assessment found that a large portion of citizens belongs to the silent majority who hold neutral views towards NBS. The findings reveal that citizens' concern for NBS projects has remained woefully limited. Based on the participatory decision-making theory, the insufficient concern is not conducive to project success and sustainability.

Fully understanding citizen participation also requires an intensive exploration of citizens' willingness to participate in the second step of the research. Therefore, based on the extended theory of planned behaviour (TPB), the status quo of citizens' willingness to participate was revealed, and how different socio-psychological factors affect citizens' willingness to participate in the decision-making process of NBS was investigated. The findings revealed that (1) the low willingness to participate

hampered citizen participation, and a large portion of citizens hold a low level of willingness belonging to the unengaged. (2) social influence, perceived benefits, and perceived enablers are three significant variables directly affecting willingness to participate, while personal characteristics, information acquisition, and consultation channels indirectly influence willingness to participate. (3) The adverse effects of social influence mediate the positive impact of information acquisition and consultation channels on perceived benefits and enablers, finally contributing to a low willingness to participate.

Finally, a novel agent-based model (ABM) reinforced by the extended TPB model is developed to simulate how citizens make decisions that shape participation behaviours and evaluate the potential impacts of different interventions on their participatory behaviours. The simulation results showed that reliance on the formal network led by the local government could increase the participation rate of the neighbourhood. In contrast, dependency on the informal network based on social networks and information dissemination has significant negative impacts. Methodologically, the study showed that ABM could capture complex emergent behavioural patterns and provide valuable insights into participatory behaviours in NBS.

The overall conclusion of this research is that citizens should be thoroughly involved in NBS to achieve community acceptance and project sustainability rather than saying yes or no in the feasibility study. The thesis also highlights the following: (1) there is an urgent need to underline the equal representation of the silent majority. (2) local government should be responsible for initiating and guiding the unengaged in participating in NBS due to their dominant position. (3) local government should improve the efficiency of information dissemination and consultation service to avoid citizens' reliance on the informal network. Notably, Chinese citizen participation in NBS continues to focus on informing citizens and lacks a standpoint for more profound levels of participation. The complicated social, political, cultural, and environmental situation in China requires a contextual and inclusive methodology to balance the informal and formal networks and better facilitate participation in NBS.

List of Abbreviations

ABM	Agent-based model
AUC	The area under the ROC curve
BBN	Bayesian Belief Network
BI	Behavioural intention
CPTs	Conditional probability tables
CFA	Confirmatory Factor Analysis
CC	Consultation channels
CB-SEM	Covariance-based SEM
DAG	Directed acyclic graph
GTT	Greedy Thick Thinning
GHG	Greenhouse gas
IA	Information acquisition
IUCN	International Union for the Conservation of Nature
EIA	Environmental impact assessment
E.U.	European Union
NBS	Nature-based solutions
NIMBY	Not in my backyard
PLS-SEM	Partial least square SEM
PRISMA	*Preferred Reporting Items for Systematic Reviews*
PB	Perceived benefits
PE	Perceived enablers
PCS	Personal Characteristics
ROC	Receiver operating characteristic

STP	Silent to participate
SI	Social influence
SCP	Sponge city projects
SEM	Structural equation modelling
TPB	Theory of planned behaviour
UICP	Urban infrastructure and construction projects
ULL	Urban living labs
UTP	Unwilling to participate
VBN	Values-beliefs-norms
WTP	Willingness to participate

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Cities are emerging as the main "human habitats" (Seto and Reenberg, 2014). Observers have suggested that urbanization has been most pronounced in developing economies, especially in Asia and Oceania, over the last ten years, with an urbanization rate increase from 43.1 in 2010 to 49.8 per cent in 2020[1]. It is predicted that over 66% of the world's population is projected to be urban by 2050, and now the number is only 54%. In developing countries, the growth of the urban population is even more pronounced and has been an irreversible trend. For example, China stands out among developing countries in urbanized societies, and the urban population has increased at an annual rate of 2.5 per cent over the period 2015 to 2020[1]. However, the carrying capacity, or in other words, the urban ecosystem, of a city is often limited. The rapid growth of the urban population means that the cost of living in the city, such as the costs of shelter and services, increases dramatically, and the demand for serviced residential sites exceeds the supply of suitable land. Therefore, urban expansion, characterized by land transitioning from rural areas into urban spaces (hardened roads), inevitably leads to the reduction of ecosystem services and the depletion of natural resources.

On the other hand, the expansion of urban areas implies increased energy consumption, and the relevant greenhouse gas (GHG) emission is expected to grow faster. The new climate economy report says that cities are currently responsible for 67–72% of global GHG emissions, with 67–76% of international energy use (Intergovernmental Panel on Climate Change, 2022). The range of collateral

[1] https://hbs.unctad.org/total-and-urban-population/#:~:text=All%20over%20the%20world%2C%20a,world%20(51.6%20per%20cent).

problems is multiplying, such as increased environmental issues like urban flooding, droughts, and heatwaves in urban areas.

Many developing countries have experienced recurring urban disasters in the past few years. These climate-related risks have severely undermined urban resilience and sustainability and posed a serious threat to citizens' life safety and property value. For example, in mid-July 2021, Zhengzhou suffered disastrous flooding, attributed to a prolonged period of heavy rainfall and fragile urban ecosystem, resulting in an economic loss of over €7.4 billion and the death of 292 people[2]. Developed countries are also facing the challenges of urban environmental issues. Severe urban floods in mid-July 2021 killed at least 220 people in Germany and Belgium[3]. These recurring urban disasters have raised concerns and reflections on current urban development strategies (Arlati, Rödl, Kanjaria-Christian, & Knieling, 2021). Against this backdrop, nature-based solutions (NBS) for sustainable urban development are highly advocated as a critical component of the urban "low-impact development" strategy in China and other countries. NBS aims to address socio-environmental challenges that no country can afford to ignore (Li, Qin, & Du, 2019; Qi et al., 2020).

However, the adoption, implementation, and diffusion of NBS usually involve a wide range of aspects and can confront various barriers. As a complex system, upscaling NBS projects requires integrated, coordinated, and multifaceted strategies involving a wide range of citizens to co-design and co-create at the neighbourhood and district levels. In many cases, lack of citizen awareness and support has been perceived as the leading barrier hampering the adoption of NBS smoothly. For example, in China, the government-led top-down decision-making style still prevails in most cities, and citizens' voices are largely excluded or marginalized in the decision-making process despite their paramount role in ensuring successful NBS implementation and maintenance (Lechner et al., 2020). While sufficient and meaningful insights into the co-benefits and barriers to the uptake and implementation of NBS have been provided

[2] https://en.wikipedia.org/wiki/2021_Henan_floods

[3] https://edition.cnn.com/2021/08/23/europe/germany-floods-belgium-climate-change-intl/index.html

in recent studies (Giordano, Pluchinotta, Pagano, Scrieciu, & Nanu, 2020; Liquete, Udias, Conte, Grizzetti, & Masi, 2016; Raymond et al., 2017; Sarabi et al., 2021), limited information about how citizens act and change their participatory behaviours in NBS projects is available. Hence, a profound understanding of citizen participation in the adoption and implementation of NBS is indispensable and essential for effectively developing and maintaining NBS, thus, for sustainable urban development.

1.2 Research questions

This research revolves around citizen participation in developing and maintaining NBS projects. It is oriented toward analysis of the status quo, determinants, and participatory behaviours rather than dwelling on the design of citizen participation for practice. To provide precise information for citizen participation in NBS adoption and implementation, one central question needs to be answered:

How can citizen participation in NBS projects be understood, assessed, and enhanced under recurring climate-related risks in China?

The following sub-questions have been formulated to answer the main question that is described above:

- How is community acceptance of NBS projects in China, and what are the determinants?
- What is the current state of citizen participation in NBS projects within the Chinese context?
- What are the factors affecting willingness to participate in NBS projects in China, and how?
- How do citizens make decisions that shape participatory behaviours in the case of Guyuan?
- How can different interventions enhance citizen participation in NBS projects in the case of Guyuan?

1.3 Aims and Objectives

Based on problem statements, this thesis aims to deepen the understanding of citizen participation in the NBS adoption and implementation in China and contribute to recommending strategies for future participatory research and practice. The findings of the PhD research can foster inclusive, transparent, and effective citizen participation in NBS within a Chinese context. In this thesis, the following objectives need to be achieved.

Firstly, a systematic investigation, including field trips and literature review, needs to be conducted to understand the status quo of citizen participation in NBS adoption and implementation in China. The inquiry on citizen participation in NBS should strike a balance between a global perspective and a Chinese context. The primary objective of the investigation is to provide an insightful assessment of the current situation, including research status, of citizen participation in NBS adoption and implementation within a Chinese context and identify the main sticking point for amplifying citizen participation.

Secondly, a set of critical factors needs to be identified and integrated to explore the impacts on community acceptance of NBS projects. The selected factors mainly consist of the public-related elements about public experience, knowledge, and perception of the proposed projects, the project-related elements about project function, site selection, and design, and the government-related elements about availability of information, availability of feedback, emergency measures, and fulfilment commitment. With the help of the Bayesian Belief Network (BBN) approach, the factors that significantly impact community acceptance of NBS projects will be filtered. The exploration of community acceptance will help better understand the current situation of NBS projects at the community level in China.

Thirdly, an investigation of the relationships between willingness to participate and citizens' socio-psychological characteristics needs to be established. The exploration will reveal how individuals shape their participatory behaviours based on the extended theory of planned behaviour. The cause-and-effect relationships underlying

behavioural intentions will be highlighted. The results will provide fundamentals for the following analysis.

Finally, a simulation will be conducted to understand citizens' behavioural changes in participating in NBS projects. The simulation results should be able to uncover the emerging participatory pattern of the whole and investigate the impacts of different interventions on citizens' participatory behaviours. The simulation findings can support predictions of new policy effects for planning citizen participation in NBS adoption and implementation and provide theoretical support for designing participatory decision-making.

1.4 Research contributions

The PhD research seeks to fully comprehend, assess, and facilitate citizen participation in NBS adoption and implementation within a Chinese context. The findings are likely to contribute to the existing knowledge of citizen participation in NBS adoption and implementation in two aspects.

Firstly, this research reveals novel findings that bridge the gaps in current research on citizen participation within a Chinese context. Focusing on willingness to participate, this study identified the unengaged with older age, low education, and income levels. The unengaged are the citizens with a humble willingness to participate in the NBS adoption and implementation. This discovery provides a new perspective for current research on citizen participation in NBS projects.

Secondly, this research hopefully contributes to understanding how citizens make decisions that shape their participatory behaviours in dynamic socio-economic, legal, and cultural settings. By integrating agent-based modelling (ABM) and the theory of planned behaviours (TPB) model, this study contributes to understanding the dynamics of participatory behaviours from the micro- to the macro-level. The extended TPB model reveals how different socio-psychological factors shape individual behaviour and could provide a theoretical underpinning for the agent in the ABM. From a theoretical perspective, the combination of ABM and the extended TPB enlarges the predictive ability of the TPB model and could simulate the

involvement and interactions dynamically. Traditionally, the research on citizen participation is static-oriented, failing to reflect citizens' participatory behaviour changes. The simulation results make it possible to provide well-founded references for decision-makers and urban planners to enhance citizen participation in NBS adoption and implementation.

1.5 Outline of the PhD thesis

The outline of the PhD thesis is illustrated in Figure 1. The PhD dissertation consists of six chapters composed of four main research content chapters based on four journal articles (Chapters II and V are under review, while Chapters III and IV are published) and two supplementary chapters explaining the research incentives and conclusions. Chapter I has briefly introduced the motivations, objectives, and contributions of the research. Chapter II exhibits a systematic literature review on citizen participation in NBS projects. This part identifies the characteristics and problems of Chinese citizen participation by examining academic publications from a global perspective.

Chapter III first investigates citizens' acceptance of NBS projects in their neighbourhood and explores key determinants for community acceptance. Community acceptance stands for citizens' impression of the benefits that new NBS technologies or circularity initiatives bring to their respective neighbourhoods. Scholars have shown that the divergence of co-benefits perception and valuation might result in various degrees of acceptance of different stakeholders, thus, hindering the adoption and implementation of NBS. The public, government, and project management perspectives are combined to examine the factors influencing NBS acceptance at the community level. A BBN approach reveals the cause-and-effect relationships between various factors and community acceptance.

Chapter IV focuses on citizens' willingness to participate in citizen participation for NBS adoption and implementation. Willingness to participate suggests potential attendant actions, reflecting citizens' psychological tendency toward participatory behaviour and concerning an essential precondition for effective participation. This study extended the theory of planned behaviour (TPB) model by including additional

variables to reveal the factors influencing willingness to participate and investigating how these factors influence willingness to participate through structural equation modelling (SEM).

Chapter V presents a novel agent-based model (ABM) reinforced by the extended TPB to simulate how citizens make decisions that shape their participation behaviours and evaluate the potential impacts of different interventions on participatory behaviours. This part applies the empirical results of Chapter IV. The path models identified in Chapter IV that interpret how socio-psychological factors shape individuals' behaviours from the extended TPB model were set as an empirical anchor for agent model specification by defining the decision criteria.

Chapter VI is the final chapter of this thesis. It summarizes the preceding chapters and concludes with the answers to all research questions of this research. It also reflects upon the broader meaning and implications of this empirical study. Finally, recommendations for policy and future research are presented.

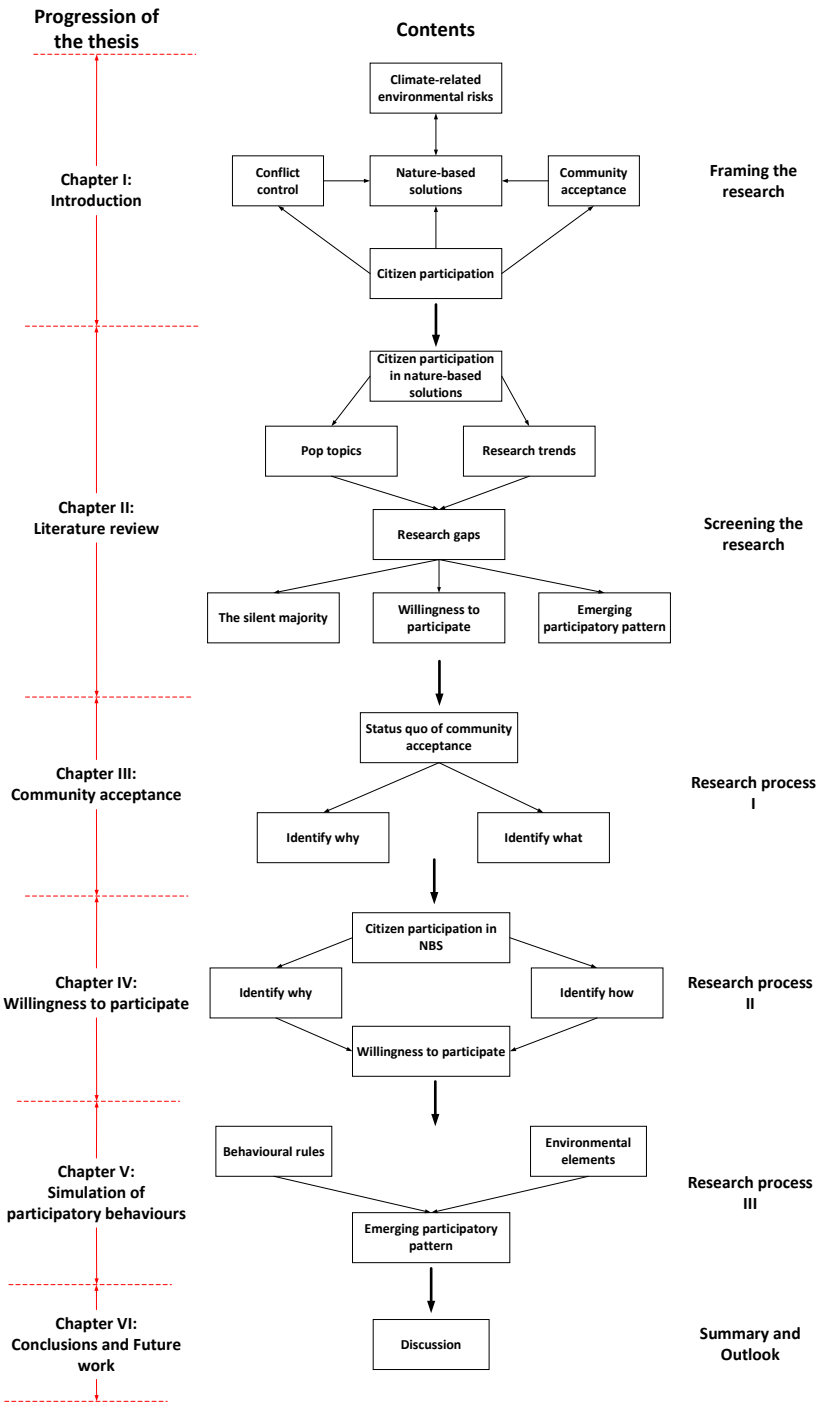

Fig. 1 Outline of the PhD thesis

CHAPTER 2
UNDERSTANDING CITIZEN PARTICIPATION IN NATURE-BASED SOLUTIONS: A SYSTEMATIC REVIEW

This chapter is prepared as:

Understanding citizen participation in nature-based solutions: a systematic review. Dai, L., Han, Q., & de Vries, B., Feb 2022, In *Habitat International*. (**Under Review**)

Abstract: Nature-based solutions are emerging with the increasing climate and environmental challenges. Nature-based solutions use natural components and their multiple functions to enhance sustainable development in the cities. The remaking natural environment must embrace citizens' ideals, which can only be achieved if effective involvement methods are ensured. With citizens' voices in the decision-making process widening, citizen participation is increasingly important in creating trust in decision-making results and facilitating project success and sustainability. Against this background, this literature review aims to provide an in-depth understanding of the current state of the art in citizen participation in nature-based solutions. Based on the SCOPUS database, 85 papers are finally identified and analyzed. The results uncovered that citizen participation in nature-based solutions is increasingly promising. However, existing studies tend to focus on limited domains, such as barriers, benefits, and levels of involvement, and stay short of paying close attention to citizens' perceptions and willingness. Finally, the systematic literature review ends by identifying future participation research directions.

Keywords: citizen participation; willingness to participate; the unengaged; nature-based solutions

2.1 Introduction

Providing citizens with a better living environment is the goal of urban development. However, the rapid urbanization process accompanied by climate changes has

resulted in an increased occurrence of environmental risks, such as super-storms, floods, and heatwaves, threatening the resilience and sustainability of the urban social ecosystem (Abebe, Kabir, & Tesfamariam, 2018; Jiang, Zevenbergen, & Ma, 2018). For example, these years, flooding in urban areas has been a common natural disaster in many Chinese cities, including metropolises such as Guangzhou and Beijing (Huang et al., 2018; Wang et al., 2020). This phenomenon causes economic losses and poses a severe threat to citizens' life and property safety. Prevalent urban flooding and other urban environmental issues are of grave concern, and there is an urgent requirement for sound, steady, and sustainable urban development. Against this background, nature-based solutions, using natural components and their multiple functions to enhance sustainable development in the cities, are merging (Essl & Mauerhofer, 2018; Faivre, Fritz, Freitas, de Boissezon, & Vandewoestijne, 2017).

Nature-based solutions (NBS) refer to "actions that work with and enhance nature to help people adapt to socio-environmental changes and disasters" (Kabisch, Korn, Stadler, & Bonn, 2017). It aims to build urban resilience and maintain sustainability within urban areas by effectively remaking nature and is beneficial for the sustainable development of the urban social ecosystem. A significant number of studies have discussed NBS from different perspectives since it is proposed, particularly in the era when citizens are generally negatively affected by environmental risks with climate change. NBS is initially generated from the ecosystem-based approaches that settle environmental risks in urban areas and are guided by NBS development; urban developers are encouraged to build urban resilience through remaking nature (Sarabi, Han, Romme, Vries, & Wendling, 2019). With prosperity in urban development, research has come to a dramatic expansion on the connotation of NBS. International Union for the Conservation of Nature (IUCN) suggests considering NBS as an umbrella concept as it is considerably overlapped with other related concepts such as "green infrastructure," "urban green space," and "ecosystem-based adaptation" (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016; Kabisch et al., 2016; (Pauleit, Zölch, Hansen, Randrup, & Konijnendijk van den Bosch, 2017). While IUCN defines NBS as actions to respond to societal challenges that "*protect, sustainably manage and restore natural or modified ecosystems that address societal challenges*

effectively and adaptively, simultaneously providing human well-being and biodiversity," European Union (E.U.) states that NBS are actions "inspired by, supported by or copied from nature and which aim to help societies address a variety of environmental, social and economic challenges in sustainable ways" (European Commission, 2015). In current literature, experts and scholars tend to adopt the E.U.'s definition as it is a more comprehensive concept and aims to maintain balances between environmental protection, economic promotion, and social benefits of NBS (Albert et al., 2019; Blau, Luz, & Panagopoulos, 2018; Davies & Lafortezza, 2019; Denjean et al., 2017; Faivre et al., 2017; Hoyle, Jorgensen, Warren, Dunnett, & Evans, 2017; van der Jagt et al., 2017). Their studies further elaborate and supplement the connotations, types, and forms of NBS based on the definitions of IUCN and the E.U. Meanwhile, these studies explore co-benefits, effects, challenges, knowledge gaps, and criteria of NBS developments from different perspectives, which improves current research on NBS (Albert, Spangenberg, & Schröter, 2017; Faivre et al., 2017; Kabisch et al., 2016; (Liquete, Udias, Conte, Grizzetti, & Masi, 2016; Raymond et al., 2017; Rizvi, Baig, & Verdone, 2015; Thorslund et al., 2017; Wild, Henneberry, & Gill, 2017). However, the complementary NBS in a broader urban development category results in frequently heated controversies around NBS (Nesshöver et al., 2017). To some extent, these controversies hinder the application of NBS development. In reality, for different purposes in urban development, NBS derived many new concepts in recent years, such as "green cities" and "sponge cities" (Chan et al., 2018; Fan et al., 2017). These derived concepts or approaches play an important role in sustainable urban management and contribute to the research of NBS conceptually and practically. For example, Sarabi et al. (2019) found that urban flooding control research is the mainstream of NBS research in the face of frequent stormwater issues in urban areas worldwide.

However, the uptake and implementation of NBS have not always been smooth as designed and may encounter many challenges, such as lack of awareness and support. Usually, the trade-offs between economic development, social benefit, and environmental protection made by citizens in NBS often result in heated debates about the social effects (Haase et al., 2017). The unequal distributions of costs and

benefits of NBS inevitably raise citizen resistance to NBS as the proposed projects that benefit one district may negatively impact next door (Wachsmuth, Cohen, & Angelo, 2016). Citizens may have different preferences and attitudes towards designing and implementing NBS based on their knowledge and belief. When citizens boycott NBS locally, economic losses, social tensions, and conflicts result (Stigka, Paravantis, & Mihalakakou, 2014). The divergence of interests between the citizens and the government on NBS is an irreconcilable conflict because these projects are usually socially beneficial but locally undesirable (Krause, Carley, Warren, Rupp, & Graham, 2014). For example, citizens are still concerned about the external effects of NBS in their neighbourhood, which may threaten citizens' life, health, and property values. With the awakening of citizens' rights and environmental awareness, their perceptions of NBS are becoming increasingly critical and often contribute to solid support for the state's development agenda (Liu, Liao, & Mei, 2018; Zeng, 2014). Therefore, the design of NBS should embrace the individual ideals of citizens, and in addition, this can only be achieved if effective methods of involvement are ensured.

Citizen participation in urban infrastructure and construction projects (UICP) is not new and has been widely acclaimed for increasing awareness, community acceptance, decision-making fairness, transparency, and, ultimately, sustainability (Johnson & Scicchitano, 2009; Mubita, Libati, & Mulonda, 2017; Uittenbroek, Mees, Hegger, & Driessen, 2019). Citizen participation could provide "an open and transparent manner" for all stakeholder groups to negotiate and exchange information between decision-makers and citizens (Bottini, 2018; Day, 2017; Li, Krishnamurthy, Pereira Roders, & van Wesemael, 2020; Sadiqi, Trigunarsyah, & Coffey, 2017). In recent decades, citizen participation has been incredibly advanced and is legally required in the environmental impact assessment (EIA) process in some countries like the Netherlands and China. Participation allows different stakeholder groups to collaborate in making collective decisions and sharing responsibilities. Therefore, many studies unanimously asserted that citizen participation is "an important component" for achieving the goals of the decision-making process and is paramount for project success (Balram & Dragićević, 2005; Glucker, Driessen, Kolhoff, &

Runhaar, 2013; Li, Thomas Ng, & Skitmore, 2012; Wu, Jia, & Mackhaphonh, 2019). However, studies that explicitly delve into the applications, benefits, or participation levels in the NBS governance domain are scarce. As reported in some literature, the involvement of major stakeholder groups in NBS is yet to mature (Kiss et al., 2022; Kotsila, Hörschelmann, Anguelovski, Sekulova, & Lazova, 2020). In most developing countries, citizen participation is still "in its fancy" (dell'Olio, Ibeas, de Oña, & de Oña, 2019; Johnson, 2020; Wei, Liu, Skibniewski, & Balali, 2016). The underrepresentation of the marginalized citizens may be exploited, thus reducing the long-term sustainability of NBS projects (Cardullo & Kitchin, 2019). Citizen participation is initiated to settle disputes and achieve a "mutually acceptable solution" in project governance between multiple stakeholder groups through thorough communication (Li, Thomas Ng, & Skitmore, 2016). The reality, however, is that citizen participation is widely criticized for its limited role in incorporating comments of different stakeholder groups, especially the opinions of the affected citizens (Bond, Palerm, & Haigh, 2004; Cuppen, Broekhans, & Enserink, 2012; Enserink & Koppenjan, 2007). Authorities are cynical about the value of consulting citizens in NBS decision-making, while the affected suspect the effectiveness of participation (Glucker, Driessen, Kolhoff, & Runhaar, 2013; Hartley & Wood, 2005; YANG, 2008). Moreover, the involvement of multiple stakeholder groups denotes more complicated interest relationships and complexities in reaching agreements. With this in mind, decision-makers are afraid that involving various actors may decrease the efficiency of the design and implementation process of NBS projects; even more, resulting in project failures (Wang, Liu, Zuo, & Rameezdeen, 2019; Xie, Yang, Hu, & PC Chan, 2014; Zou, Zhang, & Wang, 2007). On the other hand, concerning the vulnerabilities of citizens in NBS governance, citizens do not think their weak voices can make a difference in the final decision and, therefore, appear unwilling to participate. Although studies on citizen participation have been prevalent these few decades, discussions in NBS governance are still under-explored. Therefore, a thorough but concise rethink of current citizen participation research in NBS governance is desired.

This study aims to provide a systematic rethink and review of citizen participation in NBS by exploring the nexus between the involvement and NBS and identifying the current state of the art in NBS participation. This review expects to identify current research gaps in citizen participation in NBS and, more importantly, enhance effective citizen participation in NBS governance.

2.2 Materials and Methodologies

In this literature review, Scopus was used to search and review related publications on citizen participation in NBS. Scopus is an abstract and citation database. The possibility of easy navigation and broader coverage of various topics were the main advantages and reasons for using this research engine. This literature review is guided by the *Preferred Reporting Items for Systematic Reviews* (PRISMA).

The choice of publications is vital to verify the literature review's accuracy and be representative and observable. Correspondingly, the criteria for identifying the relevant publications included: (1) As citizen participation usually overlaps other terms, such as "public participation," "citizen involvement," "public involvement," "civic engagement," or "public engagement," a combination of strings is required to retrieve data to cover the research topic; (2) Similarly, NBS as an umbrella concept should cover other related terms, such as "green infrastructure," "biophilic infrastructure," "urban green space," or "urban forest"; (3) low-relevance publications should be eliminated from the research database. To this end, a four-step process was applied to search and select qualified publications. First, the combination of keywords ("nature-based solutions" OR "green infrastructure" OR "biophilic infrastructure" OR "urban green space" OR "urban forest") AND ("stakeholder" OR "citizen" OR "public" OR "resident" OR "community" OR "civic") AND ("participation" OR "engagement" OR "involvement") AND ("urban") was used as the research string in the TITLE-ABSTRACT-KEYWORDS fields without other limitations. The retrieval returned 538 documents. The preliminary search result demonstrates that citizen participation is a hot topic in the NBS field. Sorting by citation, these documents share important commonalities that elucidate the conceptual framework of citizen participation in NBS, such as the methods and

spectrums. Furthermore, 115 records were filtered out by source and document type. In this literature review, we aim to focus on the academic journal papers considering the high quality ensured by the peer-review and exclude the conference proceedings and books.

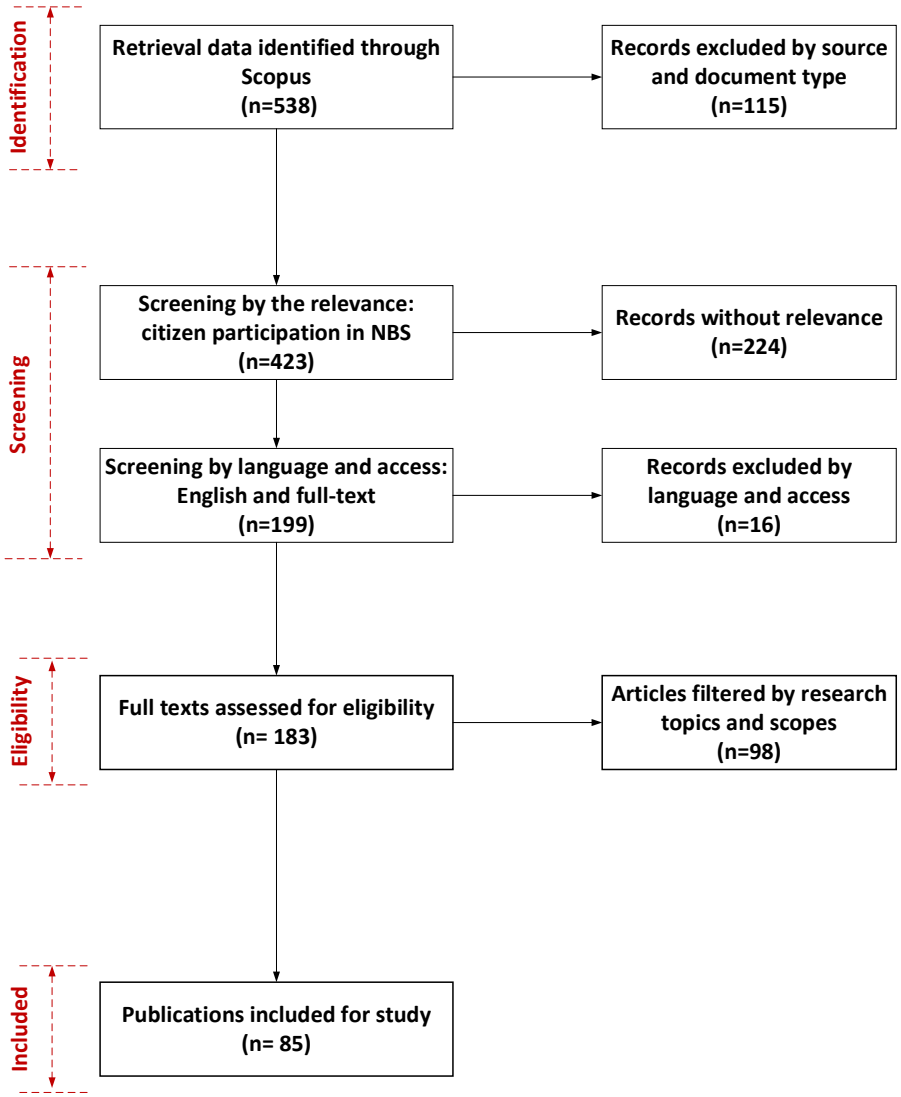

Fig. 2 Flowchart of the review process

Second, the retrieved documents were selected in English in full text, with 16 records eliminated. Third, another screening criteria are high relevance regarding citizen participation in the NBS domain. The publications on NBS, but not involve citizen participation were excluded from the review. A total of 85 papers were finally recorded concerning the research topics and scopes. Besides, the retrieving data was conducted on Feb. 16th, 2022. Figure 2 demonstrates the screening process guided by the PRISMA flow diagram.

2.3 Results of the review

This section traces the development of participation in NBS from temporal and geographical dimensions. It provides a parallel comparison of various research themes on citizen participation in NBS domains.

2.3.1 Temporal progression of participation research

The awareness of citizen participation was raised in the late 1960s and was first systematically elucidated by Arnstein in 1969. By propounding the "ladder of citizen participation" theory, Arnstein (1969) elaborated on the manners of power distributions between poor citizens and authorities through non-participation, tokenism, and citizen power. However, studies on citizen participation in NBS are relatively new. The search result showed that few studies mentioned citizen participation in NBS before 2000, and only in 1988, as displayed in Figure 3, appeared the first paper about citizen participation in the urban forests (McPherson & Johnson, 1988). However, citizen participation in NBS did not attract much attention from scholars and researchers in the following years. It was not until 2000 that another paper mentioned citizen participation in urban forests (Jim & Liu, 2000). After 2010, a growing number of studies on citizen participation in NBS emerged. With the increasing use of involvement as a norm in the sustainable development agenda, the term "nature-based solutions" related to citizen participation appeared for the first time in 2017 (van der Jagt et al., 2017). It is worth noting that NBS is an umbrella term continuously expanding, including urban forest, green infrastructure, biophilic infrastructure, and urban green space. In conclusion, the temporal progression of participation in research on NBS can be recognized into three major

phases: a fallow period with few studies in the 1980s-1990s; a development period with several studies in the 2000s; a period of expansion with the rapid growth of studies in the 2010s.

Figure 3 demonstrates a growing trend of publications on citizen participation in NBS, with a sharp increase in papers after 2010. This finding implies that citizen participation in NBS is becoming a topical issue in recent years.

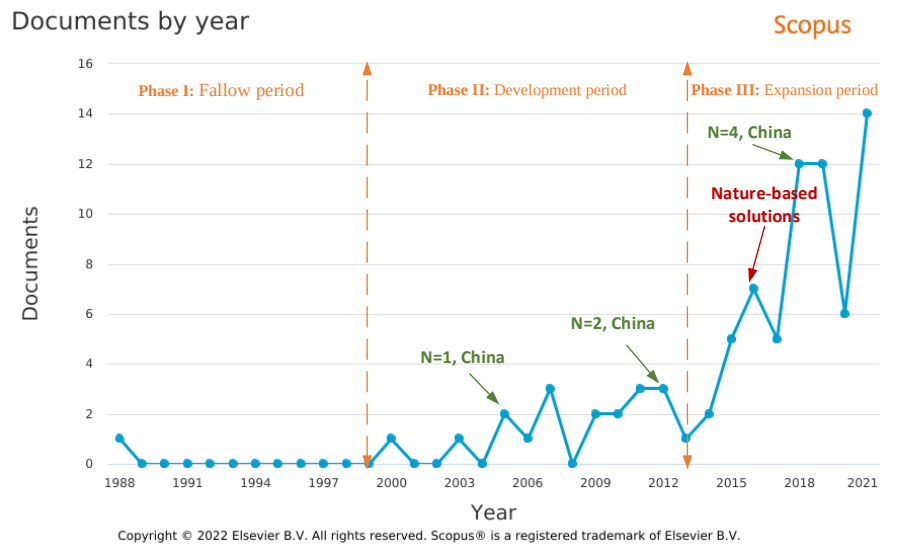

Fig. 3 Trends of the retrieved papers on citizen participation in NBS

2.3.2 Geographic distribution of participation research

The geographical distribution of the publications related to citizen participation in NBS projects is concentrated in developed and emerging developing countries. Figure 4 presents the geographic distribution of participation research on NBS by country. Among the retrieved data, a total of 10 countries (for countries with more than five case studies) were accounted for in the selected publications, encompassing mainly Europe (71 publications in seven countries) and North America (31 publications in two countries). Only one developing country, China, was on track to address citizen participation in NBS (for countries with more than five case studies).

Apparently, the developed countries (Europe and North America) play a leading role in researching citizen participation in NBS.

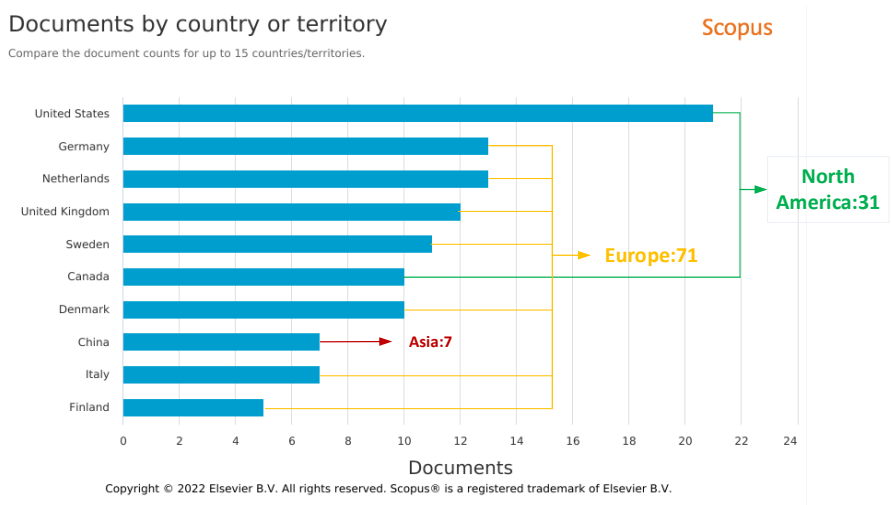

Fig. 4 The Geographic distribution of participation research on NBS by countries

2.3.3 Themes of participation research

The selected articles have covered various disciplines and topics. Citizen participation research in NBS is a promising interdisciplinary field. The scholars have explored citizen participation in NBS through a cross-disciplinary lens, such as a combination of social science and environmental science (Mok, Mačiulytė, Bult, & Hawxwell, 2021; Nunes, Björner, & Hilding-Hamann, 2021; Piga, Stancato, Rainisio, & Boffi, 2021). Concurrently, with improving the quality and quantity of the research, the academic research project and construction on citizen participation in NBS pushed the research on various themes into a new stage and presented some recent research trends, such as the research will be profound, comprehensive, and multidimensional (Dorst et al., 2022; Lupp et al., 2021; Su, Ren, Cui, Hou, & Wen, 2022). The retrieved results show that while some articles focused on the barriers, attitudes, and benefits of citizen participation, other studies focused on the analysis of the participatory process. In addition, current research on citizen participation in NBS could be divided into two main streams based on the research objectives: (a) aims to heighten perceptions of citizen participation in NBS; (b) aims to dissect the

participatory process to guide participatory behaviour in NBS. Table 1 demonstrates the division of the reviewed papers according to different research themes.

Table 1 shows the number of articles on different themes and further reveals the current research trends of citizen participation in NBS. More than half of the studies (61.25%) focused on analyzing citizens' perceptions regarding participation in NBS, trying to demonstrate the necessity and feasibility of involvement in NBS projects. The remaining body of articles (38.75%) focused on the participatory process in NBS, trying to design effective and efficient methods and tools to facilitate individual participatory behaviours. This result reflects current research trends and preferences and could enlighten scholars regarding future research directions.

Table 1 An overview of the selected articles based on different research themes

Themes	Sub-themes	Aims	Authors
Analysis of perceptions on citizen participation in NBS	Barriers	To identify the challenges of citizen participation implementation in NBS (n=12)	Dorst et al., 2022; Fors, Wiström, & Nielsen, 2019; Gulsrud, Hertzog, & Shears, 2018; Mattijssen et al., 2017; Miller, 2016; Zare, Namiranian, Feghhi, & Fami, 2015; Tian, Jim, & Tao, 2012; Green, Shuster, Rhea, Garmestani, & Thurston, 2012; Azadi, Ho, Hafni, Zarafshani, & Witlox, 2011; Hosseini, AzarKamand, & Lashgarara, 2011; Li, Wang, Liu, & Zhang, 2005; Zuniga-Teran et al., 2020
	Beliefs	To understand individual beliefs on citizen participation in NBS (n=16)	Jim & Chen, 2006; Zhang, Hussain, Deng, & Letson, 2007; Shan, 2012; Su, Ren, Cui, Hou, & Wen, 2022; Lupp et al., 2021; Piga, Stancato, Rainisio, & Boffi, 2021; Conway et al., 2021; Klein, Dove, & Felson, 2021; Lamond & Everett, 2019; Bissonnette et al., 2018; Younis et al., 2018; Alves, Gómez, Vojinovic, Sánchez, & Weesakul, 2018; Baur, Tynon, Ries, & Rosenberger, 2016; Barau, 2015; Conway & Yip, 2016; Moskell & Allred, 2013
	Benefits	To address the benefits and costs of citizen participation in NBS (n=21)	Cárdenas et al., 2021; Meyer et al., 2018; Trentanovi et al., 2021; Neumann & Hack, 2020; Wamsler, Wickenberg, et al., 2020; Wamsler, Alkan-Olsson, et al., 2020; Yao et al., 2019; Girma, Terefe, & Pauleit, 2019; Mabon, 2019; Girma, Terefe, Pauleit, & Kindu, 2019; Rall, Hansen, & Pauleit, 2019; H. Fors, Jansson, & Nielsen, 2018; Brink & Wamsler, 2018; Niță et al., 2018; Faehnle, Bäcklund, Tyrväinen, Niemelä, & Yli-Pelkonen, 2014; Baycan-Levent & Nijjkamp, 2009; Cvejić, Železnikar, Nastran, Rehberger, & Pintar, 2015; Mabelis & Maksymiuk, 2009; Nilsson et al., 2007; Balram, Dragicevic, & Meredith, 2003

Themes	Sub-themes	Aims	Authors
Analysis of the participatory process in NBS	Methods, tools, and guidelines	To analyze the participatory process and facilitate participation in NBS (n=31)	Butt, Smith, Moola, & Conway, 2021; Nunes, Björner, & Hilding-Hamann, 2021; Huang, Aguilar, Yang, Qin, & Wen, 2021; Campbell-Arvai & Lindquist, 2021; Mok, Mačiulytė, Bult, & Hawxwell, 2021; Arlati, Rödl, Kanjaria-Christian, & Knieling, 2021; Vaňo, Stahl Olafsson, & Mederly, 2021; Golladay, Craig, Depalma-Dow, Emanuel, & Gordon Rogers, 2021; Arabomen, Chirwa, & Babalola, 2020; Willems, Molenveld, Voorberg, & Brinkman, 2020; Yu et al., 2019; Møller et al., 2019; Buijs et al., 2019; van der Jagt et al., 2019; Leonard et al., 2019; Beery, 2018; Møller & Olafsson, 2018; Lieberherr & Green, 2018; Kozová, Dobšinská, Pauditšová, Tomčíková, & Rakytová, 2018; van der Jagt et al., 2017; Adjei Mensah, Andres, Baidoo, Eshun, & Antwi, 2017; Chelleri, Kua, Sánchez, Md Nahiduzzaman, & Thondhlana, 2016; Ives et al., 2017; Tran, Siry, Bowker, & Poudyal, 2017; Raymond, Gottwald, Kuoppa, & Kyttä, 2016; Afzalan & Muller, 2014; Nordström, Eriksson, & Öhman, 2010; Yamaki, 2016; Rosol, 2010; Janse & Konijnendijk, 2007; Dennis & James, 2016

2.3.3.1 Perceptions of citizen participation in NBS

Barriers

Research on barriers hindering citizen participation in NBS is a potent force topic. Scholars have discussed the obstacles from different perspectives from different backgrounds. One of the most often reported barriers is a lack of public awareness. The implementation of citizen participation in NBS requires co-creation and co-design with citizens in the early stages of the planning process (Lupp et al., 2021; Nunes, Björner, & Hilding-Hamann, 2021). However, citizens often lack environmental awareness and cannot clearly understand their significant role in effectively developing and maintaining NBS (Sarabi, Han, Romme, Vries, & Wendling, 2019). Other barriers, such as lack of resources to support, knowledge gap, lack of coordination, and scheduling conflicts, have also attracted the attention of scholars. These studies could provide an in-depth understanding of current obstacles in implementing citizen participation in NBS domains. Table 2 presents the main barriers preventing citizens from engaging and participating in NBS.

Table 2 Barriers hindering citizen participation in NBS

Barriers	Sources
Lack of public awareness	Dorst et al., 2022; Hanna Fors, Wiström, & Nielsen, 2019; Zare, Namiranian, Feghhi, & Fami, 2015; Tian, Jim, & Tao, 2012; Li, Wang, Liu, & Zhang, 2005
Lack of resources to support	Dorst et al., 2022; Mattijssen et al., 2017; Zare, Namiranian, Feghhi, & Fami, 2015
NIMBY-ism	Dorst et al., 2022
Knowledge gap	Zuniga-Teran et al., 2020; Gulsrud, Hertzog, & Shears, 2018; Hosseini, AzarKamand, & Lashgarara, 2011; Miller, 2016
Scheduling conflicts	Miller, 2016; Zare, Namiranian, Feghhi, & Fami, 2015
Effectiveness of the meetings	Miller, 2016
Lack of coordination	Mattijssen et al., 2017; Zare, Namiranian, Feghhi, & Fami, 2015; Azadi, Ho, Hafni, Zarafshani, & Witlox, 2011
Lack of motivation	Zare, Namiranian, Feghhi, & Fami, 2015
Economic reasons	Miller, 2016

Beliefs

Numerous studies have paid close attention to public perceptions towards citizen participation in NBS. Scholars have addressed that public perception is highly related to citizens' attitudes to the proposed projects and willingness to be engaged (Lamond & Everett, 2019; Shan, 2012; Zhang, Hussain, Deng, & Letson, 2007). Understanding citizens' perceptions of NBS and engaging them in decision-making can contribute to project success and sustainability (Barau, 2015; Jim & Chen, 2006). Therefore, identifying public perceptions is essential in promoting and facilitating citizen participation in NBS.

In recent years, we have witnessed increasing polarisation in existing research on public perception towards participation in NBS. Despite the growing awareness of the significance of participation in NBS, a lack of perceptions regarding involvement in NBS is frequently reported (Lupp et al., 2021). Several studies have highlighted citizens' negative perceptions of participation in NBS (Bissonnette et al., 2018; Conway et al., 2021; Younis et al., 2018). This phenomenon derives primarily from the limited required knowledge for engaging NBS initiatives. Some studies even found that the concept and ideas of citizen participation and NBS initiatives are less familiar to citizens (Conway et al., 2021). In addition, a common finding includes a belief that citizens believed the government should be responsible for NBS (Moskell & Allred, 2013). On the other hand, however, there is also evidence that citizen participation in NBS has received widespread recognition and strong support from the public (Jim & Chen, 2006; Zhang, Hussain, Deng, & Letson, 2007). These studies demonstrated the positive perceptions and strong will toward citizen participation in NBS initiatives despite socio-economic variations, in line with a global trend of increasing civic consciousness and environmental awareness.

The selected articles displayed a wide divergence of public perceptions among scholars regarding participation in NBS, which were not sufficiently addressed. However, there is notable agreement that positive public perception is indispensable in promoting and facilitating citizen participation in NBS (Lamond & Everett, 2019). Studies have argued that personal experiences and social bases primarily influence

public perceptions (Bissonnette et al., 2018; Klein, Dove, & Felson, 2021). Therefore, the analysis of public perceptions should be context specific. Table 3 demonstrates the selected publications regarding the research on public perceptions.

Table 3 Research on public perceptions towards citizen participation

Views or findings	Attitudes towards participation in NBS	Research Methods	Resources
Widespread recognition and strong support for citizen participation in NBS	Positive	Questionnaire Survey	Jim & Chen, 2006
Positive attitudes toward NBS and strong support for participation in NBS	Positive	Ordered Probit Analysis	Zhang, Hussain, Deng, & Letson, 2007
Positive attitudes and strong willingness toward participation	Positive	Questionnaire Survey	Shan, 2012
Value Orientations and Beliefs contribute to personal norms to citizen participation in NBS	Positive	Partial Least Square Structural Modeling	Su, Ren, Cui, Hou, & Wen, 2022
Lack of knowledge on citizen participation in NBS	Negative	Case studies	Lupp et al., 2021
VR/AR could enhance citizens' perceptions of participation in NBS	Positive	Simulation	Piga, Stancato, Rainisio, & Boffi, 2021
Low knowledge level and lack of awareness on participation in NBS	Negative	Questionnaire Survey	Conway et al., 2021
Personal experiences, as well as social bases, influenced perceptions	N/A	Semi-structured interviews	Klein, Dove, & Felson, 2021
Community attitudes and actions will be inextricably linked to the amenity and recreation functions provided	N/A	correlation analysis	Lamond & Everett, 2019
Critical and diverged opinions on participation in NBS	Negative	Workshop	Bissonnette et al., 2018
Not satisfied and lack awareness	Negative	Questionnaire and field survey	Younis et al., 2018

Views or findings	Attitudes towards participation in NBS	Research Methods	Resources
Different stakeholder types showed different perceptions	N/A	Co-benefits analysis	Alves, Gómez, Vojinovic, Sánchez, & Weesakul, 2018
Strong support for citizen participation in NBS	Positive	Case study	Baur, Tynon, Ries, & Rosenberger, 2016
Public perception and participation are indispensable in addressing contemporary sustainability challenges	Positive	Rasch model's Wright map and differential item functioning	Barau, 2015
Demographic differences in the level of support for participation in NBS are possibly related to individual ability or interest	N/A	Case study	Conway & Yip, 2016
The majority of respondents believed the government should be responsible for NBS	Negative	Questionnaire and field survey	Moskell & Allred, 2013

Benefits

The benefits of citizen participation in NBS have been studied for many years. Scholars have reached a consensus on the benefits of involvement in the success and sustainability of NBS in different manners. First, involving a wide range of citizens in the NBS initiatives can facilitate the practical assessment of environmental risks and raise citizens' civic and ecological awareness (Cárdenas et al., 2021; Meyer et al., 2018; Mabelis & Maksymiuk, 2009). Generally, local citizens grasp the essential information about the local circumstance, which could increase awareness of issues (Creighton, 2005; Luyet, Schlaepfer, Parlange, & Buttler, 2012). Moreover, active participation provided the citizens with an in-depth understanding of the NBS initiatives and the functional synergies, which could maintain and value spontaneous NBS projects (Brink & Wamsler, 2018). Second, involving citizens in the design and implementation process of NBS can enhance the openness and transparency of the decision-making process (Rall, Hansen, & Pauleit, 2019; Balram, Dragicevic, & Meredith, 2003). The co-design with citizens can force urban planners and decision-

makers to rethink potential attitudes and demands of citizens that might cause conflicts, ensuring collaborative, socially inclusive planning processes. The third frequently identified profit of participation is that including citizens in NBS can help overcome barriers, such as lack of public awareness and support, and ensure project success (Wamsler, Wickenberg, et al., 2020; Neumann & Hack, 2020; Yao et al., 2019; Girma, Terefe, & Pauleit, 2019). The participatory process can enhance citizens' trust in the final decision, thus promoting their acceptance and approval of the proposed projects (Mabon, 2019; Girma, Terefe, Pauleit, & Kindu, 2019; Niță et al., 2018). The consensus on the benefits of participation is the main reason for the prevalent research and practice. Table 4 presents the main perceived benefits of citizen participation in NBS identified in the selected publications.

Table 4 Main benefits of citizen participation in NBS

Benefits	Resources
Enhancing assessment of environmental risks, raising awareness	Cárdenas et al., 2021; Meyer et al., 2018; Brink & Wamsler, 2018; Mabelis & Maksymiuk, 2009
Improving representativeness and accuracy of expert-based assessments and empowering citizens	Rall, Hansen, & Pauleit, 2019; Balram, Dragicevic, & Meredith, 2003
Overcoming barriers and Ensuring project success	Wamsler, Wickenberg, et al., 2020; Neumann & Hack, 2020; Yao et al., 2019; Girma, Terefe, & Pauleit, 2019; Mabon, 2019; Girma, Terefe, Pauleit, & Kindu, 2019; Niță et al., 2018; Faehnle, Bäcklund, Tyrväinen, Niemelä, & Yli-Pelkonen, 2014; Cvejić, Železnikar, Nastran, Rehberger, & Pintar, 2015; Trentanovi et al., 2021; H. Fors, Jansson, & Nielsen, 2018

2.3.3.2 The participatory process in NBS

The research on the participatory process in NBS is another topical issue. A wide range of methods and tools have been proposed to motivate citizens to participate in NBS. However, scholars still have different opinions on critical elements of the participatory process, such as timing, degrees, and tools.

The argument on the timing of participation in NBS centred on whether to involve participants throughout the project cycle (designing, implementation, and

maintenance) or only in the decision-making process. Many scholars stated that participatory behaviours should be from the beginning of the decision-making process to achieve effective participation (Newig, Challies, Jager, Kochskaemper, & Adzersen, 2018). In line with this view, participants are encouraged to participate in the planning, design, construction, operation, and demolition phases following a whole-cycle process (Li, Thomas Ng, & Skitmore, 2012). Ideally, participants can obtain control over the proposed project through sufficient participation. However, some scholars doubt the feasibility of involving participants throughout the life cycle, considering the cost and time-consuming. Their studies focused on the decision-making process and attempted to emphasize the solicitation and analysis of public opinions in this early phase (Li, Krishnamurthy, Pereira Roders, & van Wesemael, 2020;). For example, unlike the participatory theory, which encourages participation throughout the project cycle, EIA-based participation is prevalent in China and other developing countries (Few, Brown, & Tompkins, 2007; Glucker, Driessen, Kolhoff, & Runhaar, 2013; O'Faircheallaigh, 2010; Newig, Challies, Jager, Kochskaemper, & Adzersen, 2018). These scholars deemed that involving participants in the decision-making process makes it possible to influence final decisions and ensure participatory efficiency simultaneously.

Another divergence relates to citizens' power or position in the participatory process. Arnstein (1969) divided citizen participation into non-participation, tokenism, and empowerment. The different levels of involvement indicate how citizens will be involved in the participatory process. Each level corresponds to various participation practices, such as to inform (e.g., public hearings, information release), education (e.g., public survey, focus groups), and consultation (e.g., workshops). As Puskás, Abunnasr, and Naalbandian (2021) stated, citizens are encouraged to pursue higher-level participation instead of solely being informed and educated. In addition, several studies have evaluated participation processes to understand how to conduct an effective participatory practice in a particular situation. Korfmacher (2001) suggested five guidelines for suitable participatory methods by evaluating four cases in which different participation approaches have been attempted: *transparent modelling process, continuous involvement, appropriately representative involvement,*

influence on modelling decisions, and clear role of modelling in watershed management. Likewise, some scholars also identified six critical choices that decision-makers should make in the participatory process by comparing actual participatory practices in Florida and Washington (Brody, Godschalk, & Burby, 2003). The critical choices included: *program administration, objectives to guide citizen involvement, stage of the planning process when citizens first become involved, how many and which types of groups to target, techniques for obtaining citizen input, and providing citizens with information*. However, reviewing their findings, it is possible to find that their studies are still fettered from the perspective of decision-makers and stop short of exploring citizen participation practice from local citizens' perspective.

With increasing studies on participation in NBS, scholars strive to pursue an effective and efficient participatory process by exploring participatory tools (Balram, Dragicevic, & Meredith, 2003; Møller & Olafsson, 2018). These years, participatory tools have derived various typologies in different contexts with different interpretations. Rather than viewing the tools as mutually exclusive, the literature review aims to understand the difference between these classifications and clarify their different application contexts. Table 5 presents the methods and tools for citizen participation in NBS used in the selected publications.

The government-led surveys and questionnaires continued to constitute the most prevalent tool used for the participatory process in designing and implementing NBS (n=9). This phenomenon is not surprising, given its reproducibility, efficiency, and convenience in collecting citizens' attitudes, perceptions, and concerns (Janse & Konijnendijk, 2007). However, this top-down method has received a lot of criticism for the local governments' predominant or even exclusive role in the participatory process. Under these circumstances, citizen participation plays a limited role in incorporating citizens' comments, and citizens' weak voices can hardly make a difference in the final decision. Numerous studies have addressed the high relevance between participatory tools and participation effectiveness (N. Nunes, Björner, & Hilding-Hamann, 2021; Piga, Stancato, Rainisio, & Boffi, 2021). Therefore, many

scholars have set their eyes on innovative ideas for the participatory process. The workshops/urban living labs (ULL) have recently drawn widespread attention and have become the most prevalent research (Butt, Smith, Moola, & Conway, 2021; Golladay, Craig, Depalma-Dow, Emanuel, & Gordon Rogers, 2021). A mainstream argument is that workshops and ULL can provide citizens with an appropriate and safe environment for learning-by-doing, where citizens can meet and interact (N. Nunes, Björner, & Hilding-Hamann, 2021). Through workshops and ULL, citizens can get insight into NBS and build mutual trust with urban planners and decision-makers.

Table 5 Methods/Tools for citizen participation in NBS

Methods/Tools	Resources
Workshops/Urban Living Labs (n=8)	Butt, Smith, Moola, & Conway, 2021; Golladay, Craig, Depalma-Dow, Emanuel, & Gordon Rogers, 2021; Buijs et al., 2019; Leonard et al., 2019; Nunes, Björner, & Hilding-Hamann, 2021; Arlati, Rödl, Kanjaria-Christian, & Knieling, 2021; Willems, Molenveld, Voorberg, & Brinkman, 2020; van der Jagt et al., 2019
Community-based bottom-up method (n=5)	Campbell-Arvai & Lindquist, 2021; Lieberherr & Green, 2018; Yamaki, 2016; Rosol, 2010; Vaňo, Stahl Olafsson, & Mederly, 2021
Focus group sessions/Meetings (n=2)	Mok, Mačiulytė, Bult, & Hawxwell, 2021; Beery, 2018
Questionnaire/Survey (n=9)	Arabomen, Chirwa, & Babalola, 2020； Yu et al., 2019; Adjei Mensah, Andres, Baidoo, Eshun, & Antwi, 2017; Tran, Siry, Bowker, & Poudyal, 2017; Nordström, Eriksson, & Öhman, 2010; Dennis & James, 2016; Huang, Aguilar, Yang, Qin, & Wen, 2021; Chelleri, Kua, Sánchez, Md Nahiduzzaman, & Thondhlana, 2016; Janse & Konijnendijk, 2007
E-tools/GIS-based tools (n=6)	Møller et al., 2019; Møller & Olafsson, 2018; Kozová, Dobšinská, Pauditšová, Tomčíková, & Rakytová, 2018; Ives et al., 2017; Raymond, Gottwald, Kuoppa, & Kyttä, 2015; Afzalan & Muller, 2014

The community-based bottom-up methods and E-tools have increasingly been used for the participatory process in NBS (Møller et al., 2019; Møller & Olafsson, 2018). The community-based approach is contrary to the government-led surveys and questionnaires, emphasizing citizens' dominance in the process of participation (Kozová, Dobšinská, Pauditšová, Tomčíková, & Rakytová, 2018). The citizens could

express demands, make collective decisions, and share responsibilities through the bottom-up method. With empowerment, citizens could obtain control over decision-making. E-tools can offer citizens more accessible information and consultation from the government, facilitating interactions between citizens and decision-makers.

Indeed, these studies provide an in-depth understanding of citizen participation in NBS and offer suggestions for enhancing participatory behaviours. However, concerns emerge as the higher level of involvement cannot automatically guarantee the effectiveness of participatory behaviour. The citizens are consistently found to have a low-level aspiration of involvement in NBS. Before discussing how to achieve effective participation in NBS within different contexts, some of the drawbacks and limitations of previous participation research from citizens' perspectives will be reviewed first.

2.4 Discussions

The retrieved publications have identified two predominant areas of participation research in NBS: (a) analysis of perceptions of citizen participation in NBS; (b) analysis of the participatory process in NBS. Scholars have paid close attention to the barriers, beliefs, benefits, methods, and tools of the participatory process in NBS. These studies revealed some interesting findings and helped practitioners move forward in understanding citizen participation in NBS initiatives. However, the selected publications are also criticized for the overemphasized analysis of benefits, barriers, beliefs, and the methods and tools of the participatory process. The existing studies continue to focus on conventional approaches and topics of citizen participation in NBS projects, while the need to address community-based NBS projects will probably require particular attention on local citizens. These studies have failed to examine citizens' willingness to be engaged in NBS projects and overlooked the potential participants in the decision-making process.

2.4.1 The Unengaged

The existing works have assumed an essential precondition that citizens may be actively and publicly involved considering the benefits of participation and NBS when given an opportunity. However, implementing participation cannot

automatically guarantee high-quality participatory exercise and project success, especially when ignoring citizens' willingness and capacity to participate (Li, Thomas Ng, & Skitmore, 2012; C. Shan & Yai, 2011). More importantly, as some scholars remarked, higher-level participation is sometimes confused with effective participation, exacerbating the neglect of citizen characteristics in participatory research (Swapan, 2016). Many respondents have indifferent attitudes toward the proposed projects, their environmental impacts, and the participation arrangement, which can be grouped as the unengaged in urban planning and development. However, the attitudes of the unengaged cannot be ignored due to their considerable proportion of the total population. Therefore, engaging the unengaged and obtaining their acceptance should also be critical for effective participation.

As discussed above, the unengaged is the salient element of citizen participation in NBS, which is often overlooked. The systematic exploration of *who* should be involved in the participatory process has been addressed by some scholars (Innes and Booher, 2004; Stern and Dietz, 2008; Mees, Uittenbroek, Hegger, & Driessen, 2019). However, as the implementation associates with a wide range of stakeholders and each stakeholder have different interest demands and positions in the participatory process, the definition of "who" in a participatory approach is complex and uncertain. In addition to the confirmed stakeholders (local government and project developers), the prospective stakeholders include a wide range of the affected citizens. The latter has diverse attributes and characteristics in the participatory process and influences the effectiveness of participation. Several studies have stressed the significance of the project-affected citizens in the participatory process (Shan & Yai, 2011; Xue, Shen, Yang, Zafar, & Ekanayake, 2020). However, as pointed out by some scholars, the complexities of the prospective stakeholders challenge participation effectiveness, particularly for those with a weak willingness and capacity to participate (Wall, Straka, & Miller, 2006).

Furthermore, some scholars examined the prospective stakeholders and found that many affected groups are reluctant to participate in NBS and express their opinions towards NBS initiatives (Ng, Li, & Wong, 2012; Day, 2017). There is a need to

address the equal representation of the unengaged since this group is always overlooked. As Day (2017) indicates that "*all comments and submissions (in citizen participation process) must be considered and planners should be able to demonstrate where comments have made a difference—and if not, why not*."

2.4.2 Willingness to Participate

Willingness to participate is considered one of the critical principles for effective participation (Arabomen, Chirwa, & Babalola, 2020; Tran, Siry, Bowker, & Poudyal, 2017; Yu et al., 2019). Accordingly, effective participation requires a high level of citizens' willingness to participate (Zhang et al., 2011). Yet, in many instances, citizens' lack of willingness has made participation an empty and frustrating process for prudent NBS management (W. Li et al., 2020; Swapan, 2014). However, citizens' willingness is often ignored, particularly in developing countries. Since most NBS initiatives are government-led projects, the decision-making process is designed as a "top-down" activity, and the government is in a dominant position. For example, in China, decision-makers still regard citizen participation in the decision-making process as "little more than a formality" and design it as a "top-down" process (Li, Ng, & Skitmore, 2013; Shan & Yai, 2011; Yao, He, & Bao, 2020). In such a "top-down" process, citizens possess a limited influence on final decisions and, as a result, are reluctant to participate in the participatory process and suspect the efficiency and effectiveness of such an empty and frustrating process.

A study from Swapan (2016) demonstrated that citizens with low willingness tend to avoid engaging in the formal participation process. Another study found that these unwilling citizens may prefer different participation techniques because their unwillingness might come from unawareness that the problem at hand is also their problem (Uittenbroek et al., 2019). Therefore, assessing citizens' willingness to participate is significant for effective participation. However, focusing on analyzing levels and effectiveness of participation, little research has explored citizens' willingness to participate. Factors and their interactions with each other underlying the low-level willingness of citizens remain unclear and overlooked within the NBS context. Although Arnstein and other experts' work is significant for participation

research, such efforts cannot consistently achieve positive goals. It fails to address a wide range of participants' willingness to participate in the decision-making process. Furthermore, the ladder theory was deep-rooted in the gradation of different participation types, which results in a consequence that follow-up studies focus solely on the process of transferring power from authorities to citizens, such as information exchange and institutional design for citizen participation (Bond et al., 2004; Chi, Xu, & Xue, 2014; Cuppen et al., 2012). These studies have supposed an essential precondition that citizens may express their concerns and expectations towards proposed projects and the environmental protection act when given a chance to participate in the decision-making process. Therefore, an in-depth understanding of willingness to participate is necessary in response to the urgent need to activate a wide range of the unengaged in the participatory process.

Several studies attempt to explore the willingness to participate from different perspectives. As Swapan (2014) notes, citizens' willingness to participate has remained consistently low, and only the minority seem to have the required capabilities and skills for efficient and effective participation. Meanwhile, Shan et al. (2011) indicate that citizens mainly depend on the government for large-scale projects in China, with a passive sense of ownership for these public services. Their willingness to participate has slowly faded, and their concerns and expectations have become progressively overlooked in the planning and development process (Brombal, Moriggi, & Marcomini, 2017). Furthermore, many studies have sought to identify the reasons behind citizens' propensity for participation and non-participation from citizens' perceptions. Swapan (2016) uncovered six key factors that affect the respondents' willingness to participate, namely: (a) economic condition; (b) awareness of the planning process; (c) effectiveness of communication strategies taken by the planning agency; (d) trust in planning agency; (e) sense of urgency (i.e., whether or not they were personally affected by the plan) and (f) status of social capital. However, the investigation paid little attention to how socio-psychological factors affected willingness to participate and overlooked these factors' interrelationships.

Meanwhile, the theory of planned behaviour (TPB) is widely introduced to explore the interrelationships between socio-psychological factors and willingness to participate. Based on the TPB model, Kalkbrenner and Roosen (2016) revealed how community identity, social norms, trust, and environmental concern affect citizens' willingness to be engaged in community-based projects through regression analysis. This model, however, oversimplified the determinants of willingness to participate without considering the latent characteristic of some socio-psychological variables. It is well recognized that the rational decision-making model has ranked the decisive socio-psychological factors affecting citizens' willingness to participate. In contrast, the TPB model provides a paradigm of how different socio-psychological factors shape an individual's behaviours in the context of social psychology.

In conclusion, existing studies have explored various salient elements for implementing citizen participation in NBS, such as barriers, benefits, beliefs, and methods and tools for the participatory process. However, it is worth noting that a public-based research perspective is often overlooked and the reasons underlying insufficient willingness to participate remain unclear. However, citizens' willingness to participate is deemed a critical factor influencing the efficiency and effectiveness of citizen participation in NBS. Higher-level participation in the ladder of citizen participation does not guarantee a higher level of success. However, involving more people in the decision-making does, since it reveals more opinions and increases ownership. With the insight into why they are unwilling to participate and who they are (age, education, and income), practitioners could engage the unengaged to participate and support them in expressing their opinions and getting them on board to support the NBS project. Therefore, a practical study of citizen participation is required to bridge these considerable research gaps in the following research.

2.5 Conclusions

Although an increasing number of studies have successfully talked about citizen participation in NBS from various perspectives, there is evidence that considerable deficiencies still exist, impeding the success of citizen participation in NBS projects. The present literature review shows a lack of systematic empirical research on the

unengaged and their willingness to participate, hindering the effectiveness of citizen participation and project success.

The salient elements of "who" (e.g., the unengaged) with their attributes (e.g., willingness) have received less attention in the scientific literature. Usually, the decisions made through the participatory process are produced by mutual coordination and largely depend on the weight of voices from diverse stakeholder groups. Limitations in such a process are accused of failing to involve the critical stakeholders in the involvement process effectively. Often this has arisen from a focus on the tools and levels of participation rather than the stakeholders who should be fully involved and how their attributes influence effective participation. Many studies have distinguished the unengaged from the vocal minority in the participatory process. Compared to the unengaged, the vocal minority is highly motivated to voice their concerns and tends to dominate the decision-making process of NBS, inevitably resulting in chaos. In this light, it is necessary to address this knowledge gap by examining the unengaged and evaluating their willingness to participate in NBS.

This study highlights a few knowledge gaps in NBS participation research. Future research can further quantify willingness to participate through citizen participation. More work is necessary to combine quantitative sociology insights with more qualitative data about how the underlying assumptions and attitudes of the unengaged are altered through involvement.

In summary, this chapter has presented the current state of citizen participation in NBS projects by reviewing academic discourses. The review is based on a global perspective to understand citizen participation in NBS projects. Results demonstrated that existing studies had paid little attention to the unengaged and willingness to participate despite the promising trend toward increased citizen participation in NBS projects. Taking China as an example, the following chapters attempted to bridge these gaps to further the understanding of citizen participation in NBS projects.

CHAPTER 3

APPLYING BAYESIAN BELIEF NETWORK TO EXPLORE KEY DETERMINANTS FOR NBS ACCEPTANCE OF LOCAL STAKEHOLDERS

This chapter has been published as:

Dai, L., Han, Q., de Vries, B., & Wang, Y. (2021). Applying Bayesian Belief Network to explore key determinants for nature-based solutions' acceptance of local stakeholders. Journal of Cleaner Production, 310, 127480.

Abstract: Existing research stops short of explaining why local stakeholders have a low acceptance of nature-based solutions. In this article, the public, government, and project management perspectives are combined to examine the factors that influence nature-based solutions acceptance at the community level. Based on the survey data of 657 respondents in Guyuan, China, the study has found that government-and project-related factors are more likely to influence the degree of community acceptance of nature-based solutions through the Bayesian Belief Network. These factors include the availability of feedback and information from the government perspective and project design and location from the project management perspective. Only one public-related factor is identified to influence community acceptance significantly, namely, personal experiences. In addition, this study found a large portion of respondents belonging to the silent majority in the survey that holds neutral views towards nature-based solutions. Finally, recommendations are given on translating the critical determinants into nature-based solutions policies.

Keywords: Community Acceptance; Nature-based solutions; Bayesian Belief Network; The Silent Majority; Social Acceptance

3.1 Introduction

Faced with climate change, human activities have resulted in an increased occurrence of environmental issues like urban flooding and heatwaves in urban areas. The disruption in the balance of the urban social ecosystem has an adverse effect on a wide range of citizens (Abebe et al., 2018; Jiang et al., 2018). For example, urban flooding, a common natural disaster in many Chinese cities, including some metropolises such as Beijing and Guangzhou, not only causes economic losses but also poses a serious threat to citizens' life and property safety (Huang et al., 2018; Lo et al., 2015). As a response to severe climate-related risks like prevalent urban flooding and heatwaves, NBS is devised as an appropriate measure to tackle the socio-environmental challenges by effectively remaking nature (Faivre et al., 2017; Giordano et al., 2020). NBS is highly praised by many experts and scholars for developing urban resilience and maintaining sustainability. These days, with large populations vulnerable to the impacts and risks of urban flooding and heatwaves, interest in NBS is rising. However, there are still fundamental challenges in upscaling them in urban areas. Due to the externalities of NBS projects, for example, local stakeholders' attitudes – acceptance or opposition - at the community level is a crucial challenge for the implementation success.

Concurrently, many studies address issues in forming and implementing NBS within and across disciplines (Cohen-Shacham et al., 2016; Kabisch et al., 2016; Faivre et al., 2017; Raymond et al., 2017; Dorst et al., 2019). However, the existing literature in this field tends to overemphasize the effectiveness, co-benefits, and social acceptance of NBS (Pagano et al., 2019; Santoro et al., 2019; Martín et al., 2020) and stays short of paying close attention to community benefits and community acceptance. NBS are generally socially beneficial (Cohen-Shacham et al., 2016), yet the co-benefits are not accessible equally. Despite the social and environmental benefits of NBS, side effects at the community level, such as land acquisition and visual landscape degradation, are still being questioned by local stakeholders. Therefore, although these works are of great significance for understanding the relationships between co-benefits and social acceptance of NBS, they have been

criticized for their insufficient attention to community acceptance. NBS often suffers from delays, relocation, or cancellation without community acceptance. Social acceptance places greater emphasis on the co-benefits to the whole society generated by NBS (Wolsink, 2018), while community acceptance stands for "*local stakeholders' impression of the benefits that new NBS technologies or circularity initiatives bring to their respective communities*" (Katsou et al., 2020). Scholars have shown that the divergence of co-benefits perception and valuation might result in various degrees of acceptance of different stakeholders, thus, hindering the implementation of NBS (Morris et al., 2019; Giordano et al., 2020). Another limitation associated with the emerging literature focusing on NBS acceptance (Guo et al., 2015; Enevoldsen & Sovacool, 2016) lies in a limited capability to thoroughly analyze the potential factors affecting NBS acceptance, rarely addressing the cross-perspective factors. Specifically, NBS is a co-design, co-finance, and co-evaluate project. Interactions of various elements from different perspectives may have unrevealed effects on community acceptance, which requires further consideration.

In response to the above limitations, this study focuses on community acceptance and aims to supplement current NBS acceptance research by examining NBS acceptance factors from the public, the government, and the project perspectives. In a recent study on enhancing NBS acceptance, Giordano et al. (2020) questioned the insufficient exploration of interactions between different sectors in NBS effectiveness studies and demonstrated that differences in co-benefits perception and valuation between various stakeholders might result in trade-offs and conflicts. This study focuses on community acceptance and combines the public, the government, and the project perspectives to explore how different factors affect NBS acceptance. In other words, what are the factors affecting NBS acceptance, and how does the combination of cross-perspective factors affect NBS acceptance?

This study supplements current research on NBS acceptance in two major aspects. Firstly, it is among the first attempts to explore the effects of different combinations of cross-perspective factors on NBS acceptance. Although an emerging body of literature has concentrated on NBS acceptance, most efforts have neither revealed

factors affecting NBS acceptance clearly nor discussed cross-factor effects thoroughly. Building on the public, the government, and the project perspectives, this study provides new insights into the cross-perspective analysis and a profound understanding of the factors associated with NBS acceptance. Secondly, in response to the insufficient attention to community acceptance, this study focuses on the co-benefits and perceptions of local stakeholders at the community level and addresses the issues underlying the lack of acceptance.

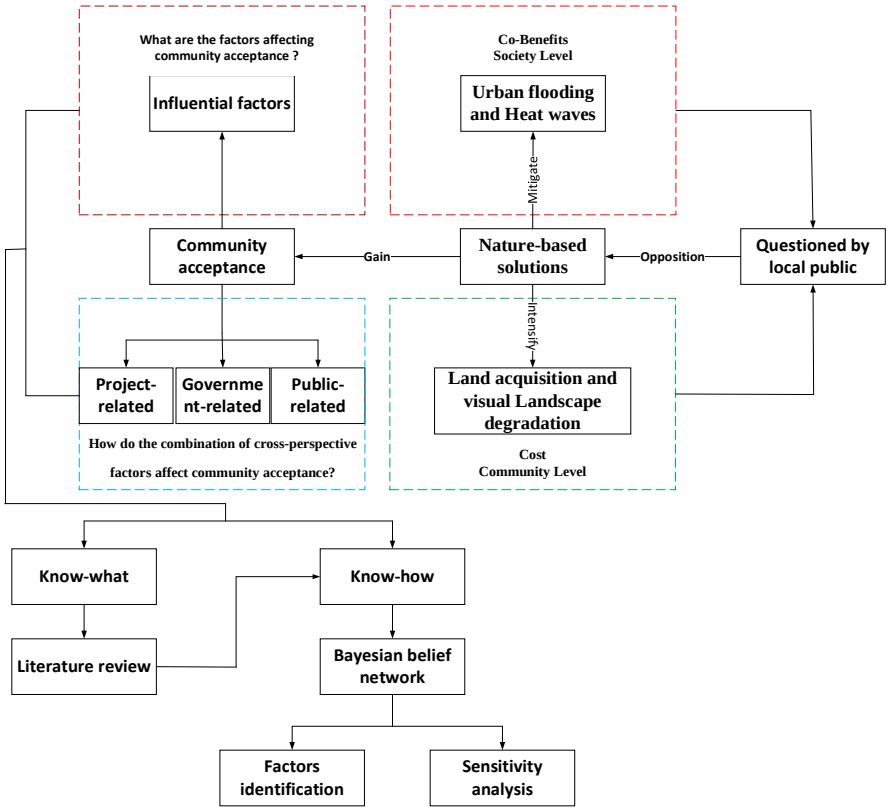

Fig. 5 Research Framework of Community Acceptance on NBS

The rest of the paper is structured as follows. Beginning with an introduction to NBS, we discuss the public, the government, and the project factors associated with NBS acceptance. Parts 3 and 4 describe the theoretical basis and the methodology, respectively. Finally, Part 5 presents the findings, and conclusions are drawn in Part

6, showing the implications and sharing the understanding. Figure 5 demonstrates the structure of the paper.

3.2 Literature Review

As cities have become the "human habitats" (Seto & Reenberg, 2014), urban problems like prevalent urban flooding and the heat island effect induced by a changing climate have caused widespread concerns. These climate-related risks have seriously threatened urban resilience and sustainability and posed a threat to citizens' life safety and property value. Against this backdrop, an increasing number of studies have discussed NBS from various perspectives since it was proposed, particularly in the era when citizens are generally negatively affected by a changing climate. European Commission (2017) defines NBS as solutions "*inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient, and systemic interventions.*" According to Cohen-Shacham et al. (2016), NBS are actions response to societal challenges that "*protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity*." Based on these definitions, we can conclude that NBS are actions that work with nature in a sustainable way to tackle climate-related risks in urban planning and development. In line with this definition, NBS is an umbrella concept as it is considerably overlapping with other related concepts such as "green infrastructure" and "ecosystem-based adaptation" (Cohen-Shacham et al., 2016; Kabisch et al., 2016; Pauleit et al., 2017).

NBS has derived many new concepts in practice for different urban planning and development purposes, such as green cities, sponge cities, and green roofs (Chan et al., 2018; Fan et al., 2017). No matter what forms of NBS are-green cities or sponge cities, they are still closely connected with local stakeholders and profoundly affect local communities. And inevitably, the externalities of NBS are borne by local stakeholders. The rehabilitation of wetlands, for example, is deployed for urban flood

protection and is believed to be beneficial to climate regulation and rainwater captured but might simultaneously harm local farming livelihoods (Nesshöver et al., 2017). Likewise, the initial or maintenance costs of installing a green roof could be crucial barriers to upscaling. Unequal distributions of costs and benefits of NBS cause local stakeholders' opposition as one district's benefits might be next door's costs (Wachsmuth et al., 2016). In this regard, NBS often involves significant trade-offs, with low-level community acceptance impeding NBS implementation in urban areas (Morris et al., 2019; Kumar et al., 2020).

Given the increasing awareness of NBS acceptance, some studies focused on evaluating NBS effectiveness and further explored NBS acceptance from different perspectives (Hoyle et al., 2017; Santoro et al., 2019; Frantzeskaki, 2019). Santoro et al. (2019) realized the significant role of stakeholders' perceptions and attitudes in promoting NBS implementation effectiveness and found that the opposition of local stakeholders is one of the critical barriers. They proposed problem structuring methods aligning the divergences and enhancing NBS acceptance based on fuzzy cognitive maps and ambiguity analysis. Santoro's work provides a heuristic method to elicit stakeholders' perceptions and attitudes in NBS implementations; however, the study stops further exploring how stakeholders' perceptions and attitudes affect NBS acceptance and whether other factors impact NBS acceptance. Similarly, by fuzzy cognitive maps, Giordano et al. (2020) believed that differences in stakeholders' co-benefit perceptions are vital barriers to enhancing NBS acceptability. Some scholars further explored the factors affecting NBS acceptance. Through a cross-case comparative analysis of fifteen cases of NBS experiments across 11 European cities, Frantzeskaki (2019) highlighted the significance of citizens' attitudes on NBS and discerned NBS design characteristics and trust in local government as another two crucial factors affecting NBS acceptance. Lack of effective communication was another barrier hindering NBS acceptance (Kumar et al., 2020). Although these studies unanimously emphasized the significant role of social acceptance in NBS implementation, they neither clearly defined what social acceptance is nor systematically analyzed the factors affecting social acceptance. So far, studies on social acceptance in NBS implementation remain fragmented, particularly on the

connotation and determinants. In social issues, acceptance is used frequently to describe a single individual's standpoint whose choices – liked or disliked, actively supported or resisted, or passively tolerated – are taken up (Baumeister & Leary, 1995). As to the project development domain, current studies did not distinguish the boundaries of social acceptance well. In other words, reviews on social acceptance in NBS implementation are fuzzy as they confuse "acceptance" at different levels, for example, the community and the city levels. Due to NBS implementation's externalities, the difference in co-benefits perception and valuation of NBS might lead to various trade-offs between community and government. We focus on community acceptance instead of social acceptance and identify fifteen factors combining public, government, and project perspectives for this study's purpose.

Although there is no extensive literature concerning community acceptance, a few studies have distinguished the relationships between community and social acceptance. Wüstenhagen et al. (2007) divided three dimensions of social acceptance: socio-political, community, and market acceptance. In line with this division, social acceptance comprises community acceptance. This view provides insight into the relationship between the community and social acceptance. However, the ensuing problem is also apparent that local stakeholders' perceptions and attitudes at the community level are often overlooked due to the excessive emphasis on the overall concept of social acceptance. Therefore, this paper focuses on community acceptance and closely follows local stakeholders' perceptions and attitudes when an NBS project is proposed in their local community. Two questions will be explored "What factors can significantly affect community acceptance of NBS?" and "To what extent do these factors affect community acceptance?"

3.3 Theoretical basis and variable selection

3.3.1 Significance of community acceptance

As stated above, community acceptance is a crucial challenge for the implementation of NBS in urban areas. Batel et al. (2013) and Guo et al. (2015) aptly pointed out that the upscaling of NBS cannot be viewed purely as a technical challenge, and local

stakeholders' perceptions and attitudes are of great significance to project success. Compared with social acceptance, community acceptance values the benefits of new NBS projects at the community level and focuses on local stakeholders' perception of new NBS implementation. In this regard, community acceptance of new NBS is largely overlooked. Research on NBS acceptance should also address "*community acceptance*" instead of focusing on "*social acceptance*."

Community acceptance is one of the critical preconditions of NBS success. These days, with the awakening of environmental awareness, local stakeholders' opinions on new NBS are becoming more crucial and often contribute to the success of the state's development agenda (Liu et al., 2018). For example, internet development enables Chinese citizens to express their opinions on new large-scale infrastructure projects frequently and conveniently. Concurrently, the government has taken community acceptance as one of the guidelines in environmental-related issues (Zhang et al., 2018).

Therefore, an in-depth understanding of community acceptance of NBS to precisely investigate the relevant factors affecting community acceptance of NBS and analyze local stakeholders' perceptions and attitudes of NBS is necessary to upscale NBS in urban areas. Through the findings, a set of strategies to promote NBS can be provided.

3.3.2 Factors affecting community acceptance

As stated above, NBS has social and environmental benefits but may damage local stakeholders' interests. For the successful implementation of NBS, community acceptance is one of the critical challenges. Therefore, determining essential factors influencing community acceptance is of considerable significance to upscale NBS at the community level.

Few studies attempted to analyze the influential factors of community acceptance of NBS. Standard variables include proximity (Guo et al., 2015), trust (Frantzeskaki, 2019), communication (Kumar et al., 2020), and project characteristics (Frantzeskaki, 2019). However, a common problem exists in these studies: the fragmented research on the identification and analysis of the influential factors facilitating or impeding

community acceptance. For example, the impact of interactions between different factors on community acceptance is largely ignored. Therefore, a systematic investigation into the influential factors on community acceptance of NBS is urgent for upscaling NBS.

Under China's system, government-led project decision-making still dominates in most instances. In such circumstances, local stakeholders' opinions towards NBS implementation – acceptance or opposition, are predominantly affected by three dimensions, as shown in Table 6: the project, the government, and the public. These three dimensions focus on the perception or characteristics of three aspects of NBS implementation: the project, policymakers, and local stakeholders. Therefore, in this study, the influential potential variables will be grouped into three categories: project-related, government-related, and public-related. The various variables can be organized through the hierarchy, and the interactions between different variables can be extracted.

3.3.2.1 The project-related factors

The project-related variables refer to the features associated with NBS itself, including the function, site selection, and proposed project design. These factors represent the proposed project's details from different aspects, which could significantly affect local stakeholders' perceptions and attitudes. For example, site selection refers to the distance between the NBS project site and local stakeholders. According to the theory of the NIMBY (not in my backyard) phenomenon, proximity is expected to have a negative impact on the acceptance of new NBS (Guo et al., 2015), especially for some environment-related projects. Likewise, the function and design of new NBS are considered to impact community acceptance significantly (Wamsler et al., 2019).

3.3.2.2 The government-related factors

The government's dominant position in the NBS implementation makes it impossible to ignore the government's actions. In this study, the government-related variables are expected to measure practitioners' activities in planning and implementing new NBS projects. Whether the government has adequately protected the interests and

met local stakeholders' concerns in practice has a significant impact on community acceptance (Guo et al., 2015). In line with this view, transparency and emergency measures are picked up from local stakeholders' perspectives to denote the government's actions in the planning and implementation process of NBS. These variables include the availability of information, availability of feedback, emergency measures, and fulfilment commitment (Rose, 2013; Li et al., 2012; Kabisch et al., 2016; Raymond et al., 2017; Nesshöver et al., 2017; Peng et al., 2018; Guo et al., 2015; Devine-Wright, 2007 and Langemeyer et al., 2018). It is widely acknowledged that information and feedback are two main factors in public-government interaction (Rose, 2013; Kabisch et al., 2016; Raymond et al., 2017; Nesshöver et al., 2017). These two factors represent the possibility and efficiency of communication between local stakeholders and the government. Previous studies reveal that effective communication can promote acceptance of NBS projects (Kumar et al., 2020). As a requirement of risk management, emergency measures indicate the awareness of the government to protect local stakeholders' interests in the implementation process (Li et al., 2012). The fulfilment commitment shows the government's credit in the planning and implementation process, which is an essential factor affecting local stakeholders' acceptance of the new NBS (Kabisch et al., 2016; Raymond et al., 2017).

3.3.2.3 The public-related factors

The public-related variables mainly refer to local stakeholders' preferences and attitudes toward NBS based on their knowledge and belief. Community acceptance is significantly affected by different personal characteristics. The public-related factors include personal experiences, peer influence, perceptions of living condition benefits, environmental protection benefits, housing demolition risk, daily disruption risk, and visual landscape degradation. The local stakeholders' experience, knowledge, and perceptions of the positive or negative impacts of NBS on their communities could significantly influence the acceptance of NBS (Sarabi et al., 2019). For example, the positive perceptions could promote community acceptance; otherwise, the concerns of displacement and disruptions induced by NBS implementation may cause opposition.

Table 6 Critical Factors of Community Acceptance to Nature-based Solutions.

	Variables	Description	Rose, 2013	Li et al., 2012	Kabisch et al., 2016	Raymond et al., 2017	Nesshöver et al., 2017	Peng et al., 2018	Guo et al., 2015	Devine-Wright, 2007	Santoro et al., 2019	Langemeyer et al., 2018
Project-related variables	Project function	Availability of facilities, e.g., green space	✓	✓	✓	✓	✓	✓		✓	✓	✓
	Project location	Site selection and distance from local citizens	✓			✓	✓		✓	✓	✓	✓
	Project design	Feasible and sustainable design of the project	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Personal experiences	Past experiences of similar projects						✓		✓		✓
Public-related variables	Living condition benefits	Perception of benefits of the project, such as an improvement in convenience		✓	✓	✓	✓		✓			✓
	Environment protection benefits	Perception of benefits of the project, such as mitigation against climate change		✓	✓	✓	✓		✓		✓	✓
	Economic benefits	Perception of benefits of the project, such as an improvement in the job opportunity		✓	✓	✓	✓		✓		✓	✓
	Housing demolition risk	Assessment of land acquisition and occupation	✓	✓	✓	✓			✓	✓	✓	

	Variables	Description	Rose, 2013	Li et al., 2012	Kabisch et al., 2016	Raymond et al., 2017	Nesshöver et al., 2017	Peng et al., 2018	Guo et al., 2015	Devine-Wright, 2007	Santoro et al., 2019	Langemeyer et al., 2018
Government-related projects	Daily disruption risk	Assessment of adverse impacts on daily life such as a disruption to transport networks	✓		✓	✓			✓		✓	
	Visual landscape degradation	Assessment of visual landscape degradation	✓		✓	✓			✓	✓	✓	
	Peer influence	Evaluation results of the project conducted by the neighbours	✓							✓		✓
	Availability of information	Necessary ways to provide project information	✓		✓	✓	✓	✓	✓	✓	✓	✓
	Availability of feedback	Necessary ways to provide feedback	✓		✓	✓	✓		✓	✓	✓	✓
	Emergency measures	Security measures government takes to protect local citizens during the construction process	✓	✓	✓			✓	✓			
	Fulfilment commitment	Fulfilment of commitments government promises to local citizens	✓	✓	✓	✓	✓	✓	✓		✓	

3.4 Material and Methodology

3.4.1 Principles of Bayesian belief network

In this study, considering the research objectives, a Bayesian Belief Network (BBN) approach is applied to analyze factors affecting community acceptance. A BBN is a probabilistic graphical model that could simulate humans' inference process for probabilistic relationships within a bunch of random variables via a directed acyclic graph (DAG) (Heckerman, 1997; Pearl, 2014). It consists of a group of nodes connected by arrows representing various variables, and each node is assumed to be conditional independent and contains a joint probability distribution. Given specific evidence, the graphic structure could conduct precise reasoning by calculating each node's posterior probability according to Bayes' rules. Figure 6 shows a brief BBN in which two variables are connected with an arrow. The node at the arrow's tail is usually defined as a parent node, while the node at the head of the arrow is defined as a child node. The causal relationship between these two variables indicates that the parent node directly affects the child node. Several concepts should be worth noting in the BBN model: a prior or unconditional probability, a conditional probability, and a posterior probability. A prior or unconditional probability refers to the probability of a specific state of a node. A conditional probability measures the probability that a node will be in a particular state, given its parent node occurs, and a posterior probability is a conditional probability, given specific evidence (Marcot et al., 2001).

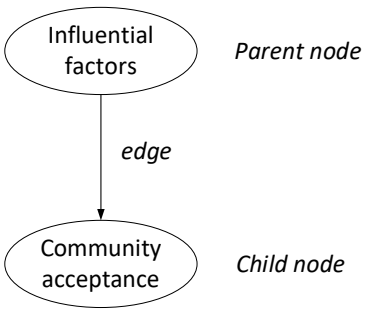

Fig. 6 A Brief Bayesian Belief Network in Community Acceptance Model

BBN was developed based on Bayes' theorem, which Thomas Bayes proposed in the late 1700s (Bayes, 1991). The Bayes' theorem is conditional probability theory and can be expressed as a simple formula:

$$P(A = a|B = b) = \frac{P(A = a) * P(B = b|A = a)}{P(B = b)}$$

While $P(A = a)$ is the probability of $A = a$, $P(A = a|B = b)$ is the probability of $A = a$ given that $B = b$ has occurred. It is worth noting that $P(A = a)$ is also known as a prior probability of $A = a$ and $P(A = a|B = b)$ is called the conditional probability of $A = a$ given that $B = b$ has occurred.

Furthermore, the joint probability distribution can be expressed as follows:

$$P(X_1, X_2, \dots, X_n) = \prod_{i=1}^{n} P(X_i|X_{i+1}, X_{i+2}, \dots, X_n)$$

While $P(X_1, X_2, \dots, X_n)$ refers to the joint probability of $X_1, X_2, \dots, X_n$, $P(X_i|X_{i+1}, X_{i+2}, \dots, X_n)$ is the conditional probability of the node X_i based on its parent nodes.

3.4.2 Justification of Bayesian belief network

The possibility of capturing probabilistic interdependency between uncertain variables was considered the main advantage and reason for using BBN in this study. A BBN model is a probabilistic inference model built on prior knowledge. Based on Bayes' theorem, a fully parameterized BBN model can effectively and efficiently compute any node's posterior probability given specific evidence. BBN's probabilistic inference ability and visual expression enable statistical analysis and demonstration of relationships between various factors and community acceptance. BBN offers opportunities to define critical variables and their relations, taking into account local stakeholders' knowledge, values, and perceptions. Admittedly, other techniques are also widely applied to measure community acceptance. For example, through a systematic literature review, Kumar et al. (2020) identified a set of barriers hindering community acceptance, like a lack of effective communication and a lack

of principles. Using binomial logistic regression, Roddis et al. (2018) composed a set of indicators related to community acceptance by exploring the role of community acceptance in planning outcomes for NBS. However, the systematic literature review cannot reveal how these factors affect community acceptance and the impact weights of various factors, while binomial logistic regression results cannot be expressed visually compared with BBN.

3.4.3 How to construct a BBN model

In a BBN model, prior knowledge is of considerable significance in determining the structure and the parameters. The prior knowledge can be extracted in two ways: expert knowledge and sample set. In line with these ways, two methods are often applied to construct a BBN model: (1) a manual method based on expert knowledge; (2) an analytical method based on the network learning from the database (Koller & Friedman, 2009). Specifically, the first method determines the interrelationships and the joint probabilities distribution of each node in the network using expert knowledge. As the numbers of nodes increase in the network, the manual method is too complicated to compute. Therefore, expert knowledge is usually used to create a small-sized network or revise the network created by the second method, which will be explained in the next part (Korb & Nicholson, 2010). The second method is widely used in diagnosing and inference problems, particularly for a complicated network, and is composed of structural and parameter learning based on the dataset.

The structural learning process aims to identify the best fit structure of a BBN model based on the sample dataset, while parameter learning determines the conditional probability tables (CPTs) of each node (Peng et al., 2018). Through the structural learning process, a suitable Bayesian belief typology can be created; in other words, the links between various nodes will be positioned in the structure. Then, the probabilistic interdependency between multiple nodes can be computed through parameter learning. Network learning provides an effective and efficient method to construct a complicated Bayesian network. There are lots of algorithms that could conduct structural learning and parameter learning from the sample dataset. The Greedy Thick Thinning (GTT) algorithm will construct the BBN models' structure in

this study. GTT is a search and score algorithm that can identify the best scoring network through two steps, which are the thickening process adding arcs to an empty graph until the maximum marginal likelihood is reached and the thinning process removing arcs until no arc deletion will result in an increase of the score (Dash & Cooper, 2004).

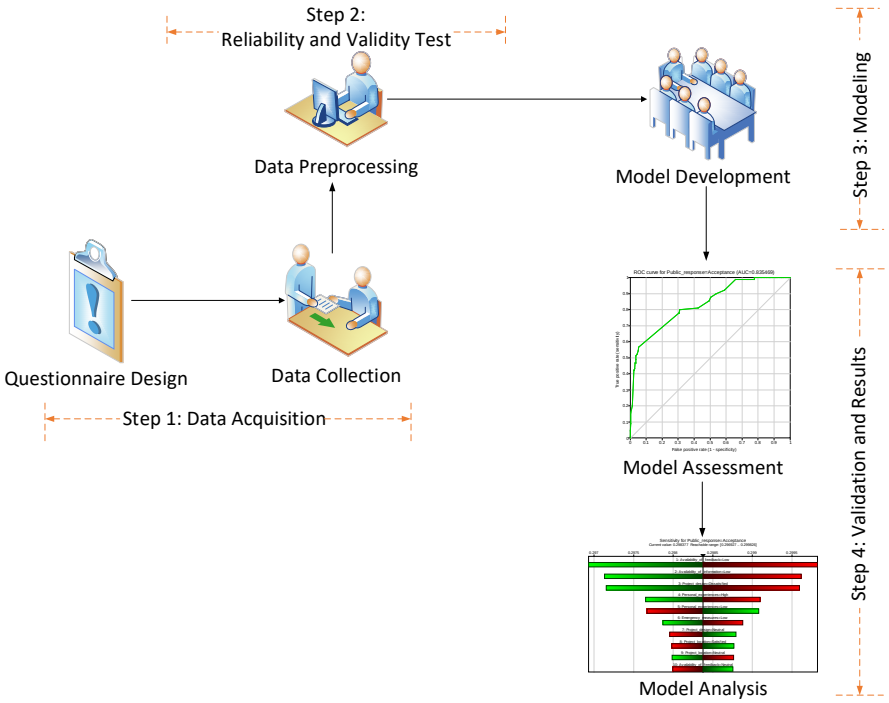

Fig. 7 A Flowchart of Steps of Research Methodology

It is worth noting that both these two approaches could be mixed. The expert could draft the model's structure using domain knowledge, and the CPTs of each node could be extracted from the sample dataset using parameter learning (Koller & Friedman, 2009). Therefore, in this study, we combined these two approaches to construct a BBN model for analyzing factors affecting community acceptance. Using GeNIe 2.3 as the modelling tool, the analysis model is first generated by the GTT algorithm and then revised based on expert knowledge by removing the arcs. The complete model methodology consists of the following steps (see Figure 7).

3.4.4 Dataset descriptions: Data collection

Previously we have demonstrated the theory and the research methodology of a BBN model, as shown in Figure 7. Furthermore, several NBS project attributes and characteristics of local stakeholders and government are prior identified by empirical research to determine the BBN model's structure and parameters.

A dataset obtained from Guyuan city, China, was used to conduct the BBN analysis. These days, to actively address climate change, NBS has become a new nationwide initiative in China, and Guyuan city is one of 16 pilot cities. Guyuan is in the west of China and confronts with extreme climatic conditions[4]. As NBS provides an effective method to increase urban resilience against a changing climate (Sarabi et al., 2019), the promotion of nature-based solutions is in full swing in Guyuan city, and the total investment of phase I has reached €657 million[5]. Part of these projects is community-oriented and connected to the local citizens' daily lives. Therefore, the success and sustainability of these NBS projects largely depend on community acceptance. A face-to-face questionnaire interview was initially designed to solicit local stakeholders' perceptions and attitudes toward NBS. It also includes a series of questions related to the factors of the NBS project and government. For example, local citizens were asked: "*Do you agree that the implementation of nature-based solution projects will bring economic benefits to you, such as an increase in income, property value, or job opportunity?*" and a three-point Likert scale followed the question with the responses from disagree (coded as 1) to agree (coded as 3). Two-stage random sampling was adopted. First, the selected house number was produced through computer sortation. Second, each house number only drew one sample considering family members' similarities. Third, considering actual research requirements, respondents aged 18 and above with financially self-sustaining were chosen. Fourth, when several people stay at home and meet the above conditions, the one willing to participate in the survey is selected; then, a face-to-face structured

[4] Source: https://en.wikipedia.org/wiki/Guyuan
[5] Sources: http://www.zgycrc.com/company/company-show-2844-.html

interview was carried out to survey ten communities in Guyuan from October 1st to October 14th of 2018. A sample of 739 residents was randomly selected (computer sortation) according to the house number in the affected communities via the assistance of related community and unit directors. A total of 657 questionnaires are usable for our study, with an 89% response rate. A breakdown of the demographic structure of the respondents is summarized in Table 7.

It is worth noting that our sample is biased toward higher education, with nearly 30% of the sampled residents completing higher education and 70% completing high school or equivalent vocational education. This bias probably arose because the survey was conducted in urban districts, excluding children and older residents. Another reason is that residents with higher education are more likely to cooperate with the questionnaire survey.

Table 7 The Demographic Structure of the Sample.

Attributes	Description	N	Per cent (%)	Population mean in Guyuan[6]
Age	[ ] Age_18 _to_25	170	25.9	36.6% (Age under 25)
	[ ] Age_25_to_35	258	39.3	14.5%
	[ ] Age_35_to_45	134	20.4	16.0%
	[ ] Age_45_to_55	77	11.7	14.2%
	[ ] Age_over_55	18	2.7	18.7%
Education level	[ ] Under junior school	10	1.5	37.6%
	[ ] High school	457	69.6	35.5%
	[ ] College	135	20.5	13.1%
	[ ] University	39	5.9	9.6%
	[ ] Master and above	16	2.4	4.2%
Income level (CNY /per month)	[ ] Under_2000	60	9.1	28%
	[ ] Between_2000_to_3000	77	11.7	12.7%
	[ ] Between_3000_to_4000	92	14.0	19.0%
	[ ] Between_4000_to_5000	109	16.6	30.2%
	[ ] Over_5000	319	48.6	10.1%

[6] Sources: http://www.stats.gov.cn/tjsj/tjgb/rkpcgb/dfrkpcgb/201202/t20120228_30398.html

3.4.5 Dataset processing: Reliability and Validity test

The data processing aims to analyze the acquired dataset's reliability and validity (Morgan & Waring, 2004). This study uses Cronbach's Alpha Coefficient to test and verify the empirical data reliability. Previous studies have proved that Cronbach's Alpha Coefficient values greater than 0.7 are considered acceptable for analysis (Morgan & Waring, 2004). Table 8 shows the reliability test results, and the value of Cronbach's Alpha Coefficient is greater than 0.7, which is deemed acceptable for further analysis.

Table 8 Reliability Test of the Dataset.

Reliability Statistics	
Cronbach's Alpha	N of items
.818	16

Table 9 Validity Test of the Dataset.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.821
Bartlett's Test of Sphericity	Approx. Chi-Square	4488.119
	df	120
	Sig.	.000

Likewise, KMO and Bartlett's test is conducted to measure the validity of the dataset. The result is shown in Table 9, and the value of KOM is over 0.7, indicating the dataset has convergent and discriminates validity (Morgan & Waring, 2004). Consequently, sixteen variables were used for the BBN analysis.

3.4.6 Model Development and Assessment

In this study, the model is developed by combining expert knowledge and network learning from the dataset. The critical point of constructing a BBN is to determine cause-and-effect relationships between the selected factors. The dataset was

randomly partitioned into two groups. The first section was used as a training dataset to construct the model structure (N=525, 80% of all samples), and the second section was used as the test section to measure the model accuracy (N=132, 20% of all samples). The training dataset was entered into the model as the findings. First, an initial construct is modelled using the greedy thick thinning algorithm with structural learning. With some expert knowledge insights, the model is revised by deleting weak relationships among pairs of factors. Figure 8 shows the final BBN model, firstly created by structural learning and then modified by expert knowledge. In this process, GeNIe 2.3 Academic is applied as the modelling tool.

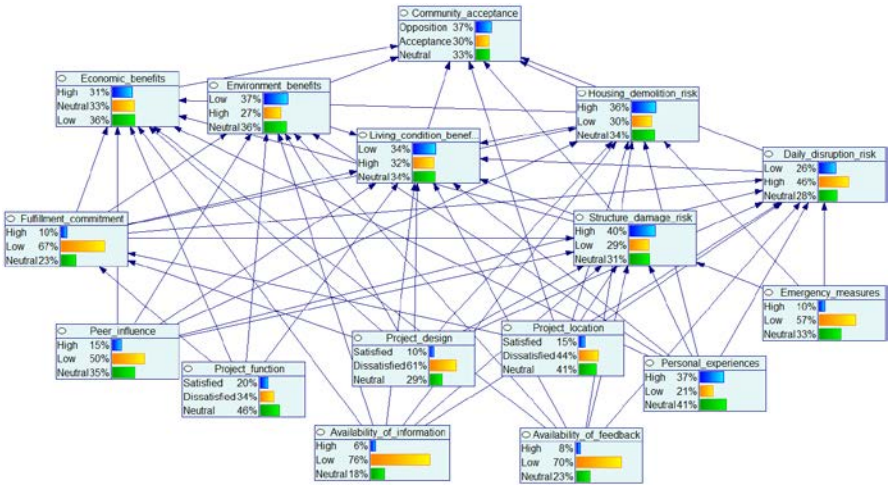

Fig.8 BBN modelling with expert knowledge and structural learning

To validate the model accuracy, two relevant indices are selected to evaluate the performance of the model using the test dataset (N=132, 20% of all samples): (1) the rate of correctly predicted examples (accuracy); (2) the metrics for evaluating overall performance (AUC) (Delen et al., 2020). The performance is measured by a 10-fold cross-validation method. In a 10-fold cross-validation process, the receiver operating characteristic (ROC) is widely used to measure the proposed model's overall performance. ROC curve plots a sensitivity (true-positive rate) by the false-positive rate (1-specificity) in every possible range (Pepe et al., 2006). Additionally, the calculation of the area under the ROC curve (AUC) can evaluate the model

performance. The values of AUC indicate various performance statuses: AUC>0.9 indicates the best performance; AUC=0.7-0.9 indicates reasonable discrimination; AUC<0.7 indicates deficient discrimination (Fielding & Bell, 1997; Greiner et al., 2000). Similarly, an accuracy higher than 0.7 is considered an efficient prediction (Delen et al., 2020).

From the 10-fold cross-validation analysis of the proposed model, the model has high overall efficiency with an accuracy of 0.714. Moreover, the AUCs shown in Figures 9-11 are all greater than 0.8. The result indicates that the model has a better performance than a randomly guessing model and conveys critical classifier information. Therefore, the model can be considered a well-tested and confirmed belief structure with reliable and accurate results, which can be used to guide further decision-making on community acceptance issues.

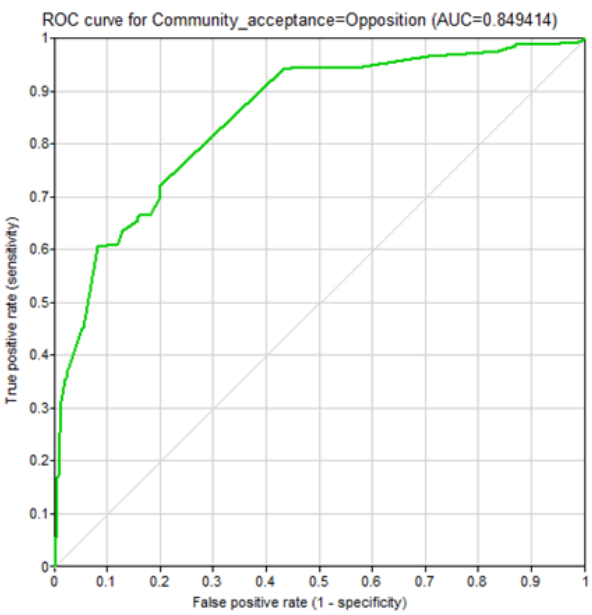

Fig. 9 ROC curves present AUC for (Status=Opposition)

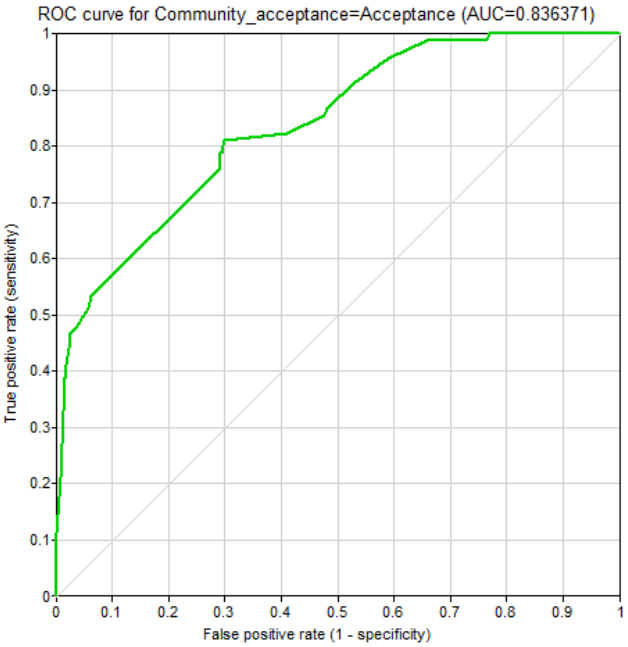

Fig. 10 ROC curves present AUC (Status= Acceptance)

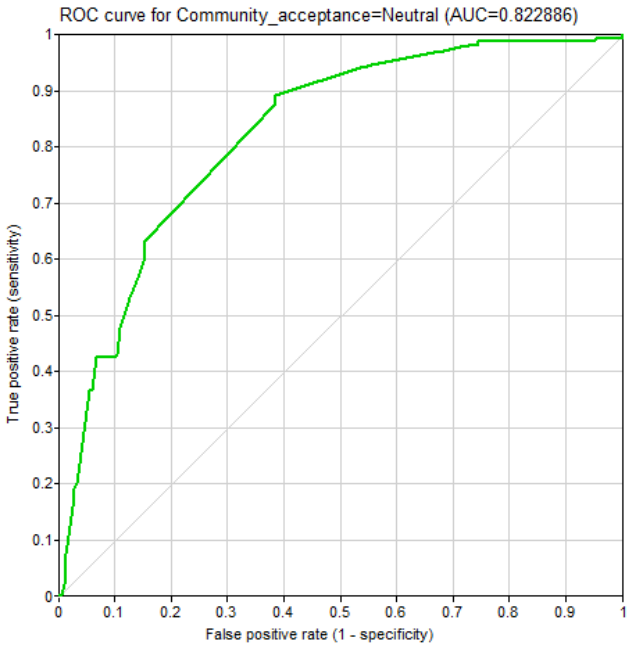

Fig.11 ROC curves present AUC (Status= Neutral)

3.5 Discussion: Sensitivity Analysis

The sensitivity analysis provides a useful technique that presents which factor gives the most accurate information about the existence of the target class. In other words, the nodes in a BBN model are identified and ranked according to their degree of influence on the target node. Highly sensitive nodes affect the reasoning results more significantly (Dlamini, 2010). By calculating the effect of small changes in numerical parameters (i.e., probabilities) on the output parameters (i.e., posterior probabilities), sensitivity analysis could identify and rank the critical factors having the most significant effects on the target nodes in Bayesian networks.

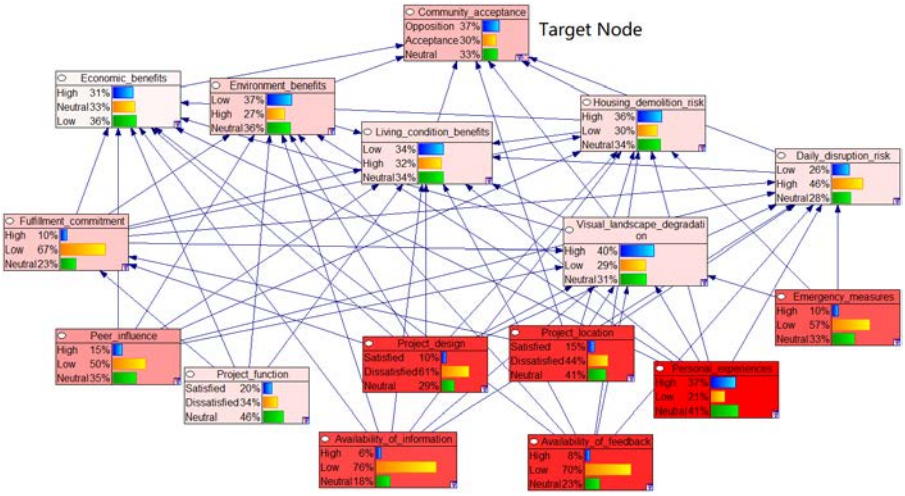

Fig. 12 Sensitivity analysis of the case study

With community acceptance as the target node, the sensitivity analysis results are presented in Figure 12. Nodes are identified in different colours according to their degree of influence on community acceptance. Specifically, the nodes coloured in red are the most significant factors influencing community acceptance of NBS. As sensitivity decreases, the colours of the nodes become lighter. Personal experiences, availability of feedback, project location, project design, availability of information, and emergency measures are the top 6 factors that significantly affect community acceptance, followed by peer influence, fulfilment commitment, and environment protection benefits. Living condition benefits, housing demolition risk, visual

landscape degradation, daily disruption risk, project function, and economic benefits have a minor influence on community acceptance. These results illustrate that these top 6 factors should be given priority in the decision-making process. Figure 13-14, the Tornado diagram, shows the predicted changes in state-beliefs of community acceptance status when the most sensitive variables change by a certain percentage. Furthermore, in Figures 13-14, the most sensitive factors are ranked for a selected state of the target node (opposition or acceptance). The horizontal axis shows the absolute change in the posterior probability of Status=Acceptance or Status=Opposition when each parameter changes by ten per cent. The bar's colour indicates the direction of the change in the target state; red expresses negative, and green represents positive change. In Figures 13-14, a baseline divides the graphic into the left and right parts. The most sensitive parameters for a selected state of the target node (in this case, the Acceptance state of the node Community acceptance) are sorted from the most to least sensitive. For example, in Figure 14, for an acceptance state of the community acceptance node, the most sensitive parameter is the Personal Experience (State=Low). The right part to the baseline is in green. It indicates that when the parameter (Personal Experience, State = Low) increases by a certain percentage, the proportion of the acceptance state will increase by the bar's length.

Therefore, the complicated relationships underlying community acceptance of NBS projects can be revealed by analyzing the Tornado Diagram. Further implications are concluded from the analytical study of the diagram. From Figure 14, the most sensitive factors that significantly influence community acceptance can be demonstrated. The public-related factor, personal experience, is a significant negative impact on community acceptance. This finding seems to contradict the previous research. In this study, personal experience depicts a single individual's experience in a former or similar NBS implementation process (Devine-Wright, 2007; Langemeyer et al., 2018; Peng et al., 2018). Previous studies suggest that personal experiences could increase NBS acceptance as experienced local stakeholders could better understand NBS (Devine-Wright, 2007; Langemeyer et al., 2018). However, we did not find any apparent positive effect of personal experience on increasing community acceptance through the BBN model. Under the Chinese context, the

negative impact of personal experience indicates the failure of involvement of local stakeholders in previous NBS development (Zeng et al., 2018). Therefore, based on a personal value judgment, local stakeholders hold opposition to the new NBS implementation. It's a common phenomenon as government-led decision-making prevails in China. While this kind of decision-making achieved efficiency to some extent, local stakeholders' voices are often overlooked. The poor experiences of local stakeholders in past NBS implementation will significantly weaken their trust in the new government-led NBS, leading to the failure of the proposed project. Besides, it's worth noting that personal experience is the only public-related factor among the top six sensitive factors. The second most critical factor is project location, the project-related factors. In line with the theory of NIMBY, the proximity (project location) of new NBS projects will improve local stakeholders' awareness of the facilities' adverse impact on their daily life. Moreover, previous studies have proved that people living closer to the facilities have a relatively lower level of support for NBS implementation, while those living further away have a higher degree of support (Guo et al., 2015;). However, it is worth noting that the location is not the only factor that significantly influences community acceptance. Community acceptance is not only a NIMBY problem but a complicated reaction from local citizens, which complements previous studies (Guo et al., 2015; Krause et al., 2014; Liu et al., 2018). As stated above, a bulk of factors affect community acceptance, and the improvement of one parameter solely might promote community acceptance but with a limited effect. Then the government-related factors, availability of feedback, and availability of information are found to have a critical impact on community acceptance. When local stakeholders can easily obtain feedback and information on NBS, their acceptance rises significantly. The findings align with previous studies, which show that communication (feedback and information) is essential to project success and sustainable development (Kabisch et al., 2016; Raymond et al., 2017). The following important factor affecting community acceptance is project design. This project-related factor implies a feasible and sustainable design of NBS. The diagram shows that unfeasible and unsustainable design could significantly decrease community acceptance. Similarly, the government-related factor, emergency measures, is

identified as another essential factor influencing community acceptance. Whether local government has taken emergency measures to protect local stakeholders' benefits during NBS implementation also affects community acceptance.

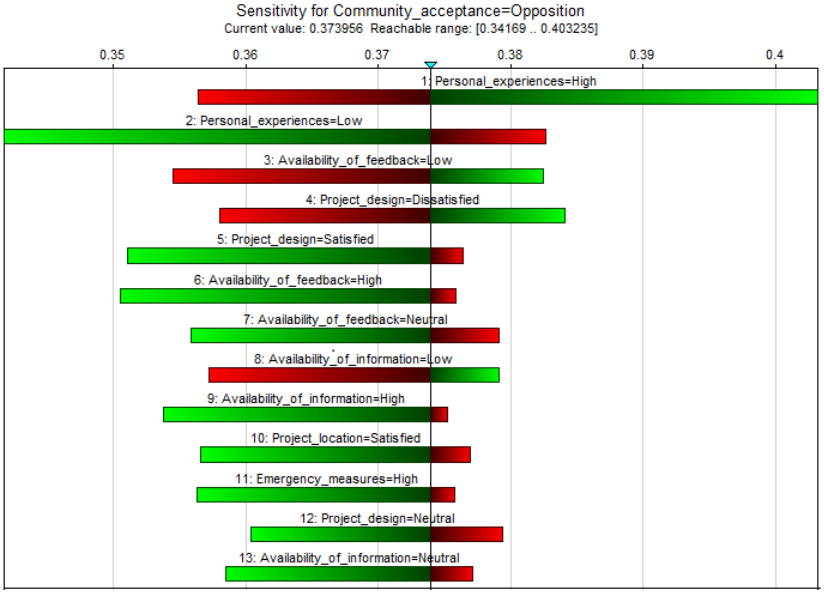

Fig. 13 Tornado diagram of community acceptance (Opposition)

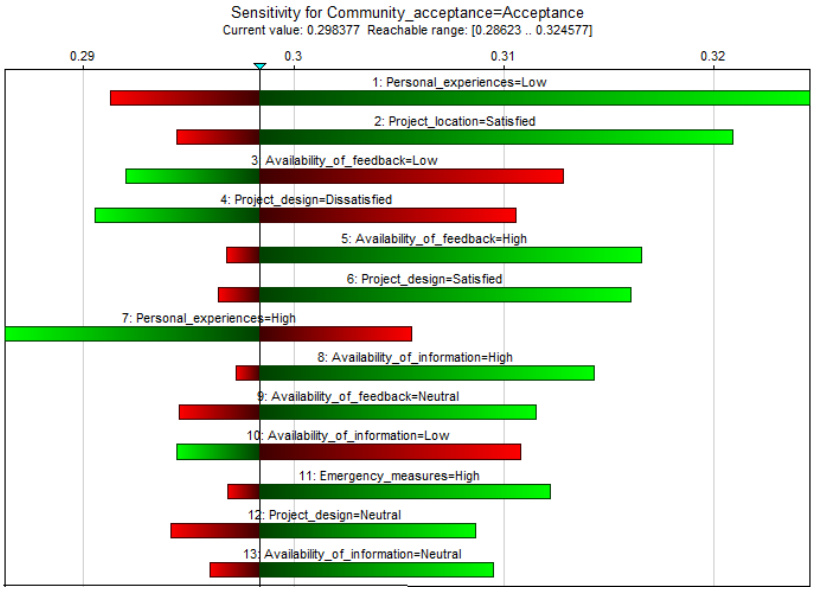

Fig. 14 Tornado diagram of community acceptance (Acceptance)

Therefore, to increase community acceptance significantly, efforts are required to involve local stakeholders in the planning and implementation phase of NBS. It is not only a thoroughly considered location selection but a profound participatory decision-making mechanism with easily accessible information and in-depth discussion on project design and function.

It is worth noting that, in the diagram, changes in some neutral attitudes could significantly influence community acceptance. For example, the positive change in the neutral attitude of project design could promote community acceptance, while the negative change in the neutral attitude toward the project location could decrease. Likewise, Figure 12 illustrates a large portion of the silent majority that hold neutral views towards NBS. This finding denotes that this group's attitudes are also crucial for increasing the proportion of community acceptance at the whole community level. However, most of the time, the attitudes of the silent majority are ambiguous. In this regard, practitioners could stimulate them to express their opinions and get them on board to support NBS implementation.

3.6 Conclusions

This article combines public, government, and project perspectives to explore factors affecting community acceptance in NBS implementation. Based on an NBS implementation survey in China, this study presents survey data analyses on 657 local stakeholders to reveal the cause-and-effect relationships between various factors and community acceptance. The findings suggest that government- and project-related factors are two main aspects affecting community acceptance, while only one public-related factor is found to have such a mega effect. Specifically, the government-related factors - availability of feedback, availability of information and emergency measures, project-related factors - project location and project design, and the public-related factor - personal experience have the most significant effects on community acceptance. Peer influence, fulfilment commitment, and environmental protection benefits have limited impacts, while living condition benefits, housing demolition risk, visual landscape degradation, daily disruption risk, and economic benefits have the most negligible influence on community acceptance of NBS.

This study makes two main contributions to current scholarly literature. First, the meagre existing literature has revealed that it remains poorly understood why local stakeholders have a low-level acceptance of NBS. This study represents one of the first efforts to fill this critical void by focusing on community acceptance. Beginning with distinguishing community acceptance from social acceptance, we construct a set of variables at the community level, such as local stakeholders' perceptions and attitudes, to explore their impacts on community acceptance. Second, we highlight the cross-sectoral effects of the public, the government, and the project factors on community acceptance to better understand the cause-and-effect relationships underlying the acceptance variables.

The findings reveal that a bulk of factors influence community acceptance greatly, and the impact is limited to only a few factors. In other words, it is impossible to increase community acceptance by solely improving the most concerning factor. Therefore, it is common for many project developers to cancel or relocate the hampered project to another community with high acceptance or indifferent attitudes at this moment. With this study, practitioners are encouraged to build an efficient communication and consultation mechanism instead, which could improve the availability of feedback and information to local stakeholders. In addition, the transparent communication and consultation mechanism could improve local stakeholders' sceptical stereotype of government-led projects and provide an in-depth discussion on project design and expectations. Finally, it is worth noting that many respondents have indifferent attitudes towards NBS, grouped as the silent majority in urban planning and development. Their attitudes cannot be ignored due to their considerable proportion of the total population. Therefore, enhancing the silent majority's acceptance is also critical to project success and urban sustainability.

Several limitations of this study should be noted. Admittedly, a single case within the Chinese context is insufficient to cover other countries' prevailing situations. For example, personal experience is an essential negative factor affecting community acceptance in this study. As stated above, this factor refers to a single individual's past experience in NBS implementation. Generally, it denotes local stakeholders'

attitudes towards government-led decision-making in this study. Obviously, different decision-making styles of NBS or socio-cultural backgrounds in other countries will change this factor's weight impact on community acceptance. Still, this study provides a new research perspective and methodology, which are of considerable significance to other countries experiencing fast growth in NBS implementation. Future research can further explore the characteristics of the silent majority and the relationships with NBS success.

This chapter built a valuable framework to explore NBS acceptance at the community level, contributing to understanding the current situation of NBS adoption and implementation in China. The assessment framework analyzed residents' attitudes and perceptions of new NBS projects in their neighbourhood and found many respondents in the survey belonged to the silent majority. With a very high probability, the silent majority indifferent to NBS projects would not be engaged in the involvement of NBS projects. Therefore, in the extended research, it is necessary to consider this when conducting fieldwork in the case of Guyuan.

CHAPTER 4

EXPLORING KEY DETERMINANTS OF WILLINGNESS TO PARTICIPATE IN EIA DECISION-MAKING OF NBS

This chapter is partially reproduced from:

Dai, L., Han, Q., de Vries, B., & Wang, Y. (2022). Exploring key determinants of willingness to participate in EIA decision-making on urban infrastructure projects. Sustainable Cities and Society, 76, 103400.

Abstract: Conflicts caused by nature-based solutions significantly threaten city sustainability. Against this backdrop, getting citizens' voices heard in project EIA decision-making has been praised highly for mitigating interest conflicts between citizens and authorities. However, the current situation of citizen participation is still stuck in the rut of excessive government intervention and low citizens' willingness. The reasons underlying citizens' low willingness to participate are unclear and often overlooked in existing studies. Based on a random survey conducted in Guyuan, this study investigates how different social-psychological factors affect citizens' willingness to participate in project EIA decision-making based on the extended theory of planned behaviour. The findings reveal that (1) social influence, perceived benefits, and perceived enablers are three significant factors directly affecting willingness to participate, while information acquisition and consultation channels indirectly influence willingness to participate. (2) Negative effects of social influence mediate the positive impact of information acquisition on perceived benefits, finally contributing to a low willingness to participate. This study provides valuable inputs for the government to promote citizens' willingness to participate in project EIA decision-making and valuable references for further participatory design and planning.

Keywords: EIA decision-making; Citizen Participation; Nature-based solutions; Willingness to Participate; the Unengaged; Structural Equation Modeling

4.1 Introduction

These days, interest in nature-based solutions (NBS) is on the rise due to its acceleration in driving urban development and tackling climate-related risks, particularly in the era of urban renewal. These projects facilitate the creation of amenities, community, and welfare facilities but still face crucial challenges in the planning and implementation. In an intricate urban context, the externalities caused by these projects, such as environmental pollution and land acquisitions, may stir up public opposition and protest, threatening project success and city sustainability. Against this backdrop, getting citizens' voices heard in the EIA decision-making of NBS is highly recommended by scholars and experts. Getting citizens' voices heard aims to mitigate conflicts between citizens and authorities and entails citizen participation. Previous studies suggest that citizen participation can enable information exchange between various stakeholder groups and allow all stakeholder groups to negotiate "in an open and transparent" manner (Li et al., 2016). Notably, citizen participation can mediate the contradictions among multiple interest groups, improve the scientific, democracy, and effectiveness of EIA decision-making, and strengthen city sustainability and community stability (Yi & Yang, 2021).

Citizen participation in EIA decision-making is an individual's subjective judgment based on various factors, including individual internal and social external aspects (Kuang & Lin, 2021; Rajapaksa et al., 2019). However, in some developing countries, government-led participation still prevails and is regarded as "little more than a formality" (Manowong & Ogunlana, 2006; dell'Olio et al., 2019). Concurrently, citizens' willingness to participate is consistently stuck at a low level, and only a minority seems to have higher aspirations for effective participation exercise (Swapan, 2014). In addition, although a variety of studies unanimously asserted that citizen participation is an indispensable condition for effective EIA decision-making, the existing scholarship in this field pays too much attention to the co-benefits, effectiveness, and degrees of participation while neglecting whether citizens are willing to participate (Koch & Christ, 2018; Mei-yung et al., 2013; Nikkhah & Redzuan, 2009).

For citizen participation, whether citizens are willing to participate in the EIA decision-making determines the effectiveness of participatory behaviours (Wilcox, 1994; Zhang et al., 2011). Without regard to the minor deviation between citizens' willingness to participate and the conduct of participation, there is an assumed potential premise in many participatory studies that citizens' attitude towards participation is completely positive when given the opportunity. For example, in the research on degrees of citizen participation, many scholars classify the degrees based on the redistribution of power between citizens and authorities while ignoring whether citizens are genuinely willing to participate. In this regard, Arnstein (1969) explained citizen participation as "a little like eating spinach": *no one is against it in principle because it is good for you*. And yet, a fundamental question may emerge: "if participation is so rewarding and effective, why does not everyone participate?" (Wandersman & Giamartino, 1987). Therefore, in response to insufficient explorations on willingness to participate, this paper tries to complement existing studies and theories by investigating factors affecting willingness to participate in the project EIA decision-making process. Specifically, this paper attempts to answer two questions: what factors affect willingness to participate in the EIA decision-making of NBS? And how do the factors affect willingness to participate?

This study bridges the gap of current participatory research on two significant aspects. Firstly, it is among the first attempts to develop a systematic understanding of how various factors affect willingness to participate in the EIA decision-making of NBS. Although a growing body of literature has noted citizens' aspirations in the participation process, most achievements have neither clearly revealed what factors can affect willingness to participate nor thoroughly examined the cross-effects of these factors. Secondly, compared with existing literature, this study provides new insights into citizens' aspirations in participating in urban development and reveals the issues behind low willingness to participate in social behaviour.

The rest of the paper is structured as follows. Beginning with introducing citizen participation, Part 2 discusses the research gap in previous participatory research. Part 3 and Part 4 describe the theoretical basis and methodologies, respectively. Part 5

presents the findings, and finally, conclusions are drawn in Part 6, showing the implications and sharing the understanding. Figure 15 demonstrates the structure of the paper.

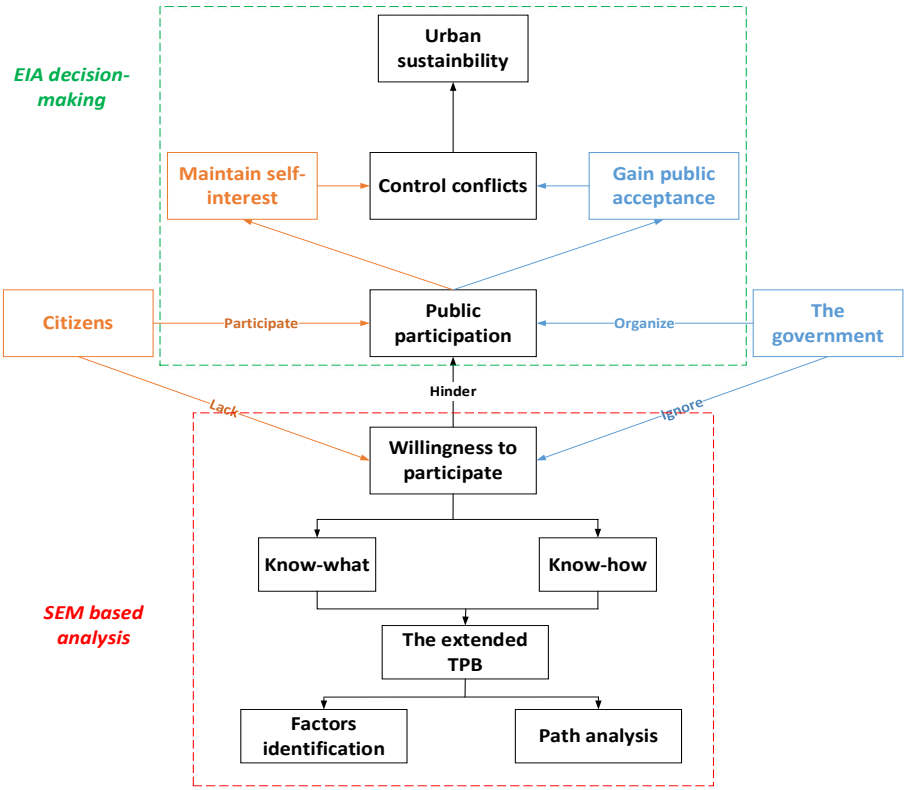

Fig. 14 Research Framework of Willingness to Participate in NBS

4.2 Literature Review

In different domains, citizen participation may vary greatly in the definitions, types, and methods. The awareness of citizen participation was raised in the late 1960s. It was first systematically elucidated by Arnstein in 1969 with the "ladder of participation" theory. Arnstein (1969) interpreted citizen participation as a power redistribution process between citizens and authorities through nonparticipation, tokenism, and empowerment. The theory mainly elaborates on types and forms of participation according to the power position of citizens and suggests that citizens

should avoid lower levels of participation to obtain control over decision-making. Arnstein's seminal work is essential for participation research as it firstly provides a clear definition and classification of citizen participation. Follow-up researchers adopt Arnstein's gradations of participation and expand her seminal study from different perspectives, such as objective discussion (Uittenbroek et al., 2019), method development (Creighton, 2005; Hampton, 1977), effectiveness evaluation (Day, 2017; Wu et al., 2019), as well as their links and interactions (Hjortsø, 2004; Xie et al., 2014).

Based on the ladder of participation theory, scholars and experts strive to pursue a higher degree of participation in a participatory process. Bruns (2003) contended that "high degrees of participation are the desirable goal and that a low degree of participation is a result of government attempts to restrict and manipulate participation." However, high-degree participation does not mean a more effective participatory exercise. Focusing instead on the effectiveness of participation, some scholars have tried to identify the expected effective participation based on the degree to which participation is applied. For example, Hjortsø (2004) deemed that the criteria for effective participation may vary according to the degree of participation targeted. Other scholars even found that different participation techniques with diverse degrees may have different effectiveness for specific stakeholder groups as various stakeholder groups may have other objectives in a participation process (Glasson et al., 2005; Hurlbert and Gupta, 2015). However, effective participation is not accessible due to diverse standpoints and tedious procedures (Buchy and Hoverman, 2000; Zhou et al., 2019). A survey revealed that citizen participation practice in China has seldom been effective in nearly 20 years (Shan, 2012). Even in many developed countries with better democratic circumstances like the Netherlands, the effectiveness of participation still leaves much to be desired (Uittenbroek et al., 2019; Yu & Leung, 2015). Against this backdrop, many scholars focused on evaluating citizen participation effectiveness and further explored the constraints hindering participation effectiveness. For example, through a game theory model and social utility equation, Wu et al. (2019) measured the effectiveness of citizen participation and found that institutional arrangements and social responsibility are two main barriers hampering the effectiveness. Relevant literature has similar studies from different perspectives to

investigate the obstacles affecting the effectiveness of citizen participation (de Oliveira and Partidário, 2020; Rowe and Frewer, 2000).

In addition to legal and institutional barriers from the local government's perspective (Yang, 2008; Heberer, 2009; Wang et al., 2020), however, there is insufficient attention to exploring the effectiveness of participation from the perspective of citizens (Li et al., 2016; Swapan, 2014). Indeed, these studies provide an in-depth understanding of the effectiveness and offer suggestions for improving citizen participation effectiveness. However, concerns are emerging these days as citizens' aspirations for participation are found increasingly crucial to effective participation (Zhang et al., 2011). Before discussing how to achieve effective participation in different contexts, some of the drawbacks and limitations of previous participation research from the perspective of citizens will be reviewed first.

Previous studies on citizen participation have inadvertently assumed a vital precondition that citizens may be actively and publicly involved in EIA decision-making when given the opportunity. However, as the main actors in the participatory process, citizens and their willingness to participate are largely overlooked. Wall et al. (2006) found that active citizens are essential to citizen participation success. And yet, the ensuing problem is also apparent: what factors can affect the willingness to participate in the EIA decision-making of NBS? Taking China as an example, Shan et al. (2011) indicated that citizens' dependence on the government for large-scale urban infrastructure projects results in a passive awareness of participation. Furthermore, the study of Swapan (2016) defines a range of social, political, and psychological factors affecting willingness to participate, such as trust in the planning agency, sense of urgency, economic condition, etc. These identified factors are then ranked based on respondents' relative judgment through a rank-order analysis. However, the rank-order analysis cannot reveal how these factors affect willingness to participate. In this sense, the study of Swapan (2016) is insufficient to explore the factors affecting willingness to participate. Meanwhile, the theory of planned behaviour (TPB) is widely introduced to explore the interrelationships between socio-psychological factors and willingness to participate. For example, Kalkbrenner &

Roosen (2016) constructed a conceptual model extended on TPB and revealed how community identity, social norms, trust, and environmental concern affect residents' willingness to participate in community-based renewable energy projects by regression analysis. This study, however, oversimplified the determinants of willingness to participate without considering the latent characteristic of these socio-psychological variables. In addition, the regression analysis is not enough to test the complex interrelationships among these socio-psychological variables. For example, the impact of interactions between different factors on willingness to participate is largely ignored. Therefore, this paper attempts to fill these gaps by exploring the determinants of willingness to participate and testing the interrelationships based on an extended TPB model.

4.3 Theoretical basis and hypotheses development

4.3.1 The theory of planned behaviour

Willingness to participate implies the behavioural intention of participatory behaviour, and it is necessary to explore willingness to participate from the perspective of behavioural analysis. At this point, the theory of planned behaviour (TPB), as given by Ajzen (1991), was adopted and extended to explore willingness to participate. The TPB model provides a paradigm of how different socio-psychological factors together shape an individual's behaviours in the context of social psychology. As shown in Figure 16, the TPB reveals the fundamentals of social behaviour. It states that an individual's behavioural intention is shaped by the attitude towards behaviour, subjective norms, and perceived behavioural control (Ajzen, 1991), which forms the theoretical backbone for exploring willingness to participate in this study.

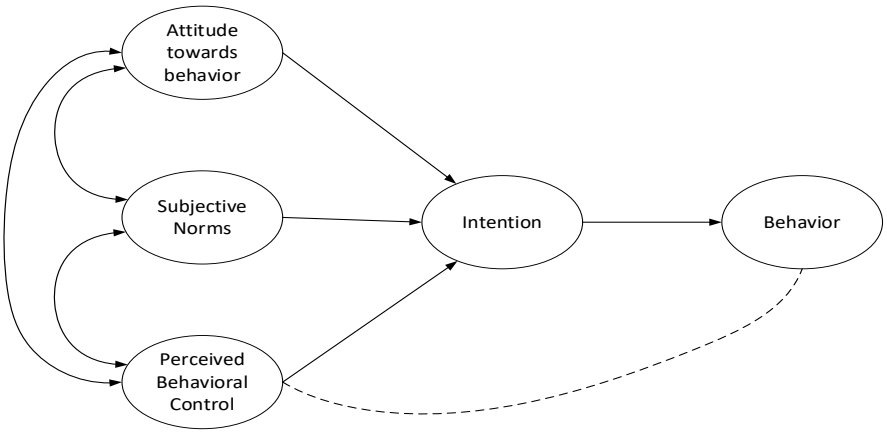

Fig. 15 Structural Diagram of Action Logical for TPB, adapted from Ajzen (1991)

4.3.2 Hypotheses development based on the extended TPB

It is worth mentioning that TPB is widely utilized to explore factors affecting citizen participation but receives a lot of criticism for insufficiency in explaining other significant predictors of specific participatory behaviour. For example, in the research on public willingness to improve air quality, Fu et al. (2019) extended the original TPB model by adding two additional factors, environmental concern and sense of duty. The new model results also prove the improvement of the explanatory ability of the extended TPB model. Therefore, some scholars deemed that supplementary variables could be comprised in the TPB model to improve the explanatory power and scope, taking into account different research contexts (Ma et al., 2018). Conceptualizing the framework of TPB into the field of citizen participation, this paper extends the TPB model by contextualizing the core components of TPB and integrating additional variables. Following the suggestion of (Swapan 2016; Rega & Baldizzone, 2015), information acquisition and consultation channels are included in the TPB model in this study. Table 10 shows the sources and descriptions of prospective factors.

4.3.2.1 Attitudes, Subjective Norms, and Perceived behaviour control

Ajzen (1991) advanced three core components in the TPB model: attitude, subjective norms, and perceived behaviour control. According to the theory, the three factors

together determine an individual's behavioural intentions. However, considering the heterogeneity of willingness to participate and understandability of variables, this study replaces attitude, subjective norms, and perceived behaviour control with perceived benefits, social influence, and perceived enablers. Furthermore, given the presence of abstract concepts in the TPB model, this study establishes observed variables for observing and measuring.

Perceived benefits are defined as the awareness or consciousness of potential positive outcomes of participatory behaviour (Ajzen, 1991). This study selects whether participatory actions will make a difference in project design, negative impact control, and social stability to measure citizens' attitudes towards participation (Lowndes et al., 2001). Previous studies have shown that perceived benefits significantly affect an individual's behavioural intention in environmental behaviour (Fu et al., 2019; Wang et al., 2018). Social influence implies participants' "perceived social pressure to perform or not perform the behaviour" (Ajzen, 1991), revealing a tendency of collective action in social networks. It refers to the influence on one's participatory behaviour from peer groups, family members, or the general culture. This study uses influences from friends, neighbours, and homeowner associations (grass-root government in China) to measure social influence. Previous studies contended that social influence shapes one's behavioural intention in participatory behaviour out of a sense of duty towards maintaining community identity and trust in others (Lelieveldt, 2004). Social influence significantly affects community activities at the local level (Kalkbrenner & Roosen, 2016). Perceived enablers refer to the perception of the government's support to make participation possible (Hartley & Wood, 2005; Shan, 2012). In this study, perceived enablers specify lowering the costs and barriers to engaging in project EIA decision-making, which could lay the foundations for active participation. Participation requires special skills and knowledge from citizens. Citizens are deterred from participation when there are lots of constraints (Lowndes et al., 2001). Therefore, perceived enablers are put forward to mention citizens' perceptions of the enablers they may get in the participatory process, referring to sufficient guidance, appropriate planning and design, and effective knowledge-sharing mechanisms. Previous studies have demonstrated that barriers, such as lack of

guidance, downcast the willingness to participate (Hartley & Wood, 2005; Kantamaturapoj et al., 2018). Citizens may be more willing to participate in an activity with fewer barriers and sufficient support (Fang et al., 2017). Then based on the original TPB, the following three hypotheses are proposed:

H1: Perceived benefits have a significant impact on willingness to participate.

H2: Social influence has a significant impact on willingness to participate.

H3: Perceived enablers have a significant impact on willingness to participate.

4.3.2.2 Additional variables in the extended TPB

In addition to the core components of the TPB model, there are some other factors affecting citizens' willingness to participate in the EIA decision-making of NBS projects. As Kuang and Lin (2021) indicated, willingness to participate is an individual's subjective judgment based on individual internal and social external factors. Among these factors, information acquisition and consultation channels have been mentioned extensively across the participatory literature (Swapan, 2016; Rega & Baldizzone, 2015).

Information acquisition refers to the process through which an individual obtains information from external sources. In this study, information acquisition mentions the ability to obtain and understand information about proposed projects and citizen participation from the formal network. As authorities are in a dominant position, information acquisition largely depends on formal information dissemination networks. In this study, information acquisition is measured by accessibility, completeness, and understandability of information. During EIA decision-making, information sharing with citizens is a very different matter to promote citizen participation (Rega & Baldizzone, 2015). Previous studies have proved that information has a considerable impact on participants' perceptions of participatory behaviour (Brombal et al., 2017). Accessible information can promote realizing a positive perception of participation (Sarvilinna et al., 2018). In some studies,

information sharing is deemed an essential form of citizen participation (Rega & Baldizzone, 2015). Consequently, the following hypothesis is proposed:

H4: Social influence has a significant impact on information acquisition.

H5: Information acquisition has a significant impact on perceived benefits.

Consultation channels denote the possibilities of formally consulting or discussing (Brombal et al., 2017). In this study, consultation channels focus more on submitting comments from citizens and feedback from authorities. In some studies, consultation meeting is considered an alternative form of citizen participation (Rega & Baldizzone, 2015). As authorities are dominant, the possibility and efficiency of consultation channels are citizens' concerned issues. Therefore, the availability, typology, and scope of consultation channels are selected to measure consultation channels in this study. Poor consultation channels could lead to low public awareness of citizen participation (Swapan, 2016). In project EIA decision-making, consultation channels ensure sufficient guidance from authorities and appropriate consideration of citizens' concerns and, therefore, lower participation thresholds (Hartley & Wood, 2005). Consequently, the following hypothesis is proposed:

H6: Consultation channels have a significant impact on information acquisition.

H7: Consultation channels have a significant impact on perceived enablers.

Figure 17 provides the hypothetical model of willingness to participate based on the extended TPB model.

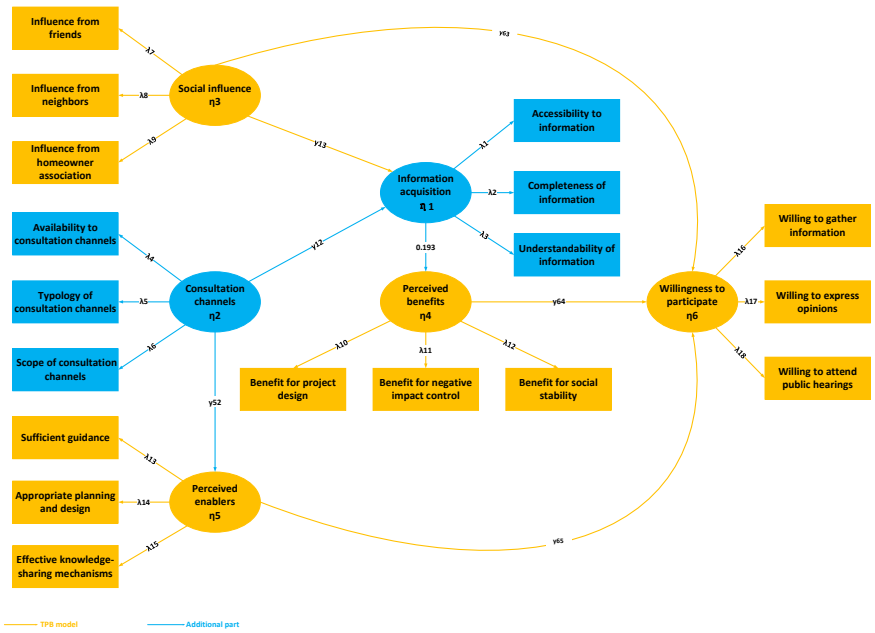

Fig. 16 Hypothetical model based on the extended TPB

Table 10 The Attributes of Identified Variables

Variables		Descriptions	Swapan, 2014, 2016	Shan, 2012	Kalkbrenner & Roosen, 2016	Fang et al., 2017	Rega & Baldizzone, 2015	Brombal et al., 2017	Lowndes et al., 2001	Hartley & Wood, 2005	Sarvilinna et al., 2018
Information Acquisition η1	Accessibility to information X_4	Information on project/participation is accessible	✓			✓	✓	✓	✓	✓	✓
	Completeness of information X_5	The acquired information is complete	✓			✓	✓	✓	✓	✓	✓
	Understandability of information X_6	The acquired information is understandable	✓			✓	✓	✓	✓	✓	✓
Consultation Channels η2	Availability of consultation channels X_7	Consultation channels are available	✓			✓	✓	✓	✓	✓	
	Typology of consultation channels X_8	Different typologies of consultation channels	✓			✓	✓	✓	✓	✓	
	Scope of consultation channels X_9	Concerns could be fully expressed through consultation channels	✓			✓	✓	✓	✓	✓	
Social Influence η3	Influence from friends X_{10}	Friends influence participation	✓		✓	✓			✓		
	Influence from neighbours X_{11}	Neighbours influence participation	✓		✓	✓			✓		
	Influence from homeowner association X_{12}	Homeowner associations influence participation	✓		✓	✓			✓		

Perceived Benefits η4	Benefit for project design X_{13}	Participation is beneficial for project design		✓		✓			✓	✓	✓
	Benefit for negative impact control X_{14}	Participation is beneficial for the negative impact control		✓		✓			✓	✓	✓
	Benefit for social stability X_{15}	Participation is beneficial for social stability		✓					✓	✓	✓
Perceived Enablers η5	Sufficient guidance from the government X_{16}	Sufficient guidance from the government for participation		✓	✓	✓			✓	✓	✓
	Appropriate planning and design X_{17}	Appropriate planning and design for participation		✓	✓	✓			✓	✓	✓
	Effective knowledge-sharing mechanisms X_{18}	An effective knowledge-sharing mechanism for participation		✓	✓	✓			✓	✓	✓
Willingness to Participate η6	Willing to gather information X_{19}	Willing to gather information about participation and project	✓	✓	✓		✓				✓
	Willing to express opinions X_{20}	Willing to express concerns	✓	✓	✓		✓				✓
	Willing to attend public hearings X_{21}	Willing to attend given opportunities available	✓	✓	✓		✓				✓

4.4 Methodology and Material

4.4.1 Principles and Justification of SEM

In this study, the structural equation model (SEM) is applied to analyze factors affecting willingness to participate. SEM is a multivariate statistical technique that includes the measurement model to estimate relationships between observed and unobserved variables and the structural model to calculate interrelationships among various unobserved variables (Qureshi & Kang, 2015; Wang et al., 2016). By measurement model, latent variables can be measured by a set of observed variables known as Confirmatory Factor Analysis (CFA). CFA is used to examine whether a cause-effect conclusion can be made from the available statistical data. When the "measurement model" is proved appropriate, it makes sense to analyze the latent variables' structural relationships. The possibility of measuring complex correlations and multiple unobserved variables was considered the main advantage and the main reason for using SEM (Hair et al., 2013). Although techniques like multiple regression analyses and rational decision-making models can measure multiple variables, these methods are unsuitable for this study as they only accommodate simple dependencies among the various variables (Qureshi & Kang, 2015). The rational decision-making model (e.g., Swapan, 2016) cannot reveal the complex interrelationships between the multiple factors, while binomial logistic regression (e.g., Kalkbrenner & Roosen, 2016) cannot be visually compared to SEM. In addition, this study aims to test and verify the hypothetical relationships constructed on the extended TPB. Considering the completeness of the data and the solid theoretical basis, this study uses covariance-based SEM (CB-SEM) rather than partial least square SEM (PLS-SEM) to conduct the analysis. Moreover, the CB-SEM is advantaged in efficiently evaluating the fitting effects through the goodness-of-fit indices. In this process, AMOS 22.0 is applied as the modelling tool.

4.4.2 Dataset descriptions: Data collection

A field survey of NBS in Guyuan was conducted to collect data from October 1st to October 14th of 2018. The design of EIA decision-making in NBS projects symbolizes the orthodox style of urban planning, which is a government-led and top-down

process. In addition, the NBS projects in Guyuan (Phase I) are under planning, and the entire EIA decision-making process can be covered and observed.

Guyuan is in the west of China and confronts with extreme climatic conditions[7]. To actively address climate-related risks, NBS has become a new nationwide initiative in China, and Guyuan city is one of 16 pilot cities. The promotion of NBS is in full swing in Guyuan city, and the total investment of phase I has reached €657 million[8]. Part of these projects is community-oriented and connected to the local citizens' daily lives. Therefore, the success and sustainability of these projects largely depend on citizens' attitudes. In this study, 16 communities were selected within Guyuan to cover all the implementation of NBS (Phase I). The residents of each community (nearly 700 households per community) were considered the sampling population. They are the affected groups and can potentially participate in the EIA decision-making of NBS. In Figure 18, the coloured areas indicate the survey scope.

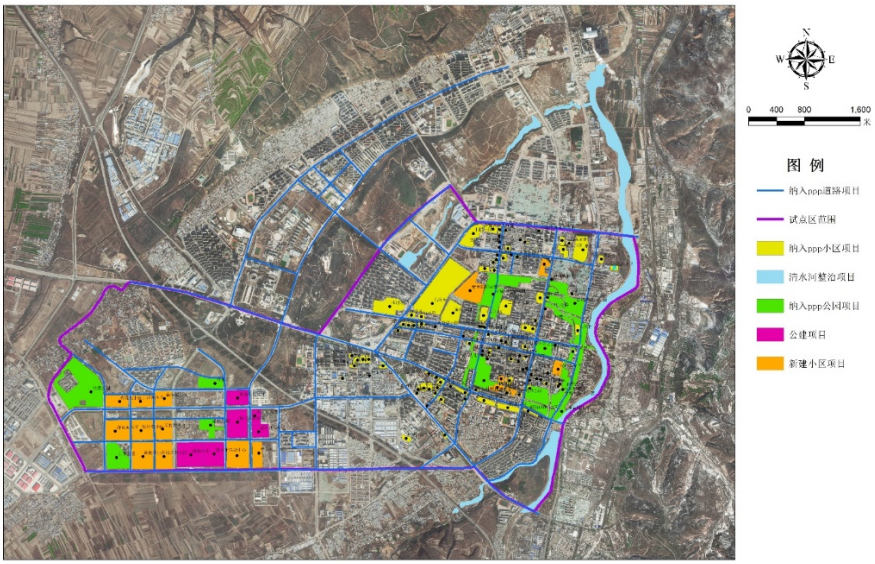

Fig. 17 The Map of nature-based solutions in Guyuan

[7] Source: https://en.wikipedia.org/wiki/Guyuan

[8] Sources: http://www.zgycrc.com/company/company-show-2844-.htm

A questionnaire was designed to solicit citizens' subjective assessment of participatory behaviour in EIA decision-making of NBS projects in Guyuan (Phase I). Based on the template of the TPB questionnaire, a five-point Likert scale was used to create the questionnaire. For example, the question used to measure information acquisition included: "How do you assess the information release in NBS: (1) Do you think the information is accessible? (2) Do you think the information is complete? (3) Do you think the information is understandable?" Respondents were required to assess each item on a five-point scale from 1 = "strongly disagree," 2 = "disagree," 3 = "neutral," 4 = "agree" to 5 = "strongly agree," with a higher score denoting a higher level.

Table 11 Sample Descriptions: Gender, Age, Education Level, and Income Category

Attributes	Description	N	Per cent (%)	Population means
Age	[] Age_18 _to_25	170	25.9	36.6%
	[] Age_25_to_35	258	39.3	14.5%
	[] Age_35_to_45	134	20.4	16.0%
	[] Age_45_to_55	77	11.7	14.2%
	[] Age_over_55	18	2.7	18.7%
Education level	[] Under junior school	10	1.5	37.6%
	[] High school	457	69.6	35.5%
	[] College	135	20.5	13.1%
	[] University	39	5.9	9.6%
	[] Master and above	16	2.4	4.2%
Income level (CNY /per month)	[] Under_2000	60	9.1	28%
	[] Between_2000_to_3000	77	11.7	12.7%
	[] Between_3000_to_4000	92	14.0	19.0%
	[] Between_4000_to_5000	109	16.6	30.2%
	[] Over_5000	319	48.6	10.1%

Two-stage random sampling was adopted. First, through the preliminary survey, the inappropriate items and semantic problems in the questionnaire are found and corrected. Then a face-to-face questionnaire survey was conducted through random sampling. According to the sample size, which was designed to be 600, each community was required to select two or three apartments randomly. Their residents were visited and interviewed, ensuring each individual had an equal probability of being chosen. First, the selected house number was produced through computer sortation. Second, each house number only drew one sample considering family members' similarities. Third, considering actual research requirements, respondents aged 18 and above with financially self-sustaining were chosen. With an 89% response rate, 657 questionnaires are valid to offer information about individual characteristics, attitudes, and perceptions towards citizen participation. A breakdown of respondents' characteristics is described in Table 11.

4.4.3 Data Reliability Testing

Data reliability testing's primary purpose is to ensure empirical data reliability for calculating and analyzing (Hair et al., 2013). In this study, Cronbach's α is used to test and verify the reliability of empirical data. Previous studies have proved that the values of Cronbach's α greater than 0.7 are considered suitable for analysis (Chen et al., 2011). In line with this view, Cronbach's α of empirical data are all greater than 0.700, indicating the reliability of data is acceptable (seen in Table 12).

Table 12 Reliability analysis.

Variables	Overall	Perceived benefits	Information acquisition	Willingness to participate	Social influence	Consultation channels	Perceived enablers
Cronbach's α	0.830	0.800	0.839	0.887	0.886	0.805	0.803

4.4.4 Model Assessment and Modification

A “good model fit” is the basis for model calculation and analysis. The goodness-of-fit of SEM implies the hypothetical model's appropriateness, reflecting how well the hypothetical model fits empirical data and is also an essential reference for model revision and development (Chen et al., 2011). Generally, goodness-of-fit indices are applied to measure the fit between the hypothetical model and the observed covariance matrix (Xiong et al., 2014). Here, six indices are chosen to measure the comprehensive goodness of fit (Table 13).

The goodness-of-fit indices of the hypothetical model indicate that the model is acceptable. At a 95% confidence interval, all variables show significant associations with other variables within a latent construct and with other variables across the entire hypothetical model, as shown in Figure 19.

4.5 Results

Since the goodness-of-fit is proved acceptable, correlations between the unobserved variables are replaced with the hypothesized causal relationships, as shown in Figure 19. The result demonstrates that citizens’ aspiration of participation in EIA decision-making is significantly affected by the variables in the extended TPB.

Table 13 Comparison of goodness-of-fit measures

Index	Reference values	Hypothetical model
Chi-square	1~3, good fit	2.43
GFI	>=0.80	0.856
AGFI	>=0.80	0.809
RMSEA	<0.05, good fit; 0.05~0.08, reasonable fit	0.012
NFI	>=0.90, good fit; 0.6~0.9, reasonable fit	0.0.797
CFI	>=0.90, good fit; 0.6~0.9, reasonable fit	0.820
TLI	>=0.90, good fit; 0.6~0.9, reasonable fit	0.787

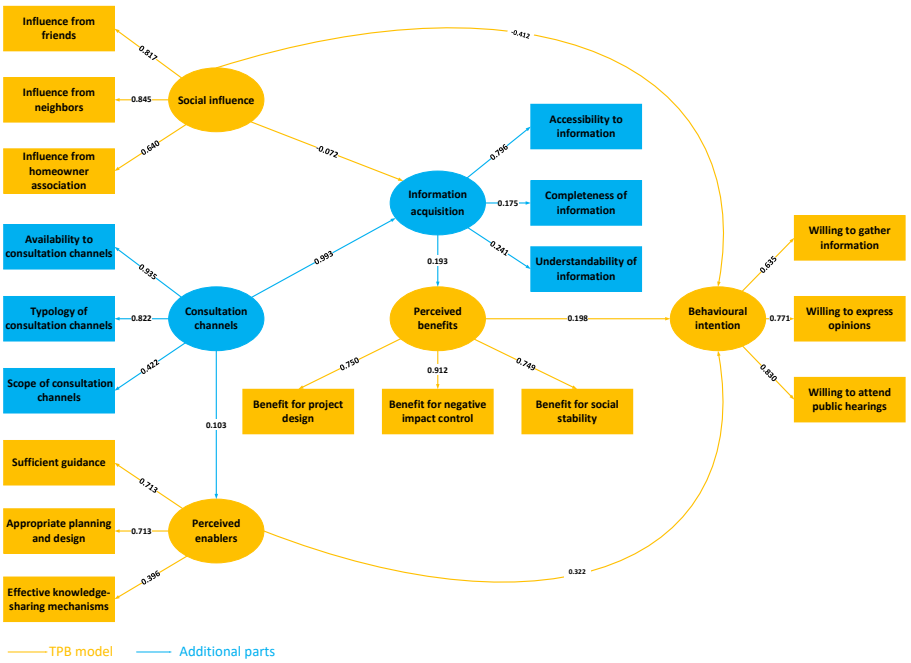

Fig. 18 Final structural equation model with all coefficient values

4.5.1 Descriptive Analysis of Willingness to Participate

A descriptive analysis was adopted to give an overview of willingness to participate, and the results are presented as follows. The results show that the respondents with negative (strongly disagree and disagree) and neutral attitudes towards participation account for the majority (nearly 70%). Therefore, considering the low-level willingness to participate in EIA decision-making, this group of respondents is classified as the unengaged. Further, this study reveals the characteristics of the unengaged, as shown in Table 14.

The distribution indicates that the unengaged have an older age, low education, and income level compared to other groups with a higher willingness to participate. With the increase in age, there is a significant growth trend in the unengaged percentage. The divergence can be seen in the age of under 45 and above 45. While the unengaged

represents less than 65% under 45, the number was up at 81.81% above 45. At the age of 18-25, the respondents with a higher-level aspiration for participation make up 72.94%, much higher than that of other age categories. A similar apparent result can be drawn when examining the respondents' education and income level distribution. As the education level increases, the unengaged decreases. In this survey, the unengaged make up 77.02% at the high school level and a sharp reduction to 60.00% at the college level. Moreover, low-income people are more inclined to be unwilling to participate in EIA decision-making. Therefore, the unengaged share common characteristics with older age (above 46), lower education (under high school), and low income (under ¥3000).

Table 14 The socio-economic distributions of the unengaged

Personal Characteristics	Category	WTP	UWTP	Percent of WTP	Percent of UWTP
Age	18~25	146	46	72.94%	27.06%
	26~35	113	145	43.80%	56.20%
	36~45	50	84	37.31%	62.69%
	46~55	14	63	18.19%	81.81%
	>55	3	15	16.67%	83.33%
Education Level	Under junior	1	9	10%	90%
	High School	105	352	22.98%	77.02%
	College	54	81	40.00%	60.00%
	University	29	10	74.36%	25.64%
	Master	14	2	87.50%	12.50%
Income Category (CNY/per month)	Under 2000	14	46	23.34%	76.66%
	2000 ~ 3000	23	54	22.82%	70.13%
	3000 ~4000	40	52	43.48%	56.52%
	4000~ 5000	55	54	50.46%	49.54%
	Over 5000	168	151	52.66%	47.34%

4.5.2 Analysis of Measurement Model

The measurement model reveals the relationships between observed and unobserved variables. Standardized regression weights are usually used to measure each observed variable's association with its corresponding unobserved variable (Qureshi & Kang, 2015). The result shows that all standard regression weights in the measurement model are significantly different from zero at the 0.001 level (two-tailed), as shown in Table 15.

Information acquisition represents an information flow between citizens and the government. The results show that the accessibility to information (λ_3=0.796) has the most significant impact on information acquisition, followed by the understandability of information (λ1=0.241) and completeness of information (λ_2=-0.157). The results denote that these three observed variables can accurately measure citizens' access to information, in line with the previous studies (Brombal et al., 2017; Sarvilinna et al., 2018). Likewise, the availability of consultation channels (λ_4=0.835) has the most considerable influence on consultation channels, followed by the typology of consultation channels (λ_5=0.822) and the scope of consultation channels(λ_6=0.865). The results show that influence from neighbours has the most considerable impact on social influence (λ8=0.845), followed by influence from homeowner association (λ9=0.817) and influence from friends (λ_7=0.640), indicating a solid correspondence and representativeness (Lelieveldt, 2004).

Concerning citizen participation, perceived benefits mean citizens' subjective judgment of their behavioural consequences (Lowndes et al., 2001). The results show that benefit for negative impact control has the most substantial impact on perceived benefits (λ_{11}=0.912), followed by the project design (λ_{10}=0.749) and the benefit for social stability (λ_{12}=0.750). Perceived enablers represent one's expectation of ease of participation (Hartley & Wood, 2005). In project EIA decision-making, the result shows that sufficient guidance (λ_{13}=0.713) and appropriate planning and design (λ_{14}=0.713) have the most significant influence on perceived enablers, followed by effective knowledge-sharing mechanisms (λ_{15}=0.396).

Willingness to participate suggests the potential attendant actions (Shan, 2012). In this study, willingness to participate is significantly affected by the willingness to attend public hearings (λ18=0.830), followed by the willingness to express opinions (λ17=0.771) and the willingness to gather information (λ16=0.635). Based on the involvement degree of "nonparticipation," "tokenism," and "empowerment" (Arnstein, 1969), this result corresponds to the participation status quo in developing countries.

Table 15 The results of the Confirmatory factor analysis

Latent variables		Measurement items	S.T. Regression Weights
Information acquisition	--->	Accessibility to information	0.796***
Information acquisition	--->	Completeness of information	-0.157*
Information acquisition	--->	Understandability of information	0.241*
Social influence	--->	Influence from friends	0.640***
Social influence	--->	Influence from neighbours	0.845***
Social influence	--->	Influence from homeowner association	0.817***
Willingness to participate	--->	Willing to gather information	0.635***
Willingness to participate	--->	Willing to express opinions	0.771***
Willingness to participate	--->	Willing to attend public hearings	0.830***

Consultation channels	--->	Scope of consultation channels	0.422**
Consultation channels	--->	Typology of consultation channels	0.822***
Consultation channels	--->	Availability of consultation channels	0.935***
Perceived enablers	--->	Effective knowledge-sharing mechanisms	0.713***
Perceived enablers	--->	Appropriate planning and design	0.713***
Perceived enablers	--->	Sufficient guidance	0.396*
Perceived benefits	--->	Benefits for project design	0.749***
Perceived benefits	--->	Benefits for negative impact control	0.912***
Perceived benefits	--->	Benefits for social stability	0.750***

NOTES: Significant at: * 0.001 level**

4.5.3 Analysis of the Structural Model

Based on information derived from the dataset, the hypotheses are verified, with all hypothetical relationships accepted. Table 16 shows the relationships of the constructs in the structural model. In addition, regression among various variables is revealed and interpreted through analyzing the structural model.

Table 16 Results of path coefficients and hypotheses testing.

Relationships among constructs			St. Regression Weights	
			Hypothetical model	
Social influence	--->	Information acquisition	-0.072*	Supported
Information acquisition	--->	Perceived benefits	0. 193**	Supported
Consultation channels	--->	Perceived enablers	0. 103**	Supported
Perceived benefits	--->	WTP	0.198***	Supported
Perceived enablers	--->	WTP	0.322***	Supported
Consultation channels	--->	Information acquisition	0.993***	Supported
Social influence	--->	WTP	-0.412***	Supported

NOTES: Significant at:

***** 0.001 level.**

Figure 19 depicts the final model with standardized path loadings. The results show that all the path coefficients are significant at $\rho<0.005$ level. Specifically, social influence, perceived benefits, and perceived enablers are found to have substantial direct effects on willingness to participate. Social influence is proved to have the highest standardized coefficient value (H2: -0.412***), followed by perceived enablers (H3: 0.322***) and perceived benefits (H1: 0.198***). Social influence refers to individuals' circle of influence on their aspiration of participation in EIA decision-making. H1 was set to measure the relationship between perceived benefits and willingness to participate based on the theoretical findings. The result suggests that perceived benefits significantly affect willingness to participate, confirming previous studies (Fu et al., 2019). Likewise, H3 was set to measure the relationship between perceived enablers and willingness to participate. The result asserts that

perceived enablers have a direct positive effect on willingness to participate. This finding implies that citizens would have a more vital willingness to participate when they assess the enablers in the participatory process at a higher level (Hartley & Wood, 2005; Kantamaturapoj et al., 2018).

Social influence, perceived benefits, and perceived enablers are the most critical variables that directly influence willingness to participate, while other variables are proven not. Although these variables do not directly affect willingness to participate, they all have solid indirect influences. Here, these indirect interactions between various variables and willingness to participate are examined, and two paths are extracted to interpret the relationships among latent variables.

Path 1: Social influence (Consultation channels)⟶Information acquisition⟶ Perceived benefits⟶Willingness to participate

Perceived benefits are proved to be a significant and direct factor that significantly promotes the willingness to participate in EIA decision-making of NBS projects (H1: 0.198***). Information acquisition can enrich citizens' perceived benefits regarding their contributions to project design, negative impact control, and social stability (H5: 0. 193***). However, social influence mediates the effects through an informal network (H4: -0.072**). Considering the existing negative impact of social influence on willingness to participate, information acquisition will mediate the effect by enhancing accessibility to information, understandability of information, and completeness of information. Social influence is the most significant and direct factor affecting willingness to participate (H2: -0.412***). As citizen participation is a government-led activity in most developing countries, the informal network is prevalent among the unengaged group (Swapan, 2016). In ***Path 1***, perceived benefits are an essential intermediate variable that directly influences willingness to participate. Information acquisition positively affects willingness to participate by enriching perceived benefits, while social influence deteriorates information acquisition. Likewise, social influence and information acquisition are the other two crucial intermediate variables in ***Path 1***. Given the relationships between information acquisition, social influence, and willingness to participate, the promotion of

information in the implementation of NBS will help alleviate the adverse effects of social influence on willingness to participate. Meanwhile, consultation channels could enhance information acquisition of citizens (H6:0.993***), indicating the formal network could facilitate information dissemination in the participatory process. In light of the existing negative effect of social influence on information acquisition, consultation channels will mediate the effect by enhancing an effective formal network.

Path 2: Consultation channels⟶Perceived enablers⟶Willingness to participate

According to ***Path 2***, perceived enablers are tested as another major and direct factor that positively affects willingness to participate (H3: 0.322***). Evidently, the significant standardized path loadings between consultation channels and perceived enablers suggest participants' different capabilities in accessibilities and availabilities of consultation channels (H7: 0.103**). Therefore, the decrease of the unengaged could improve perceived enablers in the way of consultation channels.

Table 17 shows the direct, indirect, and total effects of the latent variables. The direct effect denotes the impacts of the exogenous variable on endogenous variables, while the indirect effect presents the impact of a variable on endogenous variables via intervening endogenous variables. The total effect is the sum of the direct and indirect effects. It is worth noting that information acquisition and consultation channels play a critical role in ***Path 1 and Path 2***, respectively. The inherent socio-economic characteristics of individuals are usually reflected in varied reactions to citizen participation. Therefore, identifying the unengaged should be a priority for participatory research.

Table 17 Direct and indirect effects of the structural model

Latent Variables	Stand. Effect	Social Influence	Consultation Channels	Information Acquisition	Perceived Benefits	Perceived Enablers
Information Acquisition	Total Effects	-.072	.993	.000	.000	.000
	Direct Effects	-.072	.993	.000	.000	.000
	Indirect Effects	.000	.000	.000	.000	.000
Perceived Benefits	Total Effects	-.014	.192	.193	.000	.000
	Direct Effects	.000	.000	.193	.000	.000
	Indirect Effects	-.014	.192	.000	.000	.000
Perceived Enablers	Total Effects	.000	.103	.000	.000	.000
	Direct Effects	.000	.103	.000	.000	.000
	Indirect Effects	.000	.000	.000	.000	.000
Willingness to Participate	Total Effects	-.414	.005	.038	.198	.322
	Direct Effects	-.412	.000	.000	.198	.322
	Indirect Effects	-.002	.005	.038	.000	.000

4.6 Discussion

In this study, social-psychological factors influencing willingness to participate in EIA decision-making of NBS projects were explored based on the extended TPB model. Given the insufficient explanatory power of the conventional TPB, this study included additional constructs as the model extension and indicated several critical implications through the extended TPB model.

Empirically, this study suggests that a large group of citizens holds a low-level willingness to participate in project EIA decision-making, which can be grouped as the unengaged. As the name implies, the unengaged are constantly ignored while remaining silent in decision-making. In this regard, the unengaged are the silent majority corresponding to the vocal minority in the participatory process. In developing countries, the unengaged are a widespread group in EIA decision-making subject to an "instrumental level" of citizen participation (Brombal et al., 2017). Previous studies from Day (2017) indicate that citizen participation had often become an opportunity for a noisy minority to dominate, leading to conflicts. Because involving the silent majority (a.k.a. the unengaged) in the EIA decision-making, deliberately or not, may lead to "pseudo participation," as this group of people is either unaware of, disinterested in, or refuses to express genuine opinions. However, the silent majority's support is also imperative to a broader public acceptance of the proposed project (Giddings et al., 2010; Ng et al., 2012). But yet, engaging the unengaged in citizen participation still faces critical challenges as little is known about what factors influence willingness to participate and how these factors influence. In this regard, ***Path 1*** and ***Path 2*** extracted from the extended TPB model provide detailed interpretations of how different social-psychological factors influence willingness to participate.

Among the constructs of the extended TPB model, social influence is found to have the most significant influence on willingness to participate. In this study, social influence represents subjective norms and indicates pressures from its social network to perform expected behaviours. In citizen participation, previous studies have interpreted social influence as an informal network existing in the current

participatory process, parallel to a formal network (Swapan, 2016). In this regard, the opinions of social groups have a significant influence on willingness to participate. The other two constructs in the extended TPB model, perceived benefits and perceived enablers, are also found to influence willingness to participate significantly, confirming the previous studies (Fu et al., 2019; Hatipoglu et al., 2016; Shan, 2012; Wang et al., 2018). Previous studies have argued that negative perceptions toward government-led participation may result in a low-level willingness to participate, as citizen participation is a time-money-consuming process (Kantamaturapoj et al., 2018). Likewise, perceived enablers have a direct positive effect on willingness to participate. It is undeniable that citizen participation is a professional social activity for most citizens, given its complexity and the technical knowledge required. As a result, citizens are reluctant to invest time and effort in such a process unless the threshold of participation is low. However, the decision-making agencies often overlook citizens' demand for enablers in the participatory process, identified as sufficient technical and financial support to motivate citizens (Chi et al., 2014).

By including additional variables in the TPB model, this study further investigated how information acquisition and consultation channels contribute to willingness to participate in EIA decision-making of NBS projects. The empirical research demonstrated that the unengaged in the participatory process share common features with older age, lower education, and income level. These weak socio-economic conditions cause the unengaged to be disadvantaged in accessing information and consultation from decision-making agencies. Information acquisition increases the understanding of the proposed project and the perceived benefits of citizen participation exercise, while consultation channels assure possibilities to raise voices and increase perceived enablers, lowering the involvement thresholds (Fang et al., 2017; Rega & Baldizzone, 2015). However, the extended TPB model indicated that social influence could moderate the positive effects of information acquisition and consultation channels on participants' perceptions of benefits and enablers. In the participatory process, informal networks often take on government-led participation and become a parallel system upon which the unengaged can rely. The unengaged

with older age, lower education, and income level are more likely to be influenced by their social networks due to inadequate access to formal information and consultation.

4.7 Conclusions and Limitations

Considering the heterogeneity of citizen participation, this study extended the TPB model by including additional variables to reveal what factors can influence willingness to participate and how these factors influence willingness to participate. The results suggest that the additional variables, information acquisition and consultation channels, are all found to have substantial indirect impacts on willingness to participate. At the same time, the constructs from the TPB model, social influence, perceived benefits, and perceived enablers directly affect willingness to participate. In addition, through descriptive analysis, this study identifies a large group of respondents with older age, low education level, income category, and willingness to participate, which are grouped as the unengaged. Therefore, special attention should be paid when empowering citizens in the participatory process, as hastily involving citizens without considering their willingness may adversely affect EIA decision-making.

This study contributes to the existing knowledge in three aspects. First, this study focuses on willingness to participate in EIA decision-making by revealing who will not participate and why. In addition, this study identifies the unengaged with older age, low education level, and income category. Therefore, practitioners can apply this knowledge to identify and engage the unengaged in EIA decision-making of NBS projects accordingly. Second, this study presented and tested the mediating effect of citizens' perceptions (perceived enablers and benefits) on information acquisition, consultation channels, and willingness to participate by extending the TPB model. The revealed interrelationships help understand the principles underpinning low-level willingness to participate in EIA decision-making of NBS projects through path analysis. Third, this study demonstrates the significant role of social influence in decreasing citizens' aspirations for participation. Social influence represents the parallel system to formally engaging with decision-making agencies and has an evident mitigation effect on information acquisition and consultation channels.

From a theoretical perspective, this study supplements the citizen participation research by focusing on willingness to participate via the extended TPB model. The results of the extended TPB model verify the significant impacts of additional variables on willingness to participate. Meanwhile, by adding the additional variables, the extended TPB model provides well-explained paths between social-psychological factors and willingness to participate. Practically, valuable measures for the government to facilitate citizens' willingness to participate can be inferred. Specific measurements may include using non-technical language to release information, simplifying citizen participation processes, and providing sufficient support and guidance in the early stage. Notably, adequate attention should be paid to the unengaged group in designing and implementing citizen participation.

Admittedly, a case in Guyuan alone is not enough to represent the prevailing situation in other developing countries. The conclusions may be different since facing different socio-demographic structures and social cultures in different cities. In addition, citizens' perceptions of different kinds of NBS could cause a bias in their perception of participatory behaviour. Still, the research perspective and methodology of Guyuan's case are of considerable significance to other developing countries experiencing a fast growth of NBS projects. The unengaged and informal networks are common in the EIA decision-making process. Motivating the willingness of the unengaged to participate can ensure project success and social stability. This study has deciphered the factors underlying willingness to participate in the EIA decision-making. Future studies are expected to evaluate the impacts of citizens' capacity on the success of participation.

In this chapter, a targeted assessment framework has been established to explore key determinants of willingness to participate in EIA decision-making of NBS projects. The framework is based on a solid foundation of the extended TPB model to uncover the relationships between citizens' socio-psychological characteristics and willingness to participate. The results demonstrated that citizens' willingness to participate was at a lower level and was primarily associated with social influence and perceptions of benefits and enablers. Therefore, the following chapter continues

to explore citizens' participatory behaviours from the micro- to the macro-level through a novel simulation model.

CHPATER 5

AGENT-BASED SIMULATION OF CITIZEN PARTICIPATION IN NATURE-BASED SOLUTIONS

This chapter has been published as:

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Abstract: To deal with complex climate-related risks, these days, nature-based solutions have been identified as a critical component of urban "low-impact development" strategy. However, upscaling of NBS projects requires an integrated, coordinated, and multifaceted strategy involving a wide range of citizens in the neighbourhood. An in-depth understanding of citizens' interactions and participation behaviours is essential in raising awareness and acceptance of NBS. This paper presents a novel agent-based model reinforced by the extended theory of planned behaviour to direct citizen participation adequately. The model aims to simulate how citizens make decisions that shape participation behaviours and evaluate the potential impacts of different interventions on their participatory behaviours. The simulation results show that reliance on the formal network led by the government could increase the participation rate of the neighbourhood, while dependency on the informal network based on social networks and information dissemination has significant negative impacts. Methodologically we show that agent-based modelling can capture complex emergent behavioural patterns and provide valuable insights into participatory behaviours in nature-based solutions implementation. Finally, recommendations are given on facilitating citizen participation in nature-based solutions projects.

Keywords: Nature-based solutions; agent-based modelling; citizen participation; low-impact development; sustainability

5.1 Introduction

The pressing unsolved environmental issues such as super-storms, floods, droughts, and heatwaves have become a critical challenge in many Chinese cities, including metropolises like Beijing and Guangzhou (Huang et al., 2018; Lo, Xu, Chan, & Su, 2015). The severe climate-related risks result in economic losses and threaten citizens' life and property safety, decreasing urban resilience, sustainability, and livability. For example, in mid-July, Zhengzhou suffered disastrous flooding, attributed to a prolonged period of heavy rainfall, causing an economic loss of over €7.4 billion and the death of 292 people[9]. The recurring urban disasters have raised concerns and reflections on current urban development strategies (Arlati, Rödl, Kanjaria-Christian, & Knieling, 2021). Against this backdrop, nature-based solutions (NBS) for sustainable urban development are highly advocated as a critical component of the urban "low-impact development" strategy in China to address socio-environmental challenges (Li, Qin, & Du, 2019; Qi et al., 2020).

NBS contributes to urban resilience and sustainability by effectively nature remaking or reshaping. These days, the development of NBS in urban planning is widely adopted in cities around the world with extensive, vulnerable populations exposed to high risks of climate change (Faivre, Fritz, Freitas, de Boissezon, & Vandewoestijne, 2017; Giordano, Pluchinotta, Pagano, Scrieciu, & Nanu, 2020). The European Commission (2015) defines NBS as solutions "*that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient, and systemic interventions*." According to the International Union for Conservation of Nature (IUCN), NBS are actions response to societal challenges that "protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity" (Cohen-

[9] *https://en.wikipedia.org/wiki/2021_Henan_floods*

Shacham, Walters, Janzen, & Maginnis, 2016). Extensive studies have highlighted the importance of NBS. Amongst other countries, China is one of the pioneering countries in the global initiative of NBS development. In the context of building an ecological civilization, strengthening NBS for urban "low-impact development" is increasingly becoming a conscious action by Chinese governments at all levels and all sectors of society. Various measures of NBS have been delivered in many Chinese cities to reduce the impact of natural disasters and advance sustainable urban development (Li, Qin, & Du, 2019; Wang, Sun, & Song, 2017). For example, to actively address urban flooding, the construction of "Sponge city projects" (SCP) has been carried out across China, with 30 pilot cities included so far (Qi et al., 2020). However, efforts to adopt, implement and diffuse NBS can confront various barriers and fail to achieve the expected results.

In many cases, lack of citizen awareness and support has been considered the leading cause that impedes effective NBS development and causes vigorous opposition (Coletta et al., 2021; Sarabi et al., 2021). Upscaling NBS projects require integrated, coordinated, and multifaceted strategies involving a wide range of citizens to co-design and co-create in the neighbourhood (Giordano, Pluchinotta, Pagano, Scrieciu, & Nanu, 2020). Conversely, the government-led top-down decision-making style still prevails in most cities in China, and citizens' attitudes and participation are largely marginalized despite their paramount role in ensuring successful NBS implementation and maintenance. While sufficient and meaningful insights into the co-benefits and barriers to the uptake and implementation of NBS have been provided in recent studies, limited information about how citizens act and change their participatory behaviours in NBS projects is available. Hence, simulation of the involvement and interactions of citizens can help understand their behavioural changes in participating in the process of NBS decision-making and is essential for effectively developing and maintaining NBS.

The aim of this study is threefold: (1) integrate different research methodologies, in which agent-based modelling (ABM) is coupled with the extended theory of planned behaviour (TPB), to link the extended TPB results with the policy interventions (2)

simulate how citizens make decisions that shape participatory behaviours, (3) investigate impacts of different NBS interventions on citizens' intention to participate in NBS projects, to support the prediction of new policy effects. ABM is a powerful approach to specify how individuals act and interact with neighbours and environments, providing the possibility to explore what-if scenarios on participatory behaviours (Will, Groeneveld, Frank, & Müller, 2020). In this study, the rule-based decision-making model constitutes the central theoretical foundation for constructing a valid representation of particular behaviours in an ABM. Previous studies have found that mapping relevant behavioural processes accurately and effectively is a critical challenge in ABM development (Jager, 2021). The TPB provides a paradigm of how different socio-psychological factors together shape an individual's behaviour, comprising a theoretical underpinning for an individual agent in an ABM (Ajzen, 1991; Khansari & Hewitt, 2020). The conventional TPB is widely used to explore the factors affecting citizen participation, but it has been criticized for failing to explain other significant predictors of specific behaviours (Fu, Kurisu, Hanaki & Che, 2019). Therefore, this paper extends the framework of the TPB model into the field of citizen participation by contextualizing the core components of TPB and integrating additional variables. The combination of the extended TPB and ABM makes it possible to explore participatory behaviour dynamically.

The remaining part of the paper is structured as follows. Beginning with an introduction to NBS, the following section provides a systematic literature review on citizen participation in NBS. Section 3 describes the extended TPB-ABM approach. Section 4 and section 5 present the findings and discussions. Finally, conclusions are drawn in Section 6, demonstrating the implications and understanding.

5.2 Literature review

Involving local neighbourhood and relevant citizens is a promising new trend in NBS. However, related research is still lacking in several fields, from the interactive character of the participatory process to the participatory approach (Ferreira, Barreira, Loures, Antunes, & Panagopoulos, 2020; Puskás, Abunnasr, & Naalbandian, 2021). The uptake and implementation of NBS require a joint effort of urban planners,

communities, and citizens to fulfil project potential and achieve all dimensions of sustainability (Ferreira, Barreira, Loures, Antunes, & Panagopoulos, 2020; Nesshöver et al., 2017). According to the criteria defined by IUCN, the uptake and implementation of NBS should prioritize inclusiveness and transparency with due consideration to empowerment (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016). Citizen participation as a means of involving a wide range of citizens in the decision-making process has become a conventional approach to NBS implementation (Jones-Walters & Cil, 2011). Scholars share the increased concern on citizen participation in NBS adaptation, primarily focused on participatory benefits, applications, methods, and policies (Nunes, Björner, & Hilding-Hamann, 2021; Puskás et al., 2021; Wamsler et al., 2020).

The nexus of citizen participation and NBS is relatively simple, uncomplicated, but inextricable. A series of recent studies have indicated that citizen participation could bring numerous benefits to NBS planning, implementation, delivery, and maintenance (Cárdenas et al., 2021; Reed, 2008). In particular, with the acknowledged complexity and uncertainty of nature and societies, participation-based processes play an essential role in potential conflict resolution and raise public awareness in respect of climate change, environmental justice, and sustainable development at the community level. Based on previous studies, Blackstock and Richards (2007) have systematically defined involvement benefits into three categories: substantive benefits related to information and education (van den Hove, 2000), instrumental benefits associated with social acceptance (Parkins and Mitchell, 2005), and normative benefits related to legitimacy and democracy (Schultz et al., 2010). Similarly, innovative research from Cárdenas et al. (2021) further elucidates the indirect benefits of citizen participation in understanding the environment and promoting eco-friendly behaviour. They suggest that involving citizens in NBS projects can extend inclusiveness from the immediate local to the larger neighbourhood and overcome spatial constraints, with potential benefits for social cohesion and urban sustainability. In this research, the benefits of involvement in NBS hardly require further elaboration as comprehensive studies have thoroughly explored involvement benefits from various perspectives. However, some scholars

have pointed out that the potential benefits of citizen participation cannot be achieved without the active involvement of citizens in NBS projects (Palermo & Hernandez, 2020). Thus, what is the current status of citizen participation in NBS?

A survey revealed that Nature 2000, a coordinated network of core breeding and resting sites for biodiversity in Europe, has been criticized for limited citizen involvement in a designated location, leading to destabilizing conflict between citizens and authorities (Jones-Walters & Cil, 2011). This is the epitome of the current status of citizen participation in NBS: everyone recognizes the benefits of involvement in NBS, but participation is still insufficient in practice. The "attitude-behaviour" gap can be observed in a variety of studies. For example, van Ham and Klimmek (2017) identified that the deepest level of citizen participation in NBS is consultation, a low level of involvement according to Arnstein's ladder of citizen participation theory. Similarly, a recent study found that 'consultation' and 'partnership' are still the dominant levels of participation, indicating an urgent need for more profound levels of involvement (Puskás, Abunnasr, & Naalbandian, 2021). The literature suggests that conventional levels of participation still prevail in citizen participation and NBS, while the higher levels are inadequate.

Nevertheless, compared with developing countries such as China, developed countries still tend to have more mature citizen participation, institutionally and administratively (Brombal, Moriggi, & Marcomini, 2017). A co-creation approach has become an emerging trend in the uptake and implementation of NBS in developed countries (Puskás, Abunnasr, & Naalbandian, 2021). Co-creation highlights collaborative innovation with a wide range of stakeholders working together to co-produce knowledge and share solutions throughout the whole process of decision-making, implementation, and monitoring (Mahmoud, Morello, Ludlow, & Salvia, 2021). The co-creation process is grounded in inclusive, transparent, and empowering participation principles and is often tailor-made to bottlenecks. Following a co-creation logic, practitioners and scholars have developed similar practical guidance on implementing NBS, such as Urban Living Labs (ULL), Co-Creation Pathway, and collaborative pathways (Arlati et al., 2021; Mahmoud, Morello, Ludlow, & Salvia,

2021). However, citizen participation in NBS is even worse in developing countries and remains unsatisfactory despite progress. For example, some scholars commented that citizen participation in China is still "in its infancy," neither sustainable nor stable (Brombal, Moriggi, & Marcomini, 2017; Mei-yung et al., 2013). Although many scholars in developed countries highlight a co-creation approach, citizen participation is regarded as little more than a formality in China (dell'Olio, Ibeas, de Oña & de Oña, 2019; Manowong & Ogunlana, 2006). Only a minority seems to wish to participate actively. The variance is mainly attributable to China's sheer intensive pace of development (Qi et al., 2020). To date, citizen participation in China is merely a vehicle for informing and educating citizens on new solutions to increase social acceptance and contain the emergence of conflicts. However, in terms of NBS, a pivotal role played by citizen participation is awareness-raising on green issues, sustainable solutions, and individual behavioural changes.

In conclusion, existing literature on citizen participation and NBS is abundant, with studies that highlight potential benefits (Cárdenas et al., 2021) and evaluate conventional levels (Puskás et al., 2021), and identify applications of citizen participation in NBS (Nesshöver et al., 2017). However, as a principal stakeholder in the participatory process, citizens' behaviours that how they perceive and respond to citizen participation in NBS are often overlooked by scholars and practitioners. Although numerous studies have developed practical guidance on implementing NBS with a wide range of citizens, very few studies have attempted to figure out their perceptions and attitudes to be involved in the decision-making, implementation, and monitoring of NBS. While NBS is important, cities can gain critical insights through the information of citizens' behaviours, as they are end-users of such solutions. Therefore, this study attempts to bridge these gaps by simulating how citizens make decisions that shape participatory behaviours and investigating the impacts of different interventions on citizens' intention to participate.

5.3 Methodology

5.3.1 Theoretical basis

As a bottom-up approach, agent-based modelling is widely used to simulate complex actions and interactions of individual agents (Motieyan & Mesgari, 2018). However, a critical challenge is to capture the theoretical basis underlying behavioural rules. The behavioural rules define individual agents' decisions and interactions in ABM. Whether the adopted theory validly represents relevant behavioural processes of real-world entities concerns the valuable insights into the system and its activities. Currently, several socio-psychological theories have been adequately explored and empirically validated to provide a solid theoretical underpinning in ABM, such as the theory of planned behaviour (TPB), the values-beliefs-norms (VBN), and game theory (Khansari & Hewitt, 2020; Tong et al., 2018). In particular, TPB is one of the most prominent theories applied in the agent-based literature on behavioural dynamics exploration. As set out by Ajzen (1991), the TPB provides a paradigm of how various socio-psychological factors combine to generate an individual's behaviour and reveals the fundamentals of social behaviour. As Figure 20 illustrates, the TPB reveals the fundamentals of social behaviour. It states that an individual's behavioural intention is shaped by their attitude toward behaviour, subjective norms, and perceived behavioural control (Ajzen, 1991). The TPB is exceptionally suitable for specifying behavioural rules and has been extensively integrated with ABM to model and simulate complicated behavioural patterns of autonomous entities. There are several studies based on the TPB-ABM combination, such as technology adoption choices (Khansari & Hewitt, 2020), climate-relevant behaviour (Jager, 2021), urban development (Silva & Wu, 2014), and waste recycling (Tong et al., 2018).

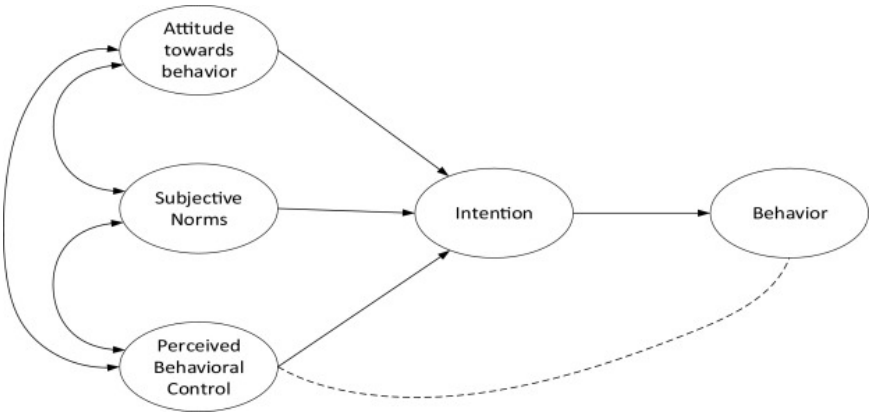

Fig. 19 Logical action in the TPB adapted from Ajzen (1991).

Nevertheless, the TPB model has been criticized for failing to elaborate on other critical elements of specific participatory behaviour and for inadequate explanatory ability (Fu, Kurisu, Hanaki, and Che, 2019). In the context of China, citizen participation in NBS implementation is characterized by a government-led process. The government-related variables cannot be ignored. Therefore, this study extends the TPB framework into the field of citizen participation by contextualizing the core components of TPB and integrating additional variables. Finally, social influence (SI), perceived benefits (PB), and perceived enablers (PE) are contextualized, which respectively correspond to subjective norm, attitude, and perceived behavioural control in the conventional TPB model.

Further, this study follows the suggestions of Swapan (2016) and Rega and Baldizzone (2015) and adds personal characteristics (PCS), information acquisition (IA), and consultation channels (CC) to the conventional TPB model. PCS is selected to assess the influence of individual attributes, such as age, education, and income level. IA and CC are supposed to evaluate the government's role in forming participation behaviour. Figure 21 demonstrates the extended TPB model with verified paths. The results show that all the path coefficients are significant at $\rho < 0.001$ level. SI, PB, and PE directly impact citizens' behavioural intentions, while CC and IA indirectly impact behavioural intentions. The extended TPB model reveals

the interrelationships between various variables and behavioural intention. A further discussion of the model can be found in Chapter IV.

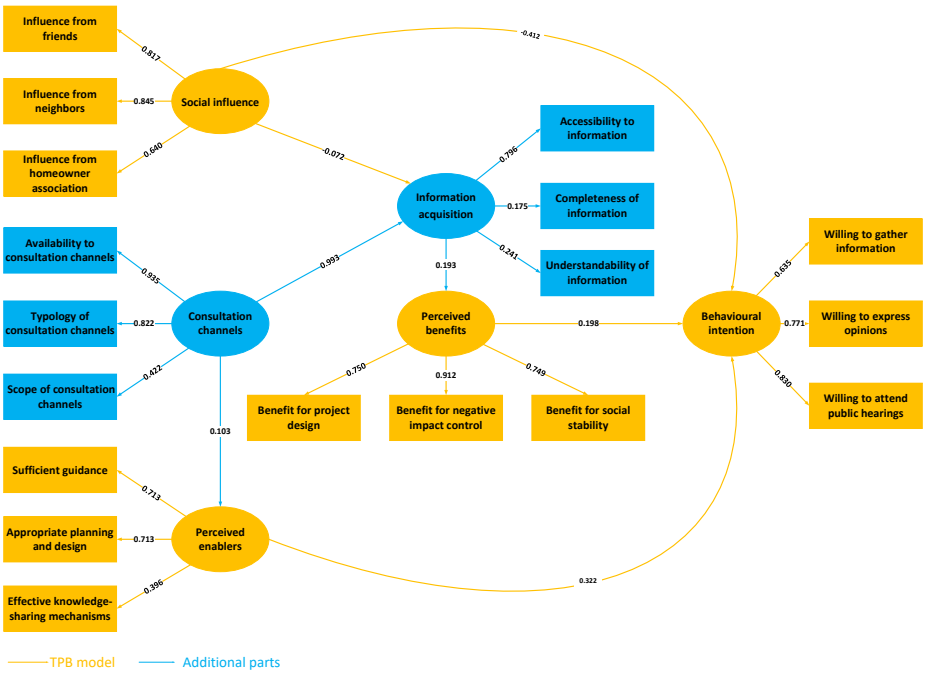

Fig. 20 The extended TPB model with verified paths

5.3.2 Model development

ABM is a heuristic approach to analyzing dynamic behaviours and exploring future scenarios such as new policies and schemes. There is an increasing concern about ABM application in urban development these days. It can be integrated with top-down approaches and offers the possibility to include an individual's decision-making process. In this study, path models that interpret how socio-psychological factors shape individuals' behaviours from the extended TPB model were set as an empirical anchor for agent model specification by defining the decision criteria.

5.3.2.1 Path models of the extended TPB

The extended TPB model is well-established to reveal how various factors affect willingness to participate. This study estimates the model based on a random survey in Guyuan, China, through the structural equation model (SEM). Guyuan is one of 30 pilot cities in the Chinese national NBS strategy and is in the northwest of China with extreme climatic conditions[10]. To increase urban resilience against a changing climate, the promotion of NBS is in full swing in Guyuan city, and the total investment of phase I has reached €657 million[11].

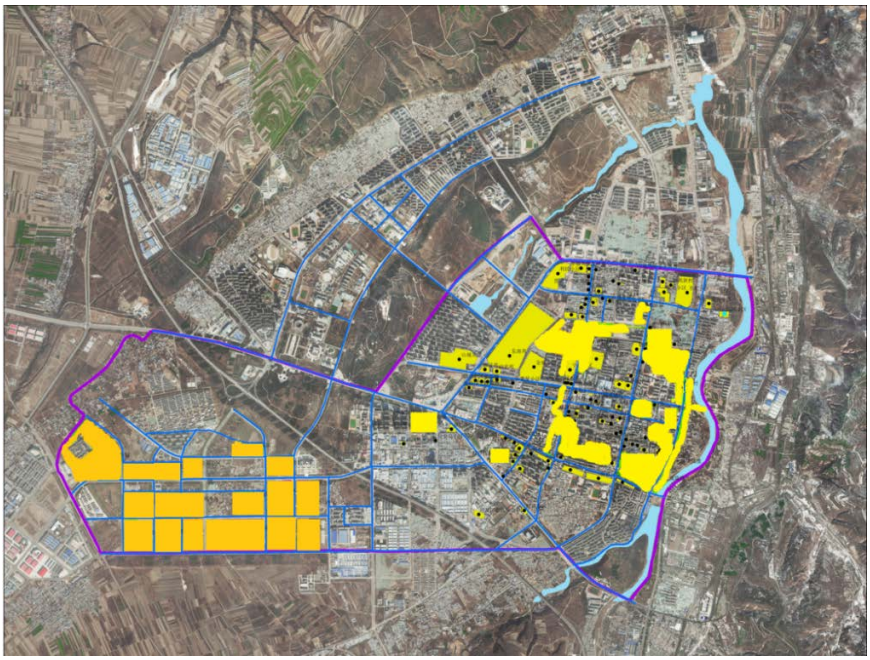

Fig. 21 The functional planning of nature-based solutions in Guyuan

The study area is located in Guyuan city's centre, including an established neighbourhood in the East and an emerging neighbourhood in the West. The operational planning of the NBS program in these two neighbourhoods can be found

[10] *https://en.wikipedia.org/wiki/Guyuan*

[11] *http://www.zgycrc.com/company/company-show-2844-.htm*

in Figure 22. A semi-structured interview was designed to solicit citizens' perceptions and attitudes toward participating in NBS. A sample of 739 citizens was randomly selected (computer sortation) according to the house number in the affected neighbourhoods via the assistance of related neighbourhood and unit directors, with a total of 657 questionnaires valid for analysis. PCS, IA, and CC are found to significantly impact willingness to participate through SI, PB, and PE. Chapter IV provides details on the extended TPB model's primary results.

5.3.2.2 Model Characteristics

The structure of the ABM model contains two primary constructs: the interactions in the neighbourhood and the participatory behavioural rules. The conceptual features of the model are elaborated in this section with a methodological combination of the extended TPB and ABM.

5.3.2.2.1 Agent

The agent in an ABM model is an independent decision-maker with different individual characteristics and shares an environment through communication and interaction with other agents. Each agent in ABM is an identifiable unit in a system with autonomous and goal-directed behaviours. Weiss (1999) defined an agent as a computational entity such as a software program that "can be viewed as perceiving and acting upon its environment and that is autonomous in that its behaviour at least partially depends on its own experience." In ABM, the interaction between agents is explicitly modelled and used for further action analysis.

The involvement of citizens in NBS at the neighbourhood level is usually household-based. Therefore, the household within a specific neighbourhood is the unit of analysis and critical decision-making entity in the presented model. Each household is a potential participant, and their willingness to participate depends on the decisions made under regulations by the extended TPB. According to the extended TPB model results, households' participatory behaviour is directly affected by SI, PB, and PE and indirectly affected by PCS, IA, and CC. Therefore, household attributes could significantly influence participatory behaviours. Besides, the elements of the

environment could also affect their intentions to participate. In this study, the attributes of the agent include:

(1) **Personal characteristics:** Age, Education level, Income level.
(2) **Behavioural status:** Willing to participate (WTP, a household is willing to participate in NBS), Silent to participate (STP, a household who does not express their opinions publicly in NBS participation), Unwilling to participate (UTP, a household is unwilling to participate in NBS participation). In the presented model, an agent receives information from outside and interacts with its neighbour agents (other agents linked with it). Then an agent makes decisions on the participatory behaviour based on the behavioural rules (see section 5.3.2.2.3).
(3) **Local status:** Neighbourhood (each household is situated in the mentioned neighbourhoods), Social network (the links among the households), Friends (other households in the neighbourhood that are part of the social network), Neighbours (the adjacent neighbours).

For computing power and simplicity reasons, the agents in the presented model do not represent all the households in the study area. Therefore, population density is taken into account to assign the number of agents to each populated cell within the neighbourhoods. Previous studies have found that certain people with social status through wealth or power accumulation were vastly better informed in the current participatory process and could influence the transfer of public resources (Swapan, 2016). This group of citizens was classified as the ‘capitalist citizen’ or ‘neighbourhood leader’, who may significantly influence the participatory process. The social network in the participatory process has the characteristics of a scale-free network in that central actors have a high number of collaborative relationships relative to other actors with only a few cooperative relations (Pyka, Gilbert, & Ahrweiler, 2009; Will et al., 2020). In this model, the interactions within agents are realized by artificially created links based on an assumption of a scale-free network. However, it is worth noting that this study did not focus on social network analysis, and the scale-free network is only used to generate a network of agents.

5.3.2.2.2 Environment elements

Besides the mentioned attributes, three primary environment elements are designed as the adjustable interventions, including IA, CC, and distance to the solution project. IA indicates the provision of information from the government. Previous studies have addressed the considerable impact of information on citizens' participatory behaviour (Brombal, Moriggi & Marcomini, 2017). However, as the government is dominant in information dissemination, citizens depend mainly on the government. Therefore, IA is selected as the adjustable intervention to explore how the government's policy will affect the citizens' participatory behaviours, which is also a crucial part of our scenario analysis, demonstrated in Section 5.4.

Similarly, CC is considered another critical factor in citizen participation, representing possibilities of formally consulting or discussing (Brombal, Moriggi & Marcomini, 2017). As Swapan (2016) contended, poor consultation channels could lead to low awareness of citizen participation in decision-making. Therefore, this predictor is selected to measure sufficient guidance from authorities, appropriate consideration of citizens' concerns, and lower participation thresholds (Hartley & Wood, 2005). The Not-In-My-Backyard (NIMBY) theory reveals the relationships between citizens and planned project sites and deems that citizens pay more attention to the projects in their neighbourhoods. In line with this theory, the distance to the solution project is selected as an essential environment element.

5.3.2.2.3 Behavioural rules

The decision criteria of each agent depend on the paths extracted from the extended TPB model. The paths from the core components to the target construct in the extended TPB model represent the agent reasoning process, which can be seen as a linear combination. Based on the assumption of rational choice, the variables with scores and total effect values calculate the participatory probability value of each agent. Figure 23 illustrates the agent-based modelling framework.

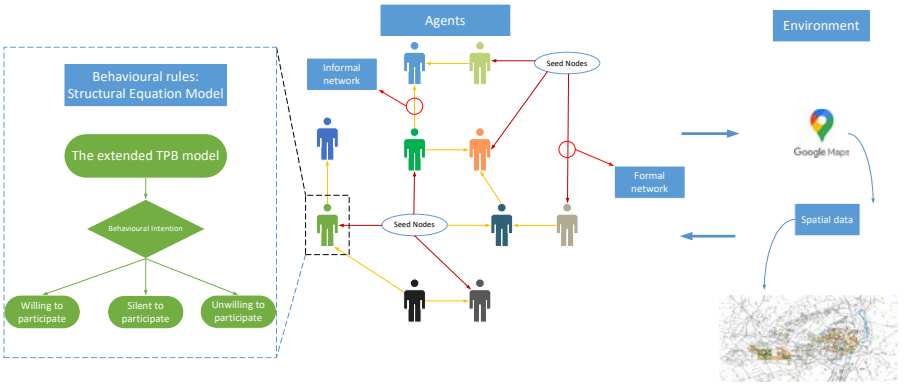

Fig. 22 Agent-Based Modeling Framework

At setup, the agents with various personal characteristics (PCS) are located across the neighbourhoods and build the social network. The PCS is the variable of the extended TPB, implying individual socioeconomic conditions. The value of PCS is assigned in line with the population means of Guyuan city. As stated above, the dominant position of government-led participation means that households depend primarily on authorities for information. Therefore, seed nodes are designed to represent information sources in the network. Seed nodes construct a one-way connection with the agents and disseminate information through the network. It is worth noting that the links in the network can be classified into short-range connections and long-distance connections. As mentioned above, seed nodes represent information sources in the network and reflect the local government's role in the participatory process. The short-range connection refers to the links among the agents, meaning the informal network based on the social network in the participatory process. The long-distance connection relates to the links between the agents and seed nodes, representing the consultation channels led by the government in the participatory process. The dissemination of information can be expressed as follows:

$$IA_i(t+1) = \max_{1 \le j \le n} \begin{cases} IA_j(t) + [IA_j(t) - IA_i(t)]SR, & if\ short-range\ connection\ between\ j\ and\ i \\ IA_i(t) + [IA_j(t) - IA_i(t)]LD, & if\ long-distance\ connection\ between\ j\ and\ i \end{cases} \quad (1)$$

While $IA_j(t+1)$ is the information acquisition of Agent i at $T = t+1$, SR indicates the transmission rate of short-range connections among the agents, and LD shows the transmission rate of long-distance connections between the agents and seed nodes.

In this model, SI implies the interactions among the agents, and an assumption was made that the level of SI is highly associated with individual divergence. In other words, the more significant the difference in agents' PCS, the weaker the influence between agents. Furthermore, the SI can be expressed as follows:

$$SI(i,j) = \begin{cases} 0, \frac{|PCS_i - PCS_j|}{PCS_i} > p_{ij} \\ \frac{|PCS_i - PCS_j|}{PCS_i}, \frac{|PCS_i - PCS_j|}{PCS_i} \leq p_{ij} \end{cases} \quad (2)$$

While $SI(i,j)$ indicates the SI between Agent i and Agent j, PCS_i are the personal characteristics of Agent i and p_{ij} is the threshold for the difference in PCS between agents.

Besides, this model attempts to incorporate the factor of the project site to explore the influence of site selection on citizens' participatory behaviour changes. The NIMBY theory suggests that households pay more attention to the proposed projects in their neighbourhoods. The phenomenon can be expressed as a simple formula:

$$PI(i,m) = a^x \quad (3)$$

While $PI(i,m)$ is the impact of the solution project on the involvement of agents, x is the shortest distance between Agent i and the solution project m. In Eq. (3), a is set as a constant ($a = 0.5$).

PB refers to the awareness or consciousness of potential positive outcomes of participatory behaviour (Ajzen, 1991). From the citizens' perspective, whether the participation action will make a difference in NBS implementation could significantly affect behavioural intention. The PB can be calculated through a simple formula:

$$PB_i = \alpha \times IA_i \times PI(i,m) \quad (4)$$

In Eq. (4), α is the standardized path coefficient and has a positive effect on PB.

PE is defined as the perception of potential support to make participation possible (Hartley & Wood, 2005; Shan, 2012). In this study, PE specifies lowering the costs and barriers to NBS participation. The PE can be calculated as follows:

$$PE_i = \beta \times LD \quad (5)$$

In Eq. (5), β is the standardized path coefficient and has a positive effect on PE.

The interaction between the agents and the environment in the neighbourhood leads to a particular intention of participatory behaviour. Behavioural intention (BI) is a linear combination of the core components in the extended TPB model. The equation is expressed as follows:

$$BI_i(t+1) = BI_i(t) + SI(i,j)\left[BI_j(t) - BI_i(t)\right] + \frac{Nseednodes}{Nagents} nPB_i + mPE_i \quad (6)$$

While $BI_i(t+1)$ represents the behavioural intention of Agent i, n and m are the weight of PE and weight PB, respectively. $Nseednodes$ is the number of seed nodes, and $Nagents$ is the number of agents in the network.

Finally, a $Min-Max$ standardization is applied to convert behavioural intentions into a probability value of each agent regarding the performance of participation.

$$Probability_i(participate) = \frac{BI_i - \min\limits_{1\le j\le n}\{BI_j\}}{\max\limits_{1\le j\le n}\{BI_j\} - \min\limits_{1\le j\le n}\{BI_j\}} \quad (7)$$

If the probability value regarding the performance of participation reaches a determined threshold, then the agent decides to take an act of participation. This model integrated the environmental elements and the extended TPB model to design the behavioural rules of the ABM. Unlike some studies, such as Tong et al. (2018), the model developed in this study considers the environmental elements during the decision-making process instead of merely amending the final decision results of the TPB model with the ecological aspects. With such an approach, the model can capture

the reality of the individual decision process in citizen participation. NetLogo 6.1.1 is applied as the modelling tool. ArcGIS 10.8 is used for the required spatial analyses of the data and the generation of maps. The study area map is extracted in ASCII format and transferred into NetLogo using GIS Extension. The supplementary materials, including the simulation code and the output of the ABM model, are provided in the Appendix.

5.4 Results and Discussion

5.4.1 Scenario analysis

As previously highlighted, government-led participation still prevails in most developing countries. In the context of low willingness to participate, it is urgent to ascertain what measures can be taken to promote citizen participation by the government. As a bottom-up approach, ABM provides the possibility to explore the effects of various top-down policies on the system in a dynamic way. For example, ABM can be used to explore plausible futures of the participation performance by taking into account several alternative measures, i.e., scenarios. Scenario analysis is a valuable tool to investigate the possible effects of interventions on participatory behaviour change in the involved process of NBS implementation.

From the perspective of Governments, three scenarios are defined to identify what measures the government can take to facilitate citizen participation in NBS implementation. The scenarios carried out in this study take into account government measures in the future. It is assumed that change in the participatory process organized by the government might affect the participatory behaviours of citizens in the neighbourhood. Thus, the scenarios are designed based on changing the policies and measures taken by the government in the participatory process. The first scenario, referred to as “information dissemination,” simulates the participatory behaviour changes by changing the number of seed nodes. The seed node represents a publicity spot in this model about citizen participation and NBS. It is a regular operation to set up publicity spots for information dissemination in the neighbourhood in China, such as a bulletin board and digital signage information release display system. This scenario is implemented with a rise in the number of seed nodes in the model. The

second scenario, referred to as the "transmission rate of short-range connection," simulates the effects of informal networks on participatory changes. Previous studies have argued that citizens tend to have a higher tendency to rely on prevalent informal networks for information and urban services in the participatory process (Swapan, 2016). An informal network is a parallel system to the formal network led by the government that represents the relationships between the citizens and their neighbourhood leaders. In this model, the short-range connection is set up to represent the informal network in citizen participation. The dominant network-informal or formal-in participatory process will change by changing the transmission rate of short-range connections. This scenario is implemented with an increase in the transmission rate. The third scenario is the "transmission rate of long-distance connection," simulating the effect of the formal network on the participatory behaviour change. The higher transmission rate of long-distance connections implies reliance on the formal network led by the government. Similarly, this scenario is implemented with a range of transmission rates.

The scenario analysis is implemented through the Behaviour Space in the NetLogo. Behaviour Space runs a model many times, systematically varying the model's settings, recording the results of each model run, exploring the model's 'space' of possible behaviours, and determining which combinations of settings cause the behaviours of interest.

5.4.2 Results of scenario analysis

5.4.2.1 Baseline simulation model

The baseline simulation experiment presents the participatory behaviours of citizens on the neighbourhood level. In this simulation, the parameters were set to emulate the reality condition so that this scenario could be the baseline for all other scenarios. Figure 24 illustrates the simulation experiment results, while Figure 25 demonstrates the evolution of the percentage of participants in the baseline simulation model. The orange patches represent the neighbourhoods in Guyuan city. The green squares imply the proposed projects, while the red stars represent the seed nodes. The circle nodes with different colours represent citizen nodes with other participatory states.

Specifically, the green nodes indicate citizens are willing to participate (WTP), and the yellow nodes indicate citizens are unwilling to participate (UTP). The silent to participate (STP) indicates the citizens are the silent majority, coloured blue. The results suggest that citizen participation is low under baseline conditions, reflecting the current situation in Guyuan, China.

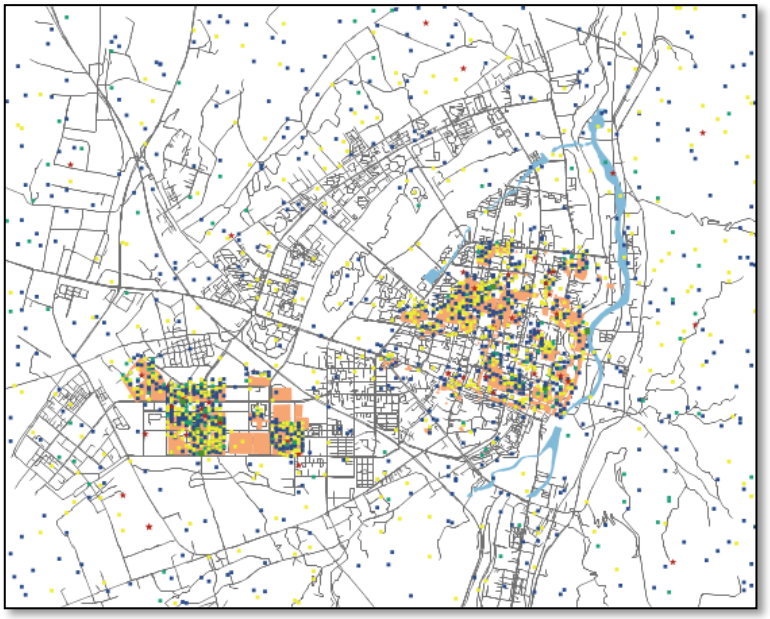

Fig. 23 The distribution of model outcomes

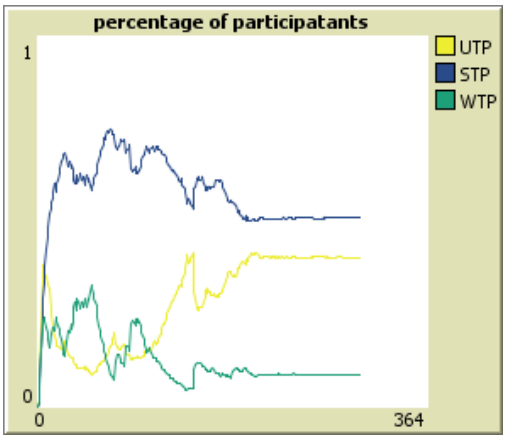

Fig. 24 The outcomes of the baseline model

5.4.2.2 Scenario 1: Information dissemination

In this scenario, information dissemination is set to explore the participatory behaviour changes in reality. Existing research has deemed that information dissemination is significant to participatory behaviour (Brombal, Moriggi & Marcomini, 2017). Information dissemination is further identified as a critical predictor of effective participation (Sarvilinna, Lehtoranta & Hjerppe, 2018). Thus, the participation rate is supposed to increase with the growth of information dissemination. The experiment is conducted by raising the number of seed nodes with an increment of 1 each time. The varying seed nodes in the model reflect China's information dissemination situation in that the local government always informs citizens on neighbourhood affairs through publicity spots. Therefore, the number of seed nodes could imply the sufficiency of information dissemination in this study. The result of Scenario 1 is depicted in Figure 26.

Figure 26 demonstrates a participation rate change with growing seed nodes. The percentage of participants displays a downward trend with an increasing number of seed nodes. This finding is intriguing and has fundamentally changed earlier perceptions of information dissemination. Plenty of previous studies had essentially highlighted the importance of information dissemination in engaging citizens in the participatory process (Fang, Ng, Wang, & Hsu, 2017; Hartley and Wood, 2005; Lowndes, Pratchett, & Stoker, 2001; Rega and Baldizzone, 2015). By contrast, Scenario 1 reached the opposite conclusion that the participation rate declined with an increased number of seed nodes. This finding suggests that in terms of engaging citizens in the participation process, the increase in information dissemination could degrade the involvement of citizens in NBS implementation. One possible reason is that existing studies ignored the informal network in the participatory process. Without a doubt, an increased number of seed nodes could result in some agents with more information. It is generally assumed that information dissemination can promote citizen participation. However, without considering the informal network, the well-informed agents may become the central agents ('capitalist citizen' or 'neighbourhood leader') in the network, decreasing the formal network dependency of other agents and further generating a more extensive informal network. As a result,

information dissemination could hardly promote citizen participation since citizens heavily rely on the informal network for general information.

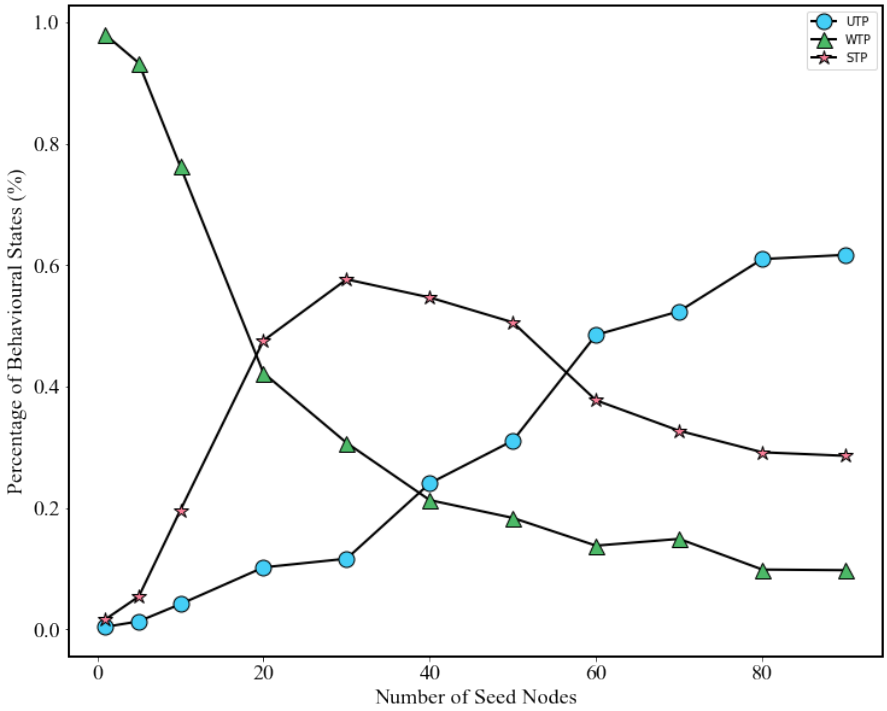

Fig. 25 Scenario result for Information dissemination

5.4.2.3 Scenario 2: Transmission rate of short-range connection

Considering the existence of the informal network in the current participatory process in China, Scenario 2 aims to explore the effects of the informal network in engaging citizens in the participation process. In this model, the short-range connection represents the link among agents. Therefore, an increase in the transmission rate of short-range connections could heighten the dominant role of the informal network in disseminating information in the neighbourhood. As a result, it is assumed that the transmission rate of short-range connections harms the participation rate. The experiment is conducted by raising the transmission rate of the short-range connection with an increment of 0.1 each time.

Figure 27 illustrates Scenario 2, changing the transmission rate of short-range connections in the model. The participation rate shows a slight decrease with an increase in the short-range connection transmission rate. This finding suggests that a greater reliance on the informal network might reduce the citizens' propensity to engage in the participatory process since an informal network is more effective than a formal network from the citizens' perspective. In the participatory process, informal networks often confront government-led participation and become a reliable parallel system offering informal means of acquiring urban services for citizens. It is worth noting that the lower participation rate of the baseline could enforce the negative effects of the informal network. Nevertheless, the slight downward trend implies a negative relationship between citizen participation and the informal network. Another interesting finding is that with an increase in the short-range connection transmission rate, the rate of STP is increasing, indicating a struggle of citizens in the decision-making process.

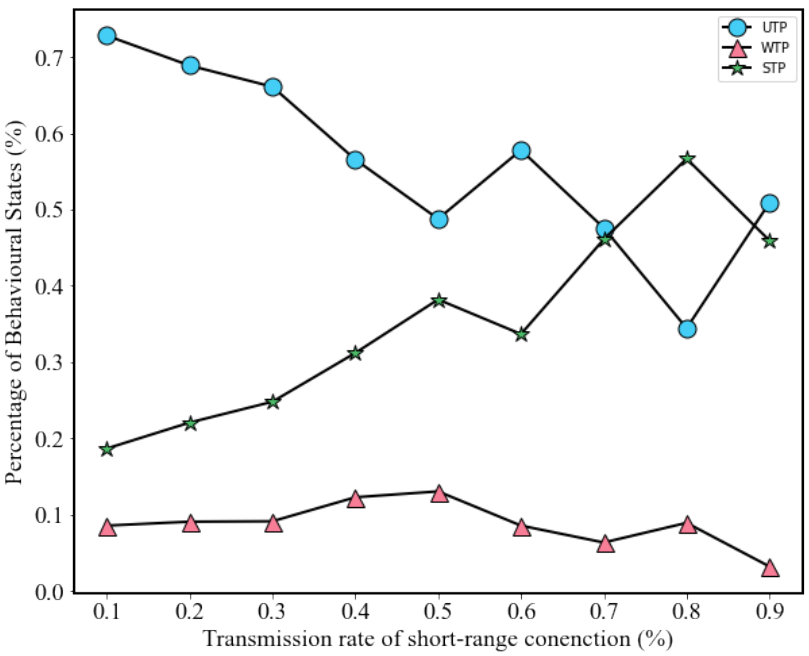

Fig. 26 Scenario result for a Transmission rate of short-range connection

5.4.2.4 Scenario 3: Transmission rate of the long-distance connection

Contrary to Scenario 2, this scenario focus on the effect of the formal network on engaging citizens in the participatory process. In this model, the long-distance connections represent the links between agents and seed nodes and imply the formal network in the neighbourhood. Similarly, a change in the long-distance connection transmission rate means the change of predominant link types in the network. Therefore, the participation rate is assumed to rise with the long-distance connection transmission rate increase. The experiment is conducted by raising the transmission rate of the long-distance connection with an increment of 0.1 each time.

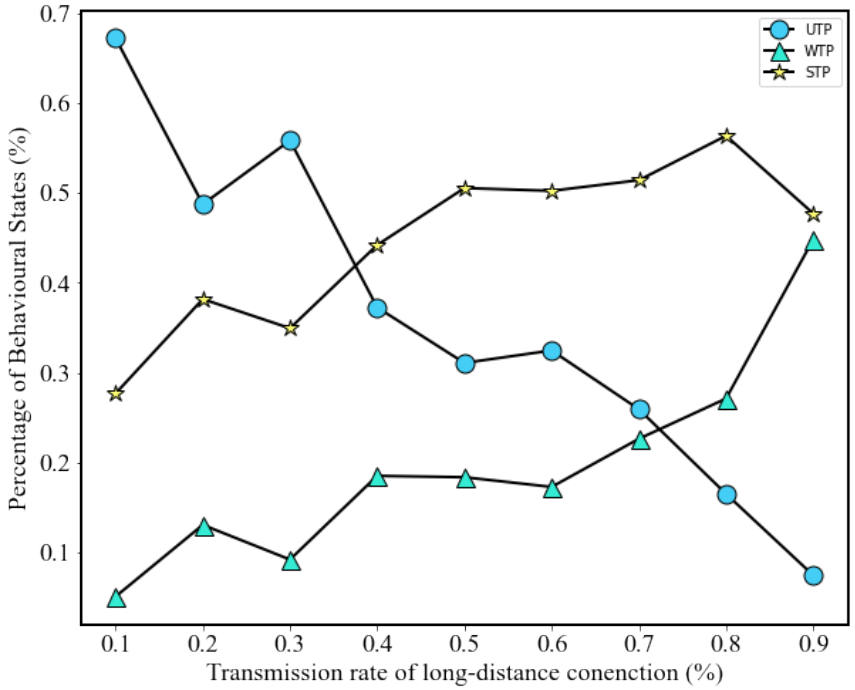

Fig. 27 Scenario result for a Transmission rate of short-range connection

Figure 28 shows the positive relationship between the participation rate and the transmission rate of long-distance connections. With a growth in the transmission rate of long-distance connections, formal work becomes dominant in the network for providing information, thus promoting citizen participation in NBS implementation.

The result confirms previous studies that reliance on the formal network for general information could facilitate citizen participation (Swapan, 2016).

5.4.3 Discussion

In this paper, an ABM is presented to simulate the participatory behaviour changes of citizens in the uptake and implementation of NBS in China. An ABM built on the extended TPB is applied to model micro-level behaviour dynamically. The agent-based model (1) integrates a bottom-up approach with top-down policies, (2) reinforces the TPB model in exploring citizens' behaviours at the micro-level, and (3) enables understanding of the behaviour of a system and what governs its outcomes. These advantages favourably distinguish the ABM from traditional models in capturing the heterogeneous agents' values and attitudes for simulation. Several important conclusions can be drawn from the scenario analysis.

Through three scenarios, this empirical study suggests that reliance on the formal network led by the government could increase the participation rate of the neighbourhood. In contrast, dependency on the informal network based on social networks and information dissemination have significant negative impacts. This finding reveals a change from micro-level participatory behaviours to macro-level participation rates. The results are intriguing, with some contradictions to existing studies. Previous studies have reached a common ground that information dissemination is critical to citizen participation and plays a positive role in raising citizens' aspirations to participation (Brombal, Moriggi & Marcomini, 2017; Sarvilinna, Lehtoranta & Hjerppe, 2018). In line with this argument, information is identified as one of the most important criteria for effective participation (Li et al., 2020). However, from Scenario 1, an opposite conclusion is drawn: information dissemination has a significant adverse effect on participatory behaviours at the neighbourhood level.

In the presented model, with an increase in information dissemination, the overall rates of participants declined significantly. Theoretically, improving information dissemination will certainly increase individuals' participation aspirations (Liu et al., 2018). This assertion, however, may overlook critical factors that affect information

dissemination, particularly in the context of incorporating the individual citizen into a dynamic social network. One of these factors is the informal network based on the social network. Essentially, participation offers citizens the formal means of acquiring new urban services. However, formal participation is not the single source for project information gathering in many countries. The simulation results show that the informal network between neighbourhood representatives (neighbourhood leaders or elite groups) and citizens prevails in the participatory process. The citizens relied heavily on the informal network and closely communicated with neighbourhood representatives to gather NBS project information. Thus, citizens feel it is unnecessary to participate in formal participation. Therefore, in Scenario 1, raising the number of seed nodes without considering the existence of an informal network could generate more central agents (neighbourhood representatives) in the network and decrease the overall participation rate.

Scenarios 2 and 3 are developed to analyze how informal and formal networks affect the participatory behaviours in the neighbourhood. In this model, the short-range and long-distance connections represent the informal and formal networks in the participatory process. Changing the transmission rate of these two connections could alter the predominant connection type. According to scenario results, reliance on the informal network could hinder participatory behaviour, while a dependency on a formal network could facilitate citizen involvement. This finding extends previous studies and proves the impact of the informal and formal networks on the participatory behaviours of citizens on the macro-level. As highlighted above, with a holistic perspective, macro-level behaviours arise from aggregated individual behaviours and the interactions between the agents. In the interaction and mutual learning process, the network citizens rely on becomes more important to the participation behaviours of the whole social system.

5.5 Conclusion

This study shares new insights into the participatory behaviours of a whole social system and what governs its outcomes. The extended theory of planned behaviour (TPB) was formalized to specify the agents in the agent-based modelling (ABM).

Three scenario analysis is conducted in Guyuan, China, systematically varying the model conditions and recording the results under a specific context. The results argue that reliance on the formal network could increase the participation rate of the whole neighbourhood. In contrast, dependency on the informal network and information dissemination have significant negative impacts on the overall rate of participants.

This finding is of great significance in the current situation in China. Although citizen participation is a full-fledged system in Western countries, it is still characterized by the following features in China: a top-down approach, government-led, formality than an effective mechanism, the low-level willingness of citizens, and so forth. This study is among the first attempts to develop a bottom-up model of individual participatory behaviour, which explains the social system's behaviour and elucidates the possible interventions the government can take to promote citizen participation. With an elaboration on the participatory behaviour changes in the neighbourhood, policymakers can realize what to do to facilitate involvement in NBS implementation.

This study contributes to the current literature in two aspects. First, by integrating ABM and TPB model, this model contributes to understanding the dynamics of participatory behaviours from the micro- to the macro-level. The extended TPB reveals how different socio-psychological factors shape individual behaviour and could provide a theoretical underpinning for the agent in the ABM. The combination of ABM and the extended TPB enlarges the predictive ability of the TPB model and could simulate the involvement and interactions dynamically. Second, this study reveals a novel finding that information dissemination has a significant role in decreasing citizen participation in the neighbourhood, as citizens may find informal networks more effective than formal participatory processes. Without the systematic improvement of the formal network at the neighbourhood level, information dissemination could hardly be effective.

This model is built based on a Chinese context. A single data source in Guyuan may not be sufficient to represent the typical situation in other developing countries. For example, citizens may have different interactive manners in different countries, which can make a difference in the behavioural rules of the ABM and thus influence

the role of the formal network. However, this study is an auspicious beginning for modelling and simulating participatory behaviours through integrating ABM with the TPB model. This paper's research perspective and methodology are of considerable significance to other developing countries experiencing fast growth in NBS adoption and implementation.

CHAPER 6

CONCLUSIONS AND FUTURE WORK

6.1 Introduction

The rapid and extensive urbanization has put decisive and concerted pressure on the quality of life and sustainability of Chinese cities in the last two decades (Yang et al., 2021). Cities are challenged by an increasing number of climate and environmental risks, such as super-storms, floods, droughts, and heat waves (Kumar, 2021). In response, a nature-remaking development strategy referred to as NBS, of using natural components and their multiple functions to enhance sustainable development in the cities, is springing up (Bauduceau et al., 2015; Cohen-Shacham, Walters, Janzen, & Maginnis, 2016). NBS is considered one of the most effective means of contributing to sustainable urban development. The concept of NBS advanced the idea of remaking nature that simultaneously benefits the environment and humans (Albert et al., 2019; Droste, Schröter-Schlaack, Hansjürgens, & Zimmermann, 2017; Faivre, Fritz, Freitas, de Boissezon, & Vandewoestijne, 2017). However, in creating NBS projects, decision-makers and urban planners often overlook personal feelings on the adoption and implementation of NBS in their neighbourhood. The critical challenge for upscaling NBS is to embrace citizens' ideals significantly (Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007; van Ham & Klimmek, 2017). However, in China, the government-led decision-making process still prevails, and citizen participation is merely a formality to appease legal requirements in most cases (Shan, 2012; Wang, Huang, Xu, & Wang, 2021). Additionally, the top-down design of citizen participation often ignored citizens' attitudes and concerns. Therefore, under the Chinese characteristics, there is an urgent need to explore citizen participation in NBS.

6.2 Reflection on Research Questions

This research proposes an assessment framework for citizen participation in nature-based solutions (NBS), exploring the participatory decision-making mechanism by

considering Chinese characteristics. The assessment framework consists of four parts: the literature review of citizen participation in NBS (Chapter II); the community acceptance of NBS at the neighbourhood level (Chapter III); the willingness to participate in NBS (Chapter IV); and the citizen participation in NBS simulation (Chapter V). This research can be a valuable input for decision-makers and urban planners in adopting and implementing NBS. Through this research, adequate attention is expected to be paid to citizen participation in NBS, thus, setting strategies for upscaling the adoption and implementation of NBS.

Against this backdrop, this research focused on assessing citizen participation in NBS. The main research question is:

How can citizen participation in NBS projects be understood, assessed, and enhanced under recurring climate-related risks in China?

This question is elaborated into four sub-questions, which were addressed respectively in Chapter II, III, IV, and V. The answers to the sub-questions are discussed below.

- **Sub-question 1: How is community acceptance of NBS projects in China, and what are the determinants?**

Assessment of community acceptance can facilitate understanding citizens' attitudes and concerns towards adopting and implementing NBS projects in their neighbourhood (Santoro et al., 2019). Although NBS projects are environment-friendly and could play a critical role in tackling climate-related risks in urban areas, citizens may have different assessments and preferences of NBS based on their knowledge and beliefs (Nesshöver et al., 2017; Wachsmuth, Cohen, & Angelo, 2016). In the decision-making process, urban planners value the social and environmental benefits of NBS, while citizens care more about self-interests. Therefore, the divergence of interest between citizens and urban planners, in most cases, the government, on NBS is an irreconcilable conflict. With the awakening of citizens' rights and environmental awareness, their opinions on NBS are becoming more critical and often contribute to the success of the state's development agenda.

In Chapter III, based on the survey in Guyuan city, a BBN model is developed to identify and rank various factors affecting community acceptance of NBS. The research reveals that project- and government-related factors are the critical determinants for community acceptance, while only one public-related factor is identified to have such a mega effect. In particular, the project-related factors involve project location and project design, and the government-related factors involve the availability of feedback, information, and emergency measures. The only public-related factor is personal experiences. These six factors are found to have the most significant effects on community acceptance of NBS. The other factors, such as peer influence, fulfilment commitment, and environmental protection benefits, are found to have limited effects, while living condition benefits, housing demolition risk, visual landscape degradation, daily disruption risk, and economic benefits have the most negligible influence on community acceptance.

- **Sub-question 2: What is the current state of citizen participation in NBS projects within the Chinese context?**

According to the literature review in Chapter II and a field investigation in Chapter IV, citizen participation in NBS is still insufficient and immature in China (Brombal, Moriggi, & Marcomini, 2017; Mei-yung, Jingyu, & Qi, 2013). Many citizens belong to the unengaged with a low willingness to participate in the adoption and implementation of NBS. Due to the ignorance of citizens and excessive government intervention, it should come as no surprise that citizens do not have sufficient opportunities or platforms to express their concerns. The existing studies tend to overemphasize the levels and benefits of citizen participation in NBS; however, research in several related domains, such as how citizens shape their participatory behaviours, is still lacking. Unlike Western developed countries, Chinese governance settings have their institutionalized features. The government-led decision-making process remains the predominant form in China (Shan, 2012; Wang, Huang, Xu, & Wang, 2021). In the last several decades, China's fast economic growth and urbanization have benefited from the centralized administrative mode, which ensures the effectiveness of decisions. The top-down decision-making process is conducive

to the quick start of the project; however, citizens' voice is rarely considered in such a process. In this light, citizens' willingness to participate is stuck at a low level, often resulting in opposition to the proposed projects. With Chinese characteristics, citizen participation in NBS missed a solid theoretical foundation and contextual analysis.

The highlight of the PhD thesis is that it reveals current situations of citizen participation in NBS with Chinese characteristics and suggests the development trend and study direction of citizen participation within the Chinese context. Based on the novel findings, the follow-up research is conducted to elaborate on the mentioned aspects: (1) an analytical framework of community acceptance to NBS projects; (2) an analytical framework of willingness to participate in NBS; (3) a simulation of how citizens shape their participatory behaviours.

- **Sub-question 3: What are the factors affecting willingness to participate in NBS projects in China, and how?**

Through in-depth interviews and questionnaire surveys with a wide range of citizens, the results reveal that the socio-psychological factors together influence citizens' willingness to participate based on the extended TPB model. The study suggests that social influence, perceived benefits, and perceived enablers are three significant factors directly influencing willingness to participate, while the additional factors, information acquisition and consultation channels, are found to impact willingness to participate indirectly. Among the constructs of the extended TPB model, social influence is a critical factor for concern. Social influence is proved to have the most significant negative influence on willingness to participate. Additionally, through the path analysis in the SEM model, social influence plays a significant role in mediating the positive impact of information acquisition perceived benefits, finally contributing to a low willingness to participate. In this study, social influence represents subjective norms and indicates pressures from its social network to perform expected behaviours. Social influence can be recognized as an informal network in the current Chinese participatory process, parallel to the formal network. The other two constructs in the extended TPB model, perceived benefits and enablers, reflect citizens' perceptions of participatory behaviour. These two factors are also found to play a significant role in

enhancing willingness to participate. It is undeniable that citizen participation would be a time-money-consuming process for a wide range of citizens. The participators should invest time and effort to engage in the participatory process to realize their rights. As a result, their perceived benefits and enablers to citizen participation could affect their willingness to participate. Citizens are reluctant to invest time and effort in such a process unless the threshold of participation is low.

It is worth noting that the additional variables, information acquisition and consultation channels, are proved to have considerable indirect impacts on willingness to participate. Information acquisition can increase the understanding of the proposed NBS and the perceived benefits of citizen participation exercise, while consultation channels assure possibilities to raise voices and increase perceived enablers, which lowers the involvement thresholds. The empirical research demonstrated that the unengaged share common features with older age, lower education, and income level. These weak socio-economic conditions cause the unengaged to be disadvantaged in accessing information and consultation from the decision-making agencies. Therefore, improving the information release and providing sufficient platforms for consultation could considerably increase the perceptions of the unengaged, thus, facilitating willingness to participate.

The novelty of the PhD study is that it extends the current TPB model by adding additional variables to explain the interrelationships between socio-psychological factors and willingness to participate. Through the extended TPB model, the research verifies the significant impacts of the supplementary variables on willingness to participate and provides well-explained paths about how different socio-psychological factors influence willingness to participate. The research results could give urban planners and decision-makers valuable input to enhance citizens' willingness to participate.

- **Sub-questions 4: How do citizens make decisions that shape participatory behaviours in the case of Guyuan?**

This study reveals citizens' interactions, status, and decision-making rules through ABM in the participatory process. In Chapter V, the extended TPB model is formalized to specify the agents in ABM. The paths from the core components to the target construct in the extended TPB model represent the agent reasoning process, which can be seen as a linear combination. Based on the assumption of rational choice, the variables with scores and total effect values calculate the participatory probability value of each agent.

The heterogeneous and complex network of participatory decision-making is fully exposed to scrutiny through ABM, and citizen participation in China is better understood. Although citizen participation is full-fledged in developed countries, it is still characterized by special Chinese features: the top-down approach, government-led, formality than an effective mechanism, and low-level willingness of citizens. Therefore, it is of great significance to reveal and understand how citizens shape their participatory behaviour with Chinese characteristics. It is unrealistic to change current institutions, but exploring and understanding citizen participation from the citizens' perspective could help identify the crux within Chinese contexts.

- **Sub-question 5: How can different interventions enhance citizen participation in NBS projects in the case of Guyuan?**

In Chapter V, three scenarios, systematically varying the model conditions and recording the results under a specific context, are conducted to explore the effects of different interventions on citizens' participatory behaviours. The results suggest that reliance on the formal network could increase the participation rate of the whole neighbourhood. In contrast, dependency on the informal network and information dissemination have significant negative impacts on the overall rate of participants. The finds disclose a variation from the micro-level participatory behaviours to the macro-level participation rates. With some contradictions to previous studies, the findings provide new insights into citizen participation. As mentioned in Chapter IV, information dissemination is proved a critical facilitator to enhancing citizen participation and plays a positive role in raising citizens' aspiration to participate. However, this assertion may ignore the interactions between citizens in the dynamic

social network. Contextualizing the reality in the ABM, the informal network has a mega effect on citizens' participatory behaviours. In this study, the informal network is parallel to the formal network, which refers to close communication with neighbourhood representatives. Within the Chinese context, reliance on the informal network still prevails in the participatory process and may negatively affect citizens' participatory behaviours.

By integrating ABM and TPB models, this study contributes to understanding the dynamics of participatory behaviours from the micro- to the macro-level. The extended TPB reveals how different socio-psychological factors shape individual behaviour and could provide a theoretical underpinning for the agent in the ABM. The combination of ABM and the extended TPB enlarges the predictive ability of the TPB model and could simulate the involvement and interactions dynamically.

6.3 Contributions

As shown in previous chapters, citizen participation and NBS are two pop topics in urban studies. Faced with recurring climate-related risks, citizens are more aware of the environmental issues, and their involvement in NBS projects is increasingly promising. However, existing studies fail to explore citizen participation in NBS in a holistic view comprehensively. Few studies have paid close attention to the unengaged in designing and planning citizen participation in NBS projects. The interaction between socio-psychological factors and willingness to participate is largely overlooked. Further, the emerging participatory pattern of the whole is unrevealed. Therefore, this thesis provided a better insight into current citizen participation in NBS projects by bridging these research gaps. In conclusion, the contributions can be summarized as follows.

6.3.1 Academic contributions

This thesis comprises four core chapters aiming to thoroughly understand citizen participation in NBS projects. The four major parts together bridge the research gaps mentioned above. The specific academic contributions can be elaborated as follows:

(1) The literature review in Chapter II systematically reviewed existing literature on citizen participation in NBS projects. The synthesis covers a broad range of issues and topics about citizen participation in NBS, tracing the emerging trends, identifying the research gaps, and presenting creative directions. Through a thorough understanding of research status and gaps, this review provides new research directions of citizen participation in NBS and contributes new insights into current participatory research in NBS, which broaden the thinking of participatory research in NBS projects.

(2) In Chapter III, through the BBN, the cause and effect relationships between various factors and community acceptance were clearly revealed, contributing to filling the critical void that existing research remains poorly understood on why local stakeholders have a low-level acceptance of NBS projects. By proposing an intuitive and effective approach, this study makes considerable contributions to understanding community acceptance of NBS projects at the neighbourhood level and provides a new approach to community acceptance research.

(3) In Chapter IV, this study explored the factors influencing willingness to participate in NBS projects through the extended TPB model. By introducing the additional variables, this extended TPB model upgrades the explanatory ability of the conventional model and provides a solid theoretical foundation for participatory research in NBS projects, which supplements current participatory research. Based on the well-explained paths between social-psychological factors and willingness to participate, the exploration of citizen participation in NBS can be significantly extended.

(4) In Chapter V, the integration of ABM and the extended TPB model contributes to understanding the dynamics of participatory behaviours from the micro- to the macro-level. The combination of ABM and the extended TPB model enlarges the predictive ability of the conventional TPB model and provides a novel approach for dynamically simulating the involvement and interactions of citizens in NBS projects.

6.3.2 Societal contributions

This thesis contributes to a better understanding of citizen participation in NBS projects in China by exploring community acceptance, willingness to participate and participatory patterns. The research supplements the existing studies by addressing the research gaps in citizen participation. Practically, this study provides a set of valuable measures and strategies for urban planners and decision-makers to facilitate citizen participation in NBS projects. The empirical research could be a solid underpinning for planning and implementing citizen participation in NBS projects. For example, practitioners can identify and motivate the unengaged in the participatory process accordingly to the novel findings. In conclusion, this empirical research provides not only an in-depth understanding of citizen participation in NBS projects but also guidance for developing sustainable NBS projects.

6.5 Limitations

It is acknowledged that citizen participation in NBS projects involves a wide range of stakeholders across different levels in China. The exploration and simulation of citizen participation in NBS could provide critical references for urban planners and decision-makers. However, apart from the chapter-specific limitations mentioned in previous chapters, it is necessary to stress the limitations from an integral perspective.

First, the model developed in this thesis depended heavily on the captured data, including scholarly literature, policy document and field investigation. However, there are inevitably subjectivity and biases in data acquisition and processing. For example, the respondents in the questionnaire survey may mask their exact ideas for some sensitive questions influenced by social morality. Besides, the qualitative analysis, including literature review, assessment of community acceptance, and exploration of willingness to participate, is manually conducted by the candidate, which may involve personal propensity. Against this backdrop, the candidate strived to conduct the research based on rigorous methodologies and analyze collected data from a neutral standpoint to reduce subjectivity and bias.

Admittedly, citizen participation is a complicated system engineering and involves various aspects across different social levels. The levels and methods of citizen

participation are highly related to political and cultural backgrounds. Therefore, the settings of the current sub-models mentioned above are still quite limited. For example, this thesis explores willingness to participate in NBS through the extended TPB model. Despite the added additional variables to enlarge the explanatory ability of the conventional TPB model, the extended TPB model is still not enough to fully elucidate the mechanism underlying willingness to participate in NBS. The extended TPB model only elaborates on citizens' aspirations for participation in the socio-psychological standpoint and fails to address the inherent cultural traditions and a shared sense of citizen rights. Therefore, the explanatory ability of the extended TPB model has some constraints considering a complicated social-environmental system. Likewise, this thesis streamlined several spatial conditionalities of the simulation model in Chapter V, considering the model efficiency. To improve the predictive performance, it is necessary to introduce more spatial constraints into the participatory patterns.

Finally, a single data source within the Chinese context may not be sufficient to cover prevailing situations in other regions. This thesis aims to assess and explore the contextualised participatory process in NBS projects within a Chinese context. However, the complicated decision-making process can not be easily prescribed. The various project types and delivery patterns of NBS restrict the representativeness of the selected cases and result in different conditions for the research on citizen participation.

In conclusion, the limitations mentioned above should be carefully addressed in future studies. The existing research framework still has room for improvement. It is necessary to establish a more complicated and comprehensive research system to explore citizen participation in NBS projects further. We hope the research framework can significantly contribute to participatory research in NBS projects through continuous improvement of the current model.

6.6 Future research

Focused on citizen participation in NBS projects, this PhD thesis explores community acceptance, willingness to participate, and participatory behaviours of citizens within

a Chinese context. This thesis concentrates on citizens' perspectives and aims to understand how citizens shape their participatory behaviours by analyzing their acceptance of NBS and willingness to participate. The study has contributed more fundamentally to the domain by assessing and exploring citizen participation in NBS. However, this specificity poses some limitations on the external validity of the findings in a broader scope, such as rehabilitation type of urban renewal projects, some particular groups of cities in China, or even global context. Therefore, based on the PhD thesis, a future agenda is suggested to advance academic literature on citizen participation.

First, more research on the silent majority (a.k.a. the unengaged) in the participatory process is needed. The silent majority is a specific group of citizens that are often the most likely to be neglected by decision-makers and urban planners. Currently, rare studies have distinguished the silent majority from the vocal minority in the participatory process. Therefore, the silent majority is always represented by the vocal minority who is highly motivated to express their concerns, tends to dominate the decision-making process, and cannot convey their attitudes and concerns. For effective citizen participation, attitudes of the unengaged cannot be ignored due to the considerable proportion of the total population. In this light, it is urgent to pay more attention to the unengaged to examine the causes of such recurring issues, evaluate their characteristics, and understand how to stimulate them to express their opinions.

Second, more solid theoretical research on citizen participation from urban development and project management perspective is needed. Citizen participation is an interdisciplinary concept and was first systematically elucidated by Arnstein in 1969 with the "ladder of participation" theory. Arnstein illuminated citizen participation from the political science perspective and focused on public administration and citizen rights in public affairs. Many studies on citizen participation in the urban development domain have adopted the "ladder of participation" theory, which is biased toward the political environments and social regimes. Little research has theoretically explored the basis of citizen participation

within an urban development context. Citizen participation in NBS has been mainly positioned within the mainstream of public administration and lacks theoretical discussion in the urban development and project management domain. Therefore, the discussion of the theoretical basis of citizen participation because of urban development and project management is necessary and will be a valuable addition to the knowledge base.

Third, considering the status quo of knowledge and approaches, more research on citizen participation in NBS within the Chinese context is needed. Although citizen participation has received sufficient attention from both academia and official, the capacity of these processes to influence decision-making remains widely debated. Some scholars argue that citizen participation in China is still at the institutional level, which merely seeks participation as an instrument to legitimize decision-making processes. The empirical study in Guyuan also reveals the plight of citizen participation in adopting and implementing NBS. Despite the repeated emphasis on involving citizens, the challenges, difficulties, and vulnerabilities of citizen participation within the Chinese context remain unsolved. Therefore, more studies on citizen participation in NBS are highly recommended to better understand citizen participation and propose inclusive frameworks to tackle current challenges and difficulties.

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Appendix A. The Questionnaire

English translation of the questionnaire

Survey of Nature-based solutions projects in Guyuan

This questionnaire will be only used by PhD candidates at the Eindhoven University of Technology to conduct research on the built environment and public behaviour. **We assure you that all responses will be strictly confidential and anonymous.** We appreciate your time and generosity.

Introduction:

Many questions in this survey make use of rating scales with five places; you are to circle the number that best describes your opinion. In making your ratings, please remember the following points:

* Be sure to answer all items – do not omit any.

* Never circle more than one number on a single scale.

Part I: Basic information

1. **What's your gender _____?**
   [ ] Male
   [ ] Female

2. **What's your age___?**
   [ ] Age_18 _to_25
   [ ] Age_25_to_35
   [ ] Age_35_to_45
   [ ] Age_45_to_55
   [ ] Age_over_55
3. **What's your highest education?**
   [ ] Under junior school
   [ ] High school
   [ ] College
   [ ] University
   [ ] Master and above
4. **What's your monthly income___?**

[ ] Under_2000
[ ] Between_2000_to_3000
[ ] Between_3000_to_4000
[ ] Between_4000_to_5000
[ ] Over_5000

5. **What's your occupation?**
[ ] Government agencies and institutions
[ ] Enterprise employees
[ ] Self-employed
[ ] Unemployed
[ ] Others

6. **What's your Hukou status_____?**
[ ] Floating population
[ ] Non-floating population

Part II: Past Behaviour: Self-Report

7. **Have you ever experienced or heard of urban waterlogging/local water shortage?**
[ ] Never
[ ] Occasionally
[ ] Not sure
[ ] Often
[ ] Very often

8. **Have you ever participated in the decision-making and implementation of the Nature-based solutions projects?**
[ ] Never
[ ] Occasionally
[ ] Not sure
[ ] Often
[ ] Very often

9. **Do you know the proposed Nature-based solutions projects?**
[ ] I don't know at all
[ ] I don't know
[ ] Generally
[ ] I know a little bit
[ ] I know very well

Part III: Awareness and attitudes

10. **Are you satisfied with the function of the proposed Nature-based solutions projects___?**

[ ] Very_Dissatisfied
[ ] Dissatisfied
[ ] Neutral
[ ] Satisfied
[ ] Very_Satisfied

11. **Are you satisfied with the location selection of the proposed Nature-based solutions projects ___?**
[ ] Very_Dissatisfied
[ ] Dissatisfied
[ ] Neutral
[ ] Satisfied
[ ] Very_Satisfied
12. **Are you satisfied with the duration of the proposed Nature-based solutions projects ___?**
[ ] Very_Dissatisfied
[ ] Dissatisfied
[ ] Neutral
[ ] Satisfied
[ ] Very_Satisfied
13. **Are you satisfied with the feasibility and sustainability design of the proposed Nature-based solutions projects ___?**
[ ] Very_Dissatisfied
[ ] Dissatisfied
[ ] Neutral
[ ] Satisfied
[ ] Very_Satisfied
14. **Do you agree that the implementation of the Nature-based solutions projects will bring economic benefits to you, such as an increase in income and land value___?**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree
15. **Do you agree that the implementation of the Nature-based solutions projects will bring living conditions benefits to you, such as an improvement in living conditions___?**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree
16. **Do you agree that implementing the Nature-based solutions projects will bring environmental protection benefits to you, such as the**

preservation of the wetland environment?
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree

17. **Do you agree that the implementation of the Nature-based solutions projects will bring job opportunity benefits to you, such as an increase in job opportunities___?**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree
18. **Do you think that the implementation of Nature-based solutions projects will bring housing demolition issues__?**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree
19. **Do you think that the implementation of Nature-based solutions projects will bring traffic disruptions__?**
[ ] Very_Low
[ ] Low
[ ] Neutral
[ ] High
[ ] Very_High
20. **Do you think that the implementation of Nature-based solutions projects will bring structural damage to existing buildings __?**
[ ] Very_Low
[ ] Low
[ ] Neutral
[ ] High
[ ] Very_High
21. **Do you think that the implementation of Nature-based solutions projects will bring noise and dust pollution__?**
[ ] Very_Low
[ ] Low
[ ] Neutral
[ ] High
[ ] Very_High
22. **How do you think about the transparency of the use of project funds___?**

[ ] Very_Low
[ ] Low
[ ] Neutral
[ ] High
[ ] Very_High

23. **How do you think about the necessary channels to release the project information___?**
[ ] Very_Low
[ ] Low
[ ] Neutral
[ ] High
[ ] Very_High
24. **How do you think about the necessary channels to express public interest demand___?**
[ ] Very_Low
[ ] Low
[ ] Neutral
[ ] High
[ ] Very_High
25. **How do you think about the decision-making styles the government usually adopt in the decision-making process___?**
[ ] Very_Low
[ ] Low
[ ] Neutral
[ ] High
[ ] Very_High
26. **Are you satisfied with the emergency measures the government has taken in the proposed Nature-based solutions projects___?**
[ ] Very_Dissatisfied
[ ] Dissatisfied
[ ] Neutral
[ ] Satisfied
[ ] Very_Satisfied
27. **Are you satisfied with the fulfilment of the commitment in the proposed Nature-based solutions projects____?**
[ ] Very_Dissatisfied
[ ] Dissatisfied
[ ] Neutral
[ ] Satisfied
[ ] Very_Satisfied
28. **Are you satisfied with the feedback of public opinions and interests in the proposed Nature-based solutions project ____?**
[ ] Very_Dissatisfied

[ ] Dissatisfied
[ ] Neutral
[ ] Satisfied
[ ] Very_Satisfied

29. **Do you think that the Nature-based solutions projects are value-for-money____?**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree
30. **Are you willing to pay for the Nature-based solutions projects ____?**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree

Part IV: Behaviours

31. **Whether or not you support the Nature-based solutions projects is influenced by your peers___.**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree
32. **Whether or not you support the Nature-based solutions projects is influenced by the local government___.**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree
33. **Whether or not you support the Nature-based solutions projects is influenced by the local media___.**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree
34. **Whether or not you support the Nature-based solutions projects is completely up to me__.**

[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree

35. **Whether or not you participate in the decision-making and implementation of the Nature-based solutions projects is influenced by your peers___.**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree
36. **Whether or not you participate in the decision-making and implementation of the Nature-based solutions projects is influenced by the local government___.**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree
37. **Whether or not you participate in the decision-making and implementation of the Nature-based solutions projects is influenced by the local media___.**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree
38. **Whether or not you participate in the decision-making and implementation of the Nature-based solutions projects is completely up to me__.**
[ ] Strongly_Disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly_Agree
39. **Please mark the bullet that best reflects the information you get about the Nature-based solutions projects _____**
[ ] Very insufficient
[ ] Not enough
[ ] Generally sufficient
[ ] Sufficient
[ ] Very sufficient

40. **Please mark the bullet that best reflects the adequacy of information release of the Nature-based solutions projects by the local government_____**
    [ ] Very insufficient
    [ ] Not enough
    [ ] Generally sufficient
    [ ] Sufficient
    [ ] Very sufficient
41. **Please mark the bullet that best reflects the main method you get information on the Nature-based solutions projects _____**
    [ ] Informed by neighbors
    [ ] Newspapers/publications
    [ ] TV broadcasts
    [ ] Internet mobile phones
    [ ] Non-single channels
42. **Please mark the bullet that best reflects the adequacy of the feedback provided by the local government in the Nature-based solutions projects_____**
    [ ] Very insufficient
    [ ] Not enough
    [ ] Generally sufficient
    [ ] Sufficient
    [ ] Very sufficient
43. **Do you think the involvement in the Nature-based solutions projects can bring personal benefits (such as improving living conditions)__?**
    [ ] Strongly_Disagree
    [ ] Disagree
    [ ] Neutral
    [ ] Agree
    [ ] Strongly_Agree
44. **Do you think the involvement in the Nature-based solutions projects (such as making suggestions) can bring benefits to others (such as improving the living conditions of relatives and friends)_____?**
    [ ] Strongly_Disagree
    [ ] Disagree
    [ ] Neutral
    [ ] Agree
    [ ] Strongly_Agree
45. **How much do you think the involvement in the Nature-based solutions projects can promote family career development/improvement of living standards__?**
    [ ] Strongly_Disagree
    [ ] Disagree
    [ ] Neutral

[ ] Agree
[ ] Strongly_Agree

46. How much do you think the involvement in the Nature-based solutions projects can contribute to the community_____?
[ ] Very small
[ ] Small
[ ] Average
[ ] Large
[ ] Very large

47. **For me, to be involved in the Nature-based solutions projects on a regular basis is_____?**
[ ] Extremely difficult
[ ] Difficult
[ ] Neutral
[ ] Easy
[ ] Extremely easy

48. I plan to attend the Nature-based solutions projects on a regular basis__.
[ ] Extremely unlikely
[ ] Unlikely
[ ] Neutral
[ ] Likely
[ ] Extremely likely

49. I am confident that if I wanted to, I could attend the Nature-based solutions projects on a regular basis_____.
[ ] Definitely false
[ ] False
[ ] Neutral
[ ] True
[ ] Definitely true

50. I will make an effort to attend the Nature-based solutions projects on a regular basis__.
[ ] Definitely false
[ ] False
[ ] Neutral
[ ] True
[ ] Definitely true

51. I intend to attend Nature-based solutions projects on a regular basis
[ ] Strongly disagree
[ ] Disagree
[ ] Neutral
[ ] Agree
[ ] Strongly agree

52. When you have positive suggestions for the Nature-based solutions projects, are you willing to offer it in some way_____?
[ ] Totally unwilling
[ ] Unwilling
[ ] Fair
[ ] Relatively willing
[ ] Very willing

53. When you have different opinions on the Nature-based solutions projects, are you willing to express it actively in some way _____?
[ ] Totally unwilling
[ ] Unwilling
[ ] Fair
[ ] Relatively willing
[ ] Very willing

54. Please mark the bullet that best reflects your preferred method to be involved in Nature-based solutions projects _____
[ ] Informing
[ ] Consultation
[ ] Involvement
[ ] Collaboration
[ ] Devolved decision-making

55. Please mark the bullet that best reflects the aspect that you think is the most important to be involved in Nature-based solutions projects _____
[ ] Time costs
[ ] Money cost
[ ] Knowledge demand
[ ] Level of participation
[ ] Expression of opinions

56. Please mark the bullet that best reflects the measures that you will take if you encounter problems in the implementation of Nature-based solutions projects ____
[ ] No action
[ ] Solving through construction unit
[ ] Solving through government
[ ] Solving through legal proceedings
[ ] Solving through media, etc.

57. Please mark the bullet that best reflects the measures that you would like the government to take to reduce the problems in the Nature-based solutions projects _____
[ ]No measures
[ ]Strengthen pre-management
[ ]Strengthen the ability to solve problems
[ ]Establish an accountability mechanism
[ ]Establish a platform for public participation

Appendix B. The code of the ABM

```
Codes:
extensions[nw csv gis]
patches-own
[
 scope
 loc
 density
 project
]
turtles-own
[state
  si
  pcs
  ia
  bi
  pro
  center
  job
]
links-own
[rewired? dis]
globals[wtp utp stp shortlink longlink top density-distribution max-bi min-bi]
to setup
  clear-all
  random-seed randomseed
  ask patches [set pcolor 9.9]
  load-gis-data
  setup-persons
  show-link?
set utp count turtles with [color = 45 and job = "resident agent"] / count turtles
with [job = "resident agent"]
set wtp count turtles with [color = 75 and job = "resident agent"] / count turtles
with [job = "resident agent"]
set stp count turtles with [color = 104 and job = "resident agent"] / count turtles
with [job = "resident agent"]
  set shortlink count links with [dis = "short"]
  set longlink count links with  [dis = "long"]
  reset-ticks
end
to setup-persons

  set density-distribution [0.3 0.2 0.15 0.35]
```

```
  nw:generate-preferential-attachment turtles links Number-of-agents 1[
    let locc random-float 1
    if locc < item 0 density-distribution
    [move-to one-of patches with [density = 3]]
       if locc > item 0 density-distribution
    and locc < item 0 density-distribution + item 1 density-distribution
    [move-to one-of patches with [density = 2]]
       if locc > item 0 density-distribution + item 1 density-distribution
    and locc < item 0 density-distribution + item 1 density-distribution + item 2
density-distribution
    [move-to one-of patches with [density = 1]]
       if locc >  item 0 density-distribution + item 1 density-distribution + item 2
density-distribution
    [move-to one-of patches with [density = 0 ]]
     set heading 360
     fd random-float 3
     set shape "circle"
     set size 1
    set bi random-float 1
    set color gray
    set pcs 1 + random-float 9
    set job "resident agent"
   ]
  set max-bi max [bi] of turtles
  set min-bi min [bi] of turtles
  let bi-scope max-bi - min-bi

  ask n-of seed-nodes turtles
  [set ia gov-initial-ia
  set job "government agent"
  set size 2
  set shape "star"
  set color 14
  ]


  ask n-of 10 turtles with [job = "resident agent" and [density] of patch-here >= 1 ]
  [ set job "project agent"
    set shape "square"
    set project 1
  ]

  set top turtles with [job = "project agent"]
  ask top [set center 1
```

```
  set size 2
  set color 54]
  update-inf
end

to show-link?
  ask links[ ifelse link-hidden? [hide-link][show-link]]
end
to go
 if ticks >= stop-ticks
  [stop]
  interact
  if move?
  [MOVE]
  update-inf
  update-links
  tick
end

to interact
  set max-bi  max [bi]  of turtles
  set min-bi  min [bi]  of turtles
  let max-pcs max [pcs] of turtles
  let min-pcs min [pcs] of turtles
  let max-ia  max [ia]  of turtles
  let min-ia  min [ia]  of turtles
  let ia-scope  max-ia - min-ia
  let pcs-scope max-pcs - min-pcs
  let bi-scope  max-bi - min-bi

  ask turtles with [job = "resident agent" and any? link-neighbors with [ia > [ia] of
myself]]
  [ let siij 0
    let sender one-of link-neighbors with [ia > [ia] of myself]
    let neighbors-max-ia max [ia]  of link-neighbors
    let max-ia-n one-of link-neighbors with-max [ia]
    ifelse distance max-ia-n < long-link-boundary
    [set ia ia + (neighbors-max-ia - ia) * sr]
    [set ia ia + (neighbors-max-ia - ia) * ld]

      ifelse abs (pcs - [pcs] of sender) / pcs > pi-scope
      [set siij 0]
    [set siij abs (pcs - [pcs] of sender) / pcs ]
    let piim 0
```

```
   let pb 0
   let pen 0
   let dis-project []
   ask patches with [project = 1] [set dis-project lput distance  myself dis-project]
   set piim a ^ (min dis-project)
   set pb alpha * ia * piim
   set pen beta * ld

   set bi bi + siij * ([bi] of sender - bi) + (seed-nodes / Number-of-agents) * pb * n +
pen * m

   set pro (abs ((bi - min-bi) / bi-scope))
   if pro < 0.5
   [set state "UTP"
   set color 45]
   if pro >= 0.5 and pro < 0.7
   [set state "STP"
   set color 104]
   if pro >= 0.7
   [set state "WTP"
   set color 75]

    ifelse show-pro?
 [ set label pro ]
 [ set label "" ]

  ]

end

to move

  ask n-of (0.6 * count turtles with [center = 0]) turtles with [center = 0]  [
let b one-of top
   face b
   fd random-float 1
   if distance b < 0.5 [bk 1]]
end

to update-inf
  ask turtles with [job = "resident agent "]
  [if state = "UTP" [SET COLOR 45]
   if state = "STP" [SET COLOR 104]
   if state = "WTP" [SET COLOR 75]
```

```
 ]
 ask links [
  ifelse link-length < long-link-boundary
  [ set dis "short" ]
  [set  dis "long"]

 ]
 set utp count turtles with [color = 45 and job = "resident agent"] / count turtles
with [job = "resident agent"]
 set wtp count turtles with [color = 75 and job = "resident agent"] / count turtles
with [job = "resident agent"]
 set stp count turtles with [color = 104 and job = "resident agent"] / count turtles
with [job = "resident agent"]
   set shortlink count links with [dis = "short"]
   set longlink count links with  [dis = "long"]
end


to load-gis-data
 let road-dataset gis:load-dataset "Final_GIS_Data/æ•°æ®8.shp"
 let community2-dataset gis:load-dataset "Final_GIS_Data/Export_Output_4.shp"
 let community3-dataset gis:load-dataset "Final_GIS_Data/Export_Output_7.shp"
 let community1-dataset gis:load-dataset "Final_GIS_Data/Export_Output_3.shp"
 let river-dataset gis:load-dataset "Final_GIS_Data/Export_Output_5.shp"
 let community3-dataset2 gis:load-dataset "Final_GIS_Data/Export_Output_6.shp"
 gis:set-world-envelope ( gis:envelope-union-of  ( gis:envelope-of road-dataset )
 ( gis:envelope-of community2-dataset )
 ( gis:envelope-of community3-dataset )
 ( gis:envelope-of community1-dataset )
  (gis:envelope-of river-dataset)
 (gis:envelope-of  community3-dataset2)

 )

 gis:set-drawing-color 4
 gis:draw road-dataset 0.4
  ask patches gis:intersecting road-dataset
 [ set loc "road" ]

  gis:set-drawing-color 27
 gis:fill community2-dataset  1.0
 gis:set-drawing-color 27
 ask patches gis:intersecting community2-dataset
 [ set loc "community2"
```

```
 set density 2]

  gis:set-drawing-color 27
    gis:fill community3-dataset 1.0
      ask patches gis:intersecting community3-dataset
 [ set loc "community3"
set density 3 ]

   ;gis:fill Export_Output_2 1.0

 gis:set-drawing-color 27
     gis:fill community1-dataset 1.0
     ask patches gis:intersecting community1-dataset
 [ set loc "community1"
set density 1 ]

   gis:set-drawing-color 97
     gis:fill river-dataset 1.0
     ask patches gis:intersecting river-dataset
 [ set loc "river"
 ]

    gis:set-drawing-color 27
     gis:fill community3-dataset2 1.0
     ask patches gis:intersecting community3-dataset2
 [ set loc "community32"
 ]

end

to update-links
  ask turtles
  [let ml count my-links
    let dl 0
    if ml != 0
    [ask my-links [
      if dis = "short"
      [if random-float 1 < SR [
        set dl dl + 1
        die]]
      if dis = "long"
      [if random-float 1 < LD [set dl dl + 1
          die]]
      ]
```

```
    ask n-of dl other turtles [create-link-with myself [hide-link]]

  ]]
 ask n-of 100 links[die]
 ask n-of 100 turtles [create-link-with one-of other turtles [set hidden? True]]

end
```

Curriculum Vitae

LI DAI was born and raised in Shandong Province, China. He studied Engineering Management at Huazhong Agricultural University and obtained his B.Sc. in 2014. From 2014 to 2017, he obtained a master's degree from Wuhan University, China. During his master's period, the research topic was *Poverty Mechanism, Residential Reconstruction, and Social Integration of Migrants in Major Construction Projects: The Perspective of Rapid Urbanization*. In September 2017, LI DAI started his PhD research in Information Systems in the Built Environment (ISBE) group at Technische Universiteit Eindhoven, the Netherlands. His PhD was fully funded by the China Scholar Council (CSC). With guidance from Pro. Bauke de Vries and dr. Qi Han, he focused on citizen participation in nature-based solutions in China. The PhD research results are presented in this dissertation.

List of publications

Dai, L., Han, Q., de Vries, B., & Wang, Y. (2022). Exploring key determinants of willingness to participate in EIA decision-making on urban infrastructure projects. Sustainable Cities and Society, 76, 103400.

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Dai, L., Han, Q., & de Vries, B. (2022). Understanding citizen participation in nature-based solutions: a systematic review. Habitat International. (Under Review)

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