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Public support for urban climate adaptation policy through nature-based solutions in Prague

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HIGHLIGHTS

- Climate change and heatwaves are seen as risk by population of Prague.
- Use of Nature Based Solutions (NBS) for adaptation is supported by the public.
- Species diversity of NBS measures is valued by respondents.
- Measures implemented in public spaces preferred over those on public buildings.
- Negative experience with heat waves increases support for NBS.

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ABSTRACT

Climate change is an urgent challenge in urban planning. Weather extremes and resulting impacts such as heat waves and flash floods are already influencing the quality of life in cities and impact on infrastructure, human health and city life. In this study, we investigated perception of and economic preferences for adaptation to climate change in one of Europe's capital cities to inform its planning policy. Through a choice experiment, we elicit the preferences of a sample (n = 550) from Prague, Czech Republic, for a citywide policy which would increase the use of six commonly used nature-based solutions (NBS) in public spaces and on public buildings across the city. Three attributes were used to describe this policy: (i) the locations where NBS would predominantly be implemented, (ii) the species diversity of these measures, and (iii) their implied costs for households. Our results showed that the NBS policy is widely supported by the public over the status quo and that this preference is mirrored in citizens' concerns about climate change and the risks posed by heatwaves particularly. Species diversity matters in the portrayed scenarios, suggesting that (bio)diverse NBS generate additional public value over single species measures and that policy which targets biodiversity may gain support. Implementation of NBS in public spaces (e.g., street trees, rain gardens) is preferred over measures implemented on public buildings (green roofs and facades). Furthermore, adverse experiences with heatwaves has increased support for the policy. The presented results provide evidence that adaptation planning through NBS is likely to generate significant public value which is expected to increase with the intensifying effects of climate change.

1. Introduction

Climate change is producing significant adverse effects on urban life and human well-being in Europe and globally (IPCC, 2019; Watts et al., 2019, 2021). Heat extremes and heat waves particularly are one of the main climate-related hazards which are placing significant stress on society, human health and well-being, ecosystems and agriculture (EEA, 2017a). Indeed, climate change has led to a steady increase in global average temperature and increased the frequency, duration and severity of heat related events (IPCC, 2019) which is the most immediate and

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direct impact of changing climate on human health (Watts et al., 2019) that may have lasting effects on human capital and productivity (Fishman, Carrillo, & Russ, 2019; Isen, Rossin-Slater, Walker, & Smith, 2017). In Europe, over the period 1980–2013, heat waves represented 1% of all natural hazards, yet alone caused 5% of all reported economic loss and were responsible for 67% of all fatalities related to natural disasters in the same period (EEA, 2017b), with death tolls of over 70,000 in 2003 and 55,000 in 2010 alone (Barriopedro, Fischer, Luterbacher, Trigo, & Garcia-Herrera, 2011; EEA, 2017b; Robine et al., 2008). In the 1991–2015 period, heat waves were the deadliest extreme weather events in Europe, with 130 cumulative deaths per million people in contrast to 12.5 in total for all other extreme weather events, i.e., cold, flooding, storms and wildfires (EEA, 2017b). These climate related risks are most pronounced in cities, where nearly 73% of European population currently resides (EEA, 2016). Under the Representative Concentration Pathway 8.5 climate scenario, an increase in the duration of heat waves and rise in maximum temperatures up to an additional 14 °C during heat waves is projected for Central European cities such as Prague and Vienna (Guerreiro, Dawson, Kilsby, Lewis, & Ford, 2018). This is likely to exacerbate the intensity of urban heat island effect (UHI), which relates to warmer air and surface temperatures in cities than in rural surroundings (Dugord, Lauf, Schuster, & Kleinschmit, 2014; Ketterer & Matzarakis, 2015; Ward, Lauf, Kleinschmit, & Endlicher, 2016). Higher UHI intensities are often caused by specific urban structures, land use patterns and high heterogeneity of the urban surface (Geletič, Lehnert, Savić, & Milošević, 2018). A projected higher frequency of days with extreme temperatures is expected to intensify UHI and its potential impact on cities worldwide (Revi et al., 2015). The elderly are most at risk. Vulnerability to extreme heat—an indicator developed by The Lancet countdown initiative on the health impacts of climate change—which takes into account proportion of older population, prevalence of diseases influenced by heat in these populations and proportion of general population exposed to UHI is rising worldwide since 1990, with Europe being the most vulnerable (Watts et al., 2019).

A large number of European cities are developing strategies to mitigate and adapt to climate related risks (Brink et al., 2016). Around 66%, 26%, and 17% of EU cities, respectively, have mitigation, adaptation, and joint plans (Reckien et al., 2018). Nature-based solutions (NBS) are promoted as an approach which can contribute to these strategies while also transforming environmental and societal challenges into opportunities for innovation (Frantzeskaki, 2019). NBS aim to provide cost-effective solutions for urban issues, with a focus on the multi-functionality of green and blue infrastructure interventions. Urban NBS include a wide range of measures such as green roofs and facades, street trees, rain gardens, urban gardens, permeable surfaces and infiltration strips (Demuzere et al., 2014; Derkzen, van Teeffelen, & Verburg, 2017; European Commission, 2015; Keeler et al., 2019). Well designed and implemented NBS could provide climate resilient responses (both adaptation and mitigation), enhance sustainable urbanisation, restore degraded natural ecosystems and improve disaster risk management while providing multiple social benefits (European Commission, 2015). NBS can also play an important role in the EU's new biodiversity strategy 2030 in which cities with populations over 20,000 have been called to prepare Urban Greening Plans by the end of 2021 (COM (2020) 380).

Recent studies from across fields demonstrate different approaches in understanding the diverse benefits of NBS for urban populations, but also underline the contextual factors which determine the value of those benefits (a comprehensive review is provided in Keeler et al., 2019). Street trees and green and blue spaces can provide significant cooling effects and reduce heat stress (Gillner, Vogt, Tharang, Dettmann, & Roloff, 2015; Lehnert, Tokar, Jurek, & Geletič, 2021; Yu et al., 2020; Ziter, Pedersen, Kucharik, & Turner, 2019). NBS and urban green spaces can provide recreational opportunities with potential positive health effects, for example, decreased stress levels (Hunter, Gillespie, & Chen, 2019; Ward Thompson et al., 2012). Visits to urban and peri-urban green areas have been also shown to benefit subjective well-being, these effects positively correlating with biodiversity (Carrus et al., 2015). NBS can provide numerous benefits, however their social, economic or environmental value are in many cases uncertain. This is because these values are moderated by multiple factors which include technology, equity concerns, the availability of (technological) substitutes and potential provision of dis-benefits (Keeler et al., 2019).

It is hence critical in future urban planning to understand how NBS policy and individual interventions can be designed to maximise their contributions to human well-being and assist in addressing the multiple (urban) challenges of climate change, resilience to natural disasters and biodiversity loss (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016). Economic analyses of public preferences for urban NBS are rather scarce despite the fact that they can provide strategic information for municipal decision makers about the public value of NBS and whether strategies or individual interventions are socially desirable and economically feasible. Direct economic surveys with citizens, like stated preference research (e.g., Johnston et al., 2017), can aid in assessing the public value of NBS benefits and enable participation of the public in urban planning. It can help in understanding which characteristics of adaptation policies citizens find important and how much they are willing to pay for them, i.e., translating social preferences in economic terms. The present study aims to provide such economic analysis to assist in adaptation to climate change in urban planning in the capital of the Czech Republic, Prague. The study employed a choice experiment (e.g., Adamowicz, Boxall, Williams, & Louviere, 1998; Johnston et al., 2017; Mariel et al., 2021) to assess the preferences of a representative sample of Prague's population for an adaptation policy which focuses on the increased use of NBS in public spaces and on public buildings in the city. The study also examined sample opinions on climate change in general and citizens perceptions of the specific benefits of individual NBS which could be a factor in policy development. Section 2 provides a literature review of relevant economic valuation studies, describes the case study city of Prague and its current policy context of adaptation to climate change, the survey instrument, the choice experiment (CE), and the statistical methods used for analysis of the CE data. Section 3 presents sample characteristics, questions related to perceptions of climate change and NBS, along with results of the CE. The final part of the paper discusses the results, their implications for policy, the limitations and potential extensions of the study, and conclusions.

2. Methods

2.1. Economic valuation literature of urban nature-based solutions

Much of the existing economic research employs revealed or stated preference methods for the valuation of urban green spaces, nature-based solutions and their benefits. The majority of the revealed preference studies use hedonic pricing methods (e.g., Czembrowski & Kronenberg, 2016; Liebelt, Bartke, & Schwarz, 2018; Melichar and Kaprova, 2013; Panduro, Jensen, Lundhede, von Graevenitz, & Thorsen, 2018; Sander, Polasky, & Haight, 2010) which measure the implicit value of non-market goods or services observing exchanges in existing markets, such as property markets. In analysing house prices, researchers can infer/measure the implicit prices of existing environmental amenities (or dis-amenities), such as presence and characteristics of NBS. Hedonic

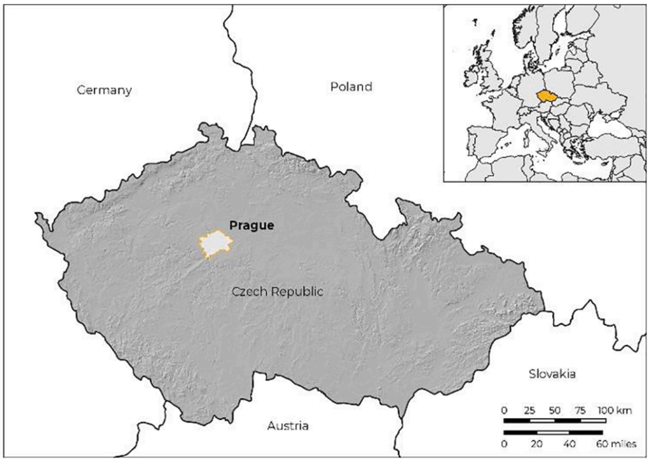


Fig. 1. Map - Prague, Czech Republic, Europe.

pricing estimates therefore can help to estimate the use values of urban green investments, as revealed through private market transactions in the property market. However, they provide little understanding of the values held for NBS by a broader set of people than those participating in the housing market (e.g. of passers-by or neighbourhood residents), nor are they helpful for assessing non-use values or designing new urban landscapes.

This is an area where stated preference (SP) methods may assist. SP methods can elicit both use and non-use values for future policy changes or specific interventions of a concerned population described by multiple characteristics, which can include a broader set of public benefits related to NBS design (e.g., amenities, protection from sun, biodiversity, etc.). Furthermore, as alternative policy changes are also associated with a payment mechanism (i.e., cost of the intervention), they simulate the context of market—and public—decisions of scarce resources, whereby respondents are positioned to carefully consider their choices. As such, SP methods are well situated in advising policy makers on public preferences for future urban planning. SP methods apply surveys to portray hypothetical scenarios of change from which preferences can be elicited, including individual and aggregate willingness-to-pay values. Bockarjova, Botzen, and Koetse (2020) presented a meta-analysis of a broad range of green intervention SP studies and concluded that cultural services and aesthetics are the most highly valued. Some studies have estimated the non-market benefits of individual projects in a municipal context (Collins, Schaafsma, & Hudson, 2017 – a green wall in Southampton, UK; Fruth et al., 2019 – street greening in Berlin, Germany; Latinopoulos, Mallios, & Latinopoulos, 2016 – an urban park in Thessaloniki, Greece; Lockwood & Tracy, 1995 – an urban park in Sydney, Australia). Other studies have focused on particular types of NBS implemented across a given city (Giergiczny & Kronenberg, 2014 – tree planting in Lodz, Poland; Majumdar, Deng, Zhang, & Pierskalla, 2011 - components of urban forests in Savannah, USA) and the specific benefits for different cities (Kim et al., 2016 – increase of urban greenery to mitigate the urban heat island effect in South Korea). The present study extends this literature in two aspects. First, it frames the valuation scenario explicitly as a climate adaptation policy change, reflecting the increased public awareness of the issue and present policy situation in the case study city. Second, the study explores the characteristics of a policy concerning a set of commonly used nature-based solutions implemented across the entire city rather than on individual NBS types or specific locations. The resultant design of the study was meant to be applicable to situations where municipal authorities are devising their adaptation plans and want to incorporate public preferences to better reflect the wishes of their citizens, increase policy support or assist in communicating the policy.

2.2. *Study area & policy context*

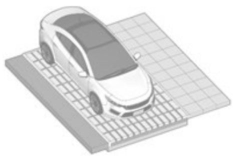
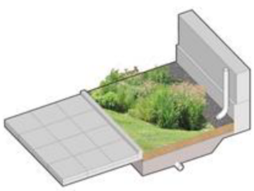
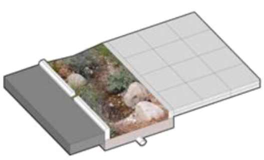
Prague is the capital city of the Czech Republic (Fig. 1) and a major European economic and commercial hub with a population of 1.3 million (13% of the total country's population). It is already experiencing the effects of climate change. The year 2018 was the hottest on record since 1775, with an average annual temperature of 12.8 °C, which is 3.2 °C higher than the annual average for the last 200 years or 1.7 °C higher than the 1981–2010 annual average (ČHMÚ, 2019). Moreover, 2018 was also the second driest year on record, with an average annual precipitation of 521 mm compared to 700 mm in 1981–2010 (*ibid*). Future climate projections show an increasing trend in the number of tropical days and heat waves, especially by the end of the twenty-first century (Štěpánek et al., 2016). For example, Geletič, Lehnert, Dobrovolný, and Žuvela-Aloise (2019) provided spatial modelling of future summer climate indices for the second largest city in Czechia and showed a higher absolute increase in the number of days with temperature extremes in densely populated urban mid-rise or compact developments.

The anticipated effects of climate change are being recognised. In 2015, the city of Prague became a member of the Covenant of Mayors for Climate and Energy international adaptation platform and initiated the process of urban adaptation planning. In 2017, the Prague City Council approved the Adaptation Strategy; in 2018 the Adaptation Action Plan for 2018–2019 was endorsed and a follow-up implementation plan was released in 2020. The city claims to prioritise Nature Based Solutions and ecosystem-based adaptation with the goal of securing quality of life for its inhabitants. This survey investigated climate change perceptions and the preferences towards NBS among Prague citizens to inform this process and future adaptation activities in the city more generally.

2.3. *Survey instrument*

A survey instrument was developed to examine the preferences of citizens of Prague for climate adaptation policy. The questionnaire was developed over a period of four months in July–October 2018 in an iterative process which allowed feedback from respondents and experts. First, a literature review and input from Prague municipality experts helped identify the key generic NBS interventions, possible policy change scenario, and attributes of the change in the context of the city's adaptation planning. Based on this input, a survey instrument was created. The questionnaire was then tested in one-to-one interviews with representative respondents from the public ($n = 10$; length of survey 40–60mins), focusing on whether the valuation scenario, attributes and their levels were considered credible and relevant to the respondents and for the city's climate adaptation strategy. This led to minor revisions in the survey instrument, which was then coded into a web-based platform and piloted online with 50 respondents. The questionnaire included a number of open-ended questions to ensure that the overall survey was comprehensible and portrayed a meaningful scenario to respondents. The pilot led to minor modifications in wording and the order of questions and provided initial estimates to optimize the design of choice cards for the main online survey. The final version of the survey was implemented online and administered by the market research and consulting firm Ipsos in November 2018, collecting responses from 550 respondents. In terms of the sampling strategy, the company followed a quota on representativeness relative to the general population according

Table 1
Types of NBS presented in the survey.

Nature-based solution	Description	Benefits (not in survey)
	**Permeable surfaces** include vegetation blocks, pavements with grassed joints, porous pavements or plastic grass blocks, permeable asphalt or concrete. Permeable surfaces can be used, for example, in car parks and pavement surfaces.	These measures retain rainwater, regulate microclimate, and can reduce noise. Lucke and Dierkes (2015)
	**Rain gardens** are terrain depressions where water runs down and is captured. The roots of vegetation serve as filters and help retain water.	Rain gardens can buffer rainwater, support infiltration, and regulate microclimate. Riley and Kraus (2016), Yang, McCoy, Grewal, and Dick (2010) and Yang, Dick, McCoy, Phelan, and Grewal (2013)
	**Infiltration strips** are lines of vegetation cover along contours which allow drainage and permeation of rainwater (and snowmelt) from the surrounding surfaces at a given location.	These measures retain rainwater, increase water quality, and regulate microclimate and noise. Akan (2014) Winston, Hunt, Osmond, Lord, and Woodward (2011)
	**Street trees** are individual trees or avenues of trees along roads, trees along creeks, trees in gardens, or residential greenery.	Street trees regulate microclimate, air quality, retain rainwater, store carbon. Kiss, Takács, Pogácsás, and Gulyás (2015), Pauleit and Duhme (2000), Tallis, Taylor, Sinnett, and Freer-Smith (2011)
	**Green walls** and facades are vertically oriented elements which are partially or completely formed, covered or planted with vegetation or climbing plants, or use growing cells integrated directly into the architectural design of the building.	These measures regulate microclimate and air quality and save energy. Eumorfopoulou and Kontoleon (2009) and Zölch, Maderspacher, Wamsler, and Pauleit (2016)
	**Green roofs** are partially or fully covered with a waterproofing membrane, growing medium (soil/ substrate) and planted with vegetation.	Green roofs regulate microclimate (decrease surface temperature), store carbon, regulate rainwater runoff and air quality and save energy. Nurmi, Votsis, Perrels, and Lehvävirta (2016), Wong et al. (2008)

to age, gender and sampled respondents from Prague only.

The final questionnaire consisted of five parts: (i) climate change and views on heat waves; (ii) the introduction of NBS; (iii) the choice experiment with six choice situations concerning the potential characteristics of the NBS adaptation policy; (iv) questions concerning the perceived benefits of individual NBS; and (v) additional control questions.

2.4. Choice experiment: valuation scenario and selection of attributes

The study employed a choice experiment (CE) (see, e.g., Johnston et al., 2017; Mariel et al., 2021). In a CE, respondents are presented with a number of choice situations which portray a policy change described by a number of attributes. In contrast to previous SP studies, this CE explores a range of the most common NBS interventions for potential implementation across the Prague municipality rather than specific locations or individual interventions. The valuation scenario (the choice situation in a CE) hence focuses on a change in the policy towards NBS *per se*, one that could be implemented across the entire city—this was specified as "*an increase in the use of NBS in public spaces and on public buildings*"—alongside presenting respondents with the six types of commonly used NBS (green roofs, green facades, permeable surfaces, street trees, rain gardens, and infiltration strips) relevant to the Prague Adaptation Strategy. Table 1 presents a summary of these measures and their visual depictions as presented to respondents, along with their benefits. The depictions were designed with an urban architect to avoid the specific visual clues possible from photographs of already implemented NBS to prevent bias in choices. The policy change alternatives were contrasted to a *no change to the present situation* option. The focus of the survey was intentionally on space and buildings in public property to avoid eliciting contrasting incentives from respondents (e.g., in relation to the need to change privately owned buildings because of imposed regulations).

Three attributes were selected to describe the potential characteristics of the policy change. They were selected to be: (a) applicable to citywide policy; (b) relevant to all major NBS interventions as listed in Table 1; and (c) informative to the Prague municipality concerning future policy direction preferred by the city's population. The first attribute (*Type*) concerned the type of measures which would frequent in the implemented policy, with three levels: majority implementation of measures in public spaces such as streets or squares (trees, infiltration strips, rain gardens and permeable surfaces); majority implementation of measures on public buildings (green roofs and green walls/facades); and balanced implementation of measures in public spaces and on public buildings. This attribute aimed to explore whether any specific preferences exist for the locations where NBS interventions should be applied. The second attribute (*Species*) concerned the species compositions of the implemented measures with three levels: one type of species (monoculture); few species; and a high number of species. This attribute was designed to jointly capture the preferences for the visual appearances of measures (e.g., grass strips composed of single species versus diverse flower grass strips), but also the biodiversity dimension of the implemented measures (e.g., how they can support insects or birds). Both of these dimensions of the attribute were explained to respondents. The two aspects are in most cases positively correlated and it would be complex to design credible generic NBS choice situations where these attributes are disjoint. We prioritised the credibility of scenarios at the expense of less specific attribute estimates. The third attribute (*Cost*) related to the hypothetical costs of the policy with seven levels (CZK 200, 500, 900, 1500, 2000, 3000, 5000), described as an increase in the annual household municipality waste disposal charge and zero cost for the status quo. Currently, this charge is around CZK 1250 (approx. 50 EUR) per household per year, with variations reflecting amount of waste produced. This payment vehicle has a number of convenient properties for the CE. All Prague residents are required to pay this local fee, and hence is relevant to the policy implemented in Prague only. The *Cost*

Table 2
Choice experiment alternatives and attribute levels.

Policy change alternatives *An increase in the use of NBS in public spaces and on public buildings*		Status Quo alternative *No change to current situation*
Attribute 1: Prevailing type of NBS measures (each dummy coded 1|0)		
Type 0	Balanced implementation of NSB measures	No change to current situation
Type 1	Majority implementation of trees and grass-based measures	
Type 2	Majority implementation of building-based measures	
Attribute 2: Species composition of the NBS measures (each dummy coded 1|0)		
Species 0	Single-species measures (monoculture of grass, flowers, plants or trees)	No change to current situation
Species 1	Few-species measures (few species of grass, flowers, plants or trees)	
Species 2	Multi-species measures (high number of grass, flowers, plants or trees)	
Attribute 3: Costs in terms of an annual increase in waste bin charge for households *(coded as continuous)*		
Cost	CZK 200, 500, 900, 1500, 2000, 3000, 5000 (approx. EUR 8–200)	No change to current situation

attribute is a fundamental feature of a stated preference scenario (Johnston et al., 2017), as it provides a numéraire to select from alternative options and is used to estimate the willingness to pay values. The range of values was set from the results of pre-testing and the pilot survey. Table 2 presents the attribute levels. An illustrative choice situation is presented in Figs. A1 and A2 in the Appendix.

2.5. Choice experiment: experimental design

The CE can employ experimental design techniques which help to increase the statistical efficiency of estimates and decrease the sample size requirements. An efficient design approach was used in the present study, implemented in Ngene software (Ngene, 2018). The theory of efficient designs builds on the fact that if the analyst has some prior knowledge of the expected attribute estimates, it is possible to design choice situations which can better extract information from respondents than if no prior information is available (Ferrini & Scarpa, 2007). The experimental design was devised in a two-stage process. In the first step, a D-efficient design was constructed with no prior knowledge for the parameters (assumed zero), with *Type* and *Species* attributes dummy coded and *Cost* attribute as continuous. In the second stage, estimates from a simple conditional logit model (McFadden, 1973) applied to the pilot data were used as input for a D-efficient Bayesian priors design. This approach incorporates uncertainty around the estimates into the design. This is done by assuming random distribution of the parameters in the design creation by Ngene, where each parameter distribution is described by the parameter estimates from the pilot data, i.e., the mean values and calculated standard deviations from the estimated standard errors. In both pilot and main designs, four blocks of choice questions were generated. Respondents were allocated randomly to one of the blocks of six questions, and within each block (i.e. each survey version in terms of choice tasks presented), the order of questions was randomized for each respondent. Similarly, the position (left, middle or right column) of the status quo option was randomized for each choice situation. We randomised both the order of questions and position of status quo in order to avoid possible bias of the results.

2.6. Choice experiment: modelling approach

The CE data was analysed using the Random Utility Framework (McFadden, 1973). In this context, the choices which respondents make in a choice situation are analysed according to how the attributes and their levels affect the respondents' utility and consequently the probability of the choice. The modelling strategy followed the Mixed Logit (MXL) modelling approach (McFadden & Train, 2000; Train, 2009), which can reflect the panel structure of choices (i.e., each respondent faces more than one choice situation), heterogeneity in preferences, and heteroscedasticity in the error term, making the model a very flexible form of specification.

The MXL model is commonly used in applied studies similar to the present research (e.g., Collins et al., 2017; Glenk & Martin-Ortega, 2018). In the MXL model, the *k*th-respondent's utility from choosing alternative *i* in the *j*-th choice situation is represented by $\boldsymbol{U_{ijk}} = \boldsymbol{\beta}'_k \boldsymbol{X_{ijk}} + \boldsymbol{\varepsilon_{ijk}}$, where $\boldsymbol{\beta}'_k$ is a vector of preference parameters which, in the general case, are individual-specific and randomly distributed across the population (with parameters of distribution to be estimated); $\boldsymbol{X_{ijk}}$ is the attributes of the NBS policy; and $\boldsymbol{\varepsilon_{ijk}}$ is an error term assumed to be i.i.d. Gumbel distributed. Simulated maximum likelihood methods are used to estimate the parameters of mixed logit models (Train, 2009). The willingness to pay (WTP) values were calculated as the negative proportion between the mean estimates and the cost estimate as $\boldsymbol{WTP_{attribute}} = -\boldsymbol{\beta_{attribute}}/\boldsymbol{\beta_{cost}}$, using the Stata's 'nlcom' command, which is based on the delta method.

In the MXL model, the challenge often is to select the appropriate specification of the random parameter distributions. Common approach in selecting the appropriate "mixing" (i.e., which parameters should be modelled as random and which as fixed) is use of the Lagrange multiplier test (McFadden & Train, 2000), or treating all variables as randomly distributed preferences across the sample. Furthermore, the cost attribute is often assumed log-normal distribution to satisfy its theoretically expected negative effect on the probability of the choice which enables less-problematic calculation of the willingness to pay values (Daly, Hess, & Train, 2012). We followed this approach, as the models with log normally distributed *Cost* attribute also outperformed models with normal distribution in terms of Bayesian Information Criterion (BIC) and Akaike Information Criterion (AIC). In the main text, we report the model where *Cost* was assumed log-normally distributed and all the remaining parameters were normally distributed which is considered to provide more flexible model than when some parameters are assumed fixed (Mariel et al., 2021). This model performed better in terms of AIC and McFadden pseudo R^2 than the model where random parameters were selected by the Lagrange Multiplier test (LM). The LM model performed better on the BIC measure and we therefore report it also in the Appendix alongside the models reported in the main text. An alternative to MXL modelling is the latent class approach in which the respondents' heterogeneity is clustered using a class membership function. This approach can provide superior information when the targeted intervention of specific neighbours are the objective of the study (e.g. Liao, Farber, & Ewing, 2015). However, the objective of the present study was to assess generic NBS policy; the MXL approach is considered the most flexible in portraying the preference heterogeneity of the population.

3. Results

3.1. Sample

The survey request was sent to 1054 people, of which 550 Prague residents responded to the full survey (52% response rate). Using follow-up questions, 25 respondents (5% of the sample) were identified as

Table 3
Main socio-economic characteristics of the respondents (n = 525).

Variable	Census*	Sample Mean (st. dev)	Variable description
Socio-economic variables			
Gender	51.50%	50.50%	Portion of sample that is female
Age	42	40.1 (12.5)	Average age
20–39	36%	52%	Percentage of population in the age group
40–59	34%	38%	Percentage of population in the age group
60+	31%	10%	Percentage of population in the age group
Income	750	880 (440)	Average monthly net salary (approx. in EUR)
Education	45%	47%	Portion of people with university education
Survey-related variables			
Consequantiality		74%	Percentage of people believing the survey can influence policy
Length of stay 10y+		65%	Percentage of people living in the same location for longer than 10 years
# SQ choices		0.97	Number of times respondent chose Status Quo (out of 6 choices)
Survey time		23 min (17.1)	How many minutes it took to answer the survey
Air-conditioning		52%	Portion of people having air-conditioned workplace, home or both
Heat experience		63%	Portion of sample that indicated either not feeling well or having health problems related to heat

* Census data from: Statistical yearbook of Prague 2019 (ČSÚ, 2019).

protest respondents, i.e., respondents who systematically rejected the constructed scenario (Mariel et al., 2021), and were removed from the sample for analysis. The main socio-economic characteristics of the respondents are shown in Table 3 and additional details of the sample are given in Appendix. The respondents represent the census characteristics of Prague well, on average, although our respondents were over-representing younger age groups and are wealthier than other citizens. The sample respondents are residents of all Prague districts with varying degrees of urban greenery present (see Figs. A3–A5), with 30% living in their given district for more than 20 years and 23% no longer than 3 years. The majority of the sample (75%) saw the survey as a possible means to influence decisions in Prague. Most of the respondents believed that the results could partly (69 %) or would definitely (6%) influence urban planning in the city, while 17% were certain that it could not and 8% were unsure. The likelihood that the respondents' choices might have an affect on policy in question and that they might be required to pay for it (consequentiality) is important for a choice experiment (Johnston et al., 2017); the fact that three quarters of our sample believe this provides credibility to the policy messages presented below.

3.2. Perceptions of climate change, heat waves and NBS

The respondents perceived both climate change and heat waves as risks. The majority of the sample agreed that climate change (CC) is occurring (47% strongly agreed, 41% agreed, the remainder either disagreed or were not sure). Two thirds of the sample sees CC occurring as a result of human causes, while one quarter see it as only naturally occurring variability. CC is seen as having either a strong or some impact on future generations (91%), on the respondents themselves (74%), their neighbourhood (76%), the city of Prague (82%) or their property (45%), (see Appendix Fig. A6). Concerning heat waves, 63% of the sample experience the adverse effects of heat waves (48% do not feel well, 15% perceive a negative effect of heat waves on their health, Appendix Fig. A7), and a significant majority of the sample perceives heat waves as a risk to Prague and present quality of life in the city (79%) and looking into the future (80%). Over half of the respondents would be interested in participating in adaptation planning in their municipalities, while one fifth were not sure about it. The most preferable form of participation would be via surveys (71%) and online formats such as interactive maps (48%), while in-person or more demanding formats would also be an option for some respondents (around 30% would be interested in community planning, focus groups or seminars for the public).

In terms of NBS perceptions, over 70% of the respondents rated air quality, microclimate regulation and water retention as the most important benefits of urban NBS, justifying our inquiry into the use of NBS for climate adaptation (see Fig. A8 in Appendix). According to the respondents, NBS should focus on both the reduction of temperatures during heatwaves and storm water management (57%) rather than on either heat waves or storm water management only (30% and 13%, respectively). Regarding individual NBS interventions, the respondents were asked which of the proposed interventions they would like to see implemented in Prague or their neighbourhood (see Fig. A9 in Appendix). The highest scores were given to street trees and rain gardens (57% and 47%, respectively), followed by permeable surfaces (24.5%), green facades (20%), green roofs (15.3%) and infiltration strips (14.5%).

3.3. Choice experiment

Table 4 reports the results of a selected mixed logit model (MXL) with all parameters assumed to be normally and *Cost* log-normally distributed, estimated on 3150 choice situations, i.e., six choices made by each of 525 respondents (see Table A1 for a base conditional logit and Table A2 for other specification). The model was estimated with correlated coefficients using 1000 Halton draws in Stata 16 by a 'mixlogit' command (Hole, 2007). For each characteristic of NBS policy, the model provides the mean effect as the importance of that attribute relative to the others and the standard deviation which captures the heterogeneity of preferences around the average. *Type* and *Species* are dummy coded variables, and their interpretation and that of the estimated *SQ* coefficient is relative to the baseline, which was set at *Type0* and *Species0* policy change. The *SQ* variable represents the alternative specific constant which captures the preference for the "do nothing" option against the baseline NBS policy.

The mean values show whether the attribute has a statistically distinguishable effect on the choices, on average, while a statistically distinguishable standard deviation indicates whether and how much the preferences are heterogeneous across the sample. *SQ* presents, in absolute terms, the highest mean effect (−5.9), which indicates that the respondents attached a statistically significant disutility to the current "do nothing" option but also the largest standard deviation (3.8), which implies a wide heterogeneity in preferences. Nonetheless, the model suggests that the majority of respondents (94%) wanted to move away from the "do nothing" option and implement the NBS policy (this percentage was calculated as a positive portion of the normal distribution, specified by estimated mean and standard deviation values).

Type1 is not statistically significant, which suggests that the respondents are undecided on policy which implements the majority of measures in public spaces and that which evenly implements measures in public spaces and on public buildings. By contrast, the negative *Type2* coefficient suggests that interventions implemented mainly on public buildings are less desirable than baseline policy (i.e., *Type0*), but the wide distribution suggests that only a minority of respondents (22%) preferred NBS interventions predominantly on public buildings.

The respondents derived positive utility from species compositions of

Table 4
Mixed logit model estimates and Willigness to Pay (WTP) values (in both CZK & EUR per household per year).

	Mean (st.err.)	S.D. (st.err.)	WTP CZK [95% conf. int.]	WTP EUR [95% conf. int.]
Type1	0.154	0.486**	38	1.47
	(0.090)	(0.154)	[−6, 81]	[−0.22, 3.17]
Type2	−0.547***	0.698**	−133***	−5.23***
	(0.123)	(0.215)	[−202, −65]	[−7.9, −2.55]
Species1	0.965***	0.71***	235***	9.22***
	(0.105)	(0.162)	[154, 317]	[6.02, 12.41]
Species2	1.151***	0.834***	281***	11***
	(0.132)	(0.201)	[180, 381]	[7.08, 14.93]
SQ	−5.846***	3.822***	−1425***	−55.87***
	(0.465)	(0.375)	[−1797, −1053]	[−70.46, −41.29]
Log (Cost)[A]	−7.216***	1.855***		
	(0.111)	(0.09)		
Cost[B]	−0.0041***			
	(0.0006)			
Number of observations			9450	
Number of respondents			525	
Log-likelihood			−2184	
McFadden pseudo-R2			0.295	
AIC			4421	
BIC			4614	

Asterisks indicate significance:* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
[A] : estimate of the log normally distributed *Cost* coefficient.
[B] : The mean coefficient for *Cost* used in calculation of the WTP values was recalculated following Revelt and Train (1998) as follows: mean(*Cost*) = $exp\left(\beta_{Log(Cost)} + \frac{\sigma^2_{Log(Cost)}}{2}\right)$, where $\beta_{Log(Cost)}$ and $\sigma^2_{Log(Cost)}$ are the mean and standard deviation estimates from the model.

the NBS policy. A high number of species attributes (*Species2*) is preferable to few species (*Species1*), which is preferable to one species only (*Species0*). In line with diminishing marginal utility, a high number of species is only slightly more preferred than few species, looking at the relative sizes of the *Species2* and *Species1* coefficients. While there is preference heterogeneity for both *Species1* and *Species2* in the sample, only a minority of respondents derived negative utility from either of the attributes (9% and 8%, respectively).

The *Cost* attribute had a negative effect on the probability of choice, in line with theoretical expectations, suggesting that with increasing cost, policy change is less likely to be selected over status quo. The *Cost* attribute also embodies a large heterogeneity, suggesting that perception of the cost attribute might be influenced by a variety of factors (e.g., income, green lexicographic motivations, etc.).

While the model in Table 4 reports an overall heterogeneity in the sample, Table 5 presents the WTP values of a split sample analysis where we considered the observed heterogeneity induced by the respondents' stated experiences with heat waves (for the model estimates and more details, see Table A2 and Table A3 in the Appendix). The respondents in the subsample "model Heat" (n = 336), who answered that heat waves either negatively impacted their health or made them feel unwell, presented distinctively different preferences/WTP from the respondents of the subsample "model NoHeat" (n = 189), who included those who answered that they either enjoy heat waves or do not register them at all. The subsample which had negative experiences with heatwaves was willing to pay more for the change from the status quo and for all attributes except *Type2*, for which they were willing to pay less relative to the baseline policy than the second subsample.

Table 5
Split sample models in relation to experience with heat waves and WTP values (in both CZK & EUR per household per year).

	Model Heat WTP EUR [95% conf. int.]	Model NoHeat WTP EUR [95% conf. int.]
Type1	2.72	0.57
	[−0.41, 5.86]	[−1.02, 2.16]
Type2	−7.03**	−3.11*
	[−11.49, −2.56]	[−5.67, −0.56]
Species1	13.28***	5.21***
	[8.61, 17.94]	[2.57, 7.84]
Species2	14.72***	6.42***
	[9.01, 20.43]	[3.4, 9.7]
SQ	−77.69***	−33.81***
	[−96.09, −59.29]	[−45.01, −22.62]
Number of respondents	336	189

Asterisks indicate significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

4. Discussion

This research examined the public preferences for NBS in Prague, one of the large European cities likely to be increasingly affected by climate change. The study explicitly frames the valuation scenario as a climate adaption policy which would lead to an increase of six commonly used NBS in the city. Four major messages can be taken from the results. First, the sample supports an increased use of NBS *per se*. This result is reflected in the statistically significant effect of the *SQ* parameter which signals a disutility with the present situation relative to the alternatives with NBS (e.g., Scarpa, Ferrini, & Willis, 2005). While multiple motivations might be influencing the tendency to choose change over the status quo, positive preference for a policy change is held by an overwhelming majority of the sample, suggesting strong support for greener adaptation policy in the city. NBS offer a solution to the raised concerns about climate change and heat wave related risks which respondents are prepared to pay for. These results are in line with both monetary (e.g., Collins et al., 2017; Fruth et al., 2019; Giergiczny & Kronenberg, 2014) and non-monetary studies (e.g., Derkzen et al., 2017; Fischer et al., 2018) which similarly show public support for greener urban planning in other countries. Furthermore, our sample responses show that people perceive the different purposes for which NBS can be used, suggesting that highlighting the multifunctionality of NBS might help increase public support for their use in climate adaptation (Derkzen et al., 2017). Second, the diversity of NBS is valued by a significant majority of our sample. Policy options consisting of highly diverse NBS were preferred to less diverse alternatives and those to alternatives based on single species, reflected in decreasing WTP values for *Species* attributes. Collins et al. (2017) also reported positive WTP for NBS which increases biodiversity, and other studies have provided ample evidence that people want biodiversity in their cities (e.g., Fischer et al., 2018; Fischer et al., 2020). While our data does not suggest what motives are driving WTP for the *Species* attribute—whether it is biodiversity concerns, aesthetic reasons, or, perhaps, recognition of diversifying NBS for climate resilience—an increased species composition is likely to contribute to these aspects. Third, the respondents support balanced implementation of NBS in public spaces and on public buildings. When faced with the choice of either, policy focused on measures implemented in public spaces are preferred to those implemented on public buildings. This can be derived from the negative mean estimate for *Type2* relative to the *Type0* baseline and statistically indifferent *Type1* estimate, but also from the control questions—when asked directly, the three most preferred individual NBS (street trees, rain gardens, permeable surfaces) are public space-oriented. Finally, negative experience with heat waves increases support for the policy in our sample. The split sample analysis showed that people who did not feel well during heat waves or whose health was adversely affected by them have stronger preferences—and willingness to pay—for each of the aspects of the policy described in the previous three points. This intuitive result suggests that with the expected increasing impacts of climate change, support for the adaptation policy (and value of NBS) is likely to rise simply because people will suffer more heat waves. Europe is the most vulnerable region globally to heat exposure due to its aging population, high level of urbanisation and high prevalence of cardiovascular and respiratory diseases and diabetes (Watts et al., 2019). This makes climate adaptation through NBS perhaps even more urgent.

This study was designed to provide information about the relative importance of individual aspects of the NBS policy and to provide a general perspective of preferences for future adaptation planning in the city. It provides more general advice on the direction of climate adaptation policy *per se*; however, this generalisation necessarily implies a lack of advice on specific NBS interventions (and aspects thereof) or particular locations. We also presented estimated relative willingness to pay (WTP) values, but these estimated values should be interpreted with caution. The WTP values do not relate to scalable policy, and as such, cannot be meaningfully aggregated or used for cost-benefit analysis. This is because the valuation scenario did not specify the policy in a unit form (e.g., number of new interventions) which would be possible to use for these purposes. Nonetheless, the results and the WTP values showed that significant non-market, economic benefits can be expected from the increased use of NBS in Prague and that the public supports these solutions. In further research, we aim to provide more specific advice related to NBS and climate adaptation strategy in the city. Aside from linking scalable measures to the CE scenario and understanding the costs of NBS across space, this includes exploring spatial heterogeneity in WTP of the present data (e.g. Czajkowski, Budziński, Campbell, Giergiczny, & Hanley, 2016), incorporating spatial aspects of the stated preferences into future research design, both in terms of survey design (e.g. Badura, Ferrini, Burton, Binner, & Bateman, 2020) and data analysis (e.g., De Valck & Rolfe, 2018; Glenk, Johnston, Meyerhoff, & Sagebiel, 2020), and integrating these with spatially explicit heat wave modelling of alternative changes to the urban fabric (e.g., Geletič, Lehnert, & Jurek, 2020; Lehnert et al., 2020), urban vulnerability and participatory approaches (e.g., Lorencová et al., 2018).

Aside from assisting in adaptation to the effects of climate change, NBS can contribute to biodiversity policy (see Aronson et al., 2017; Lepczyk et al., 2017), potentially offering win–win solutions, although their planning and management may be challenging. Greening of urban and peri-urban areas of European cities features in the new EU biodiversity strategy 2030 (COM (2020) 380), and cities' efforts should hence not only aim at just 'green' but biodiverse urban planning, where possible. The additional benefits might outweigh the costs of added complexity. Besides changes in economic welfare from the increased diversity of NBS, as shown in this paper and in Collins et al. (2017) for example, diverse urban planning can have a positive impact on subjective well-being (Carrus et al., 2015; Mavoa, Davern, Breed, & Hahs, 2019), and biodiversity itself might also have positive effects on the mental health of the urban population (Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007). While these effects might be indirect and influenced by familiarity (Southon, Jorgensen, Dunnett, Hoyle, & Evans, 2018), exposure to green spaces has been shown to decrease human stress levels (Hunter et al., 2019; Ward Thompson et al., 2012). This might be because of the aesthetic and sound aspects of biodiverse green spaces, which are distinguished and perceived more positively than less diverse spaces by both nature-oriented urban-oriented people (Gunnarsson, Knez, Hedblom, & Sang, 2017). Adaptation policy which also explicitly addresses biodiversity is likely to be supported by the public. Biodiverse greenspaces are viewed as adding value over simple green spaces, and this holds true across different components of the urban fabric in five EU cities (Fischer et al., 2018). Similarly, converting lawns into meadows for the sake of biodiversity was strongly supported by the population across 19 European cities (Fischer et al., 2020). An overall tidy and neat appearance achieved via combining near natural and more classic elements can increase public acceptance of such biodiverse friendly green spaces (Fischer et al., 2020), while colourful planting can provide aesthetic attractiveness (Hoyle, Hitchmough, & Jorgensen, 2017).

Climate adaptation through NBS therefore represents a promising avenue for urban planning, but it also has its challenges. Practical implementation of NBS can be mired by legal obstacles or lack of information. In the Czech Republic, for example, green infrastructure has until recently been in a legally disadvantaged position relative to grey solutions, data on the condition of green infrastructure elements is often missing, complicating assessment of their value. Context specificity of many of NBS benefits often makes the transferability of results from other locations, cities or countries problematic, and developing well-documented case studies takes time and expertise which is not always available. In some cases, NBS might not be the right solution or their costs may be prohibitively high. This highlights the fact that NBS are not panacea—their value is moderated by the social, ecological and technological context which, in some situations, might make them sub-optimal compared to non-green substitutes (Keeler et al., 2019). Similarly, developing greener urban areas might lead to displacement and gentrification, highlighting the need to consider equity in the NBS design (Keeler et al., 2019; Wolch, Byrne, & Newell, 2014). Addressing urban challenges in the twenty-first century will require unprecedented transformative solutions which—especially in view of the challenges of global pandemic—carefully consider socio-economic resilience and sustainability in their implementation (see Elmqvist et al., 2019).

5. Conclusions

This stated preference study focused on an adaptation policy for the increased use of commonly used Nature Based Solutions (NBS) across Prague, Czech Republic. The paper provided an analysis of preferences for individual characteristics of such policy and data on the perception of climate change and NBS. The sample respondents overwhelmingly supported the increased use of NBS for climate adaptation and expressed concerns about the effects of climate change. The respondents value species diversity in NBS with a decreasing rate, suggesting that policy addressing both climate and biodiversity concerns is likely to be supported. The sample supported the implementation of measures in public spaces rather than on public buildings only or evenly distributed measures. Adverse experiences with heat waves increases the willingness to pay for the policy and all attributes, suggesting that in view of the increasing effects of climate change, support for NBS adaptation policy is likely to grow if those effects are not avoided by other means. Overall, our results showed that urban NBS are positively viewed by our sample and that a welfare gain from their increased use in climate adaptation strategy is likely. The survey design provides a simple and reproduceable approach which can be adapted to different scales of city planning and issues (e.g., lower administrative areas or specific policy questions), particularly when advice on general aspects of public opinion on adaptation planning is required.

Nature-based solutions, whether on their own or in combination with grey infrastructure, can help adaptation to the mounting pressures from climate change and help address other urban challenges (Keeler et al., 2019). Our results and similar research suggest that urban planners (particularly in European cities) aiming to employ NBS for climate adaptation are likely to be supported by the public if they (i) highlight multifunctionality of NBS measures and their contribution to both climate and biodiversity policy (ii) recognise that it matters which measures are implemented and (iii) are reflective of spatial distribution of heat impacts across their cities. NBS policy can also help create more liveable—and living—cities in which diverse nature is part of the urban fabric, with numerous positive effects on urban living. Investing in ecological infrastructure in urban areas can generate significant socio-economic benefits (Elmqvist et al., 2015). Returning nature to urban and peri-urban areas should also help halt the loss of biodiversity—in Europe, cities have been called on to develop Urban Greening Plans to support this goal (COM (2020) 380). Urban green spaces have also gained a new dimension of value and importance during the pandemic; however, the resulting economic downturn might side-line investments into urban nature, especially since the quantification of their benefits is not straight-forward. Inter- and transdisciplinary understanding of the multiple values associated with NBS is needed to make these values visible and inform urban decision makers and planners to design resilient and vibrant cities of tomorrow which can withstand the upcoming challenges. Public input, such as the one presented in this paper, but also other forms of participation, can provide useful information for future adaptation planning and increase its support throughout the urban population.

CRediT authorship contribution statement

Tomas Badura: Conceptualization, Methodology, Software, Formal analysis, Investigation, Writing – original draft, Writing - review & editing, Project administration. **Eliška Krkoška Lorencová:** Conceptualization, Investigation, Writing – original draft, Writing - review & editing, Project administration, Funding acquisition. **Silvia Ferrini:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing - review & editing. **Davina Vačkářová:** Conceptualization, Writing – original draft, Writing - review & editing, Project administration, Funding acquisition.

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Appendix A

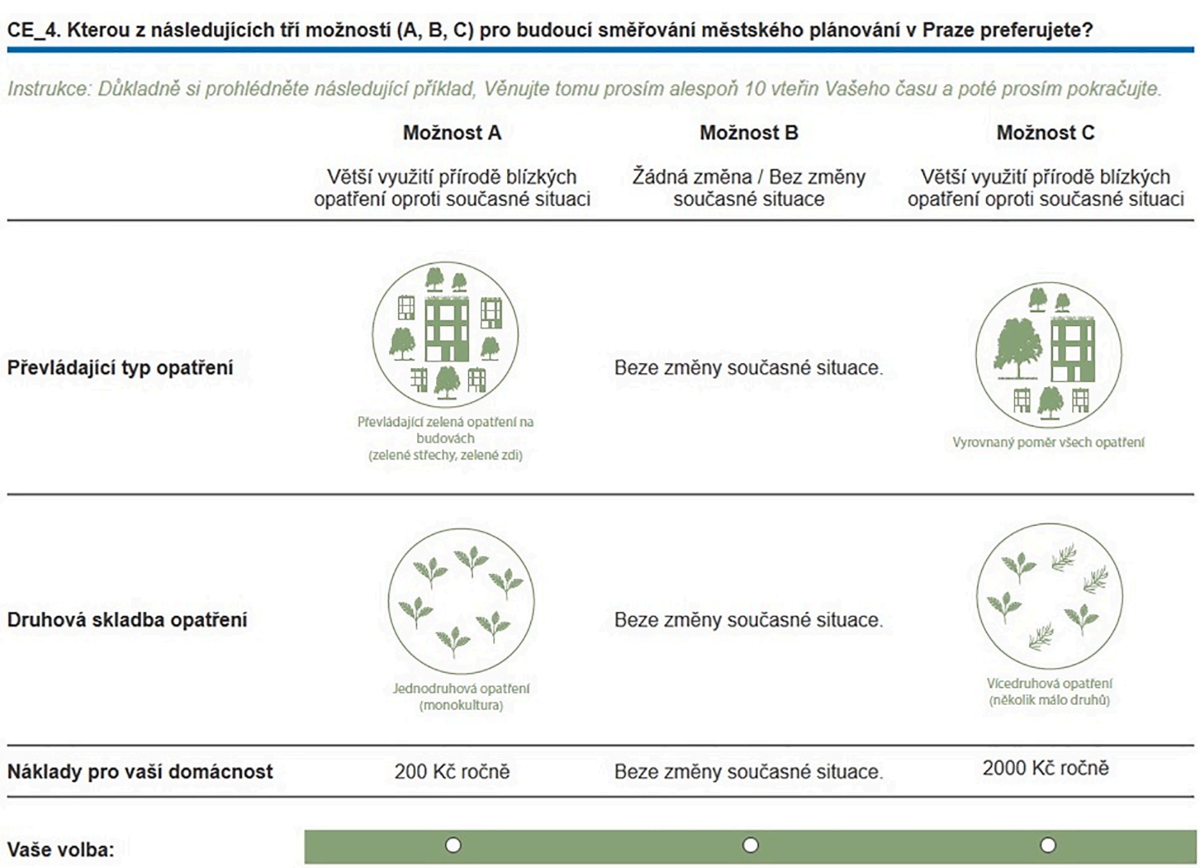

Fig. A1. Example of a Choice card (in CZ, as portrayed). In order to avoid bias towards particular visual clue, description of the attribute as well as the biodiversity and visual aspects of the change were provided in the CE only in a written format and via pictograms (designed by an urban architect). Also note that we ensured with the programmers of the survey that the no change (Status Quo) column randomly changed position (i.e. sometime it was located in the second column, as in the example choice set above, but other time it was located in the first or third column, as shown in Fig. A2).

Which of the following options (A, B, C) you prefer for the future direction of planning in Prague?			
	Choice A Increased use of NBS compared to current situation	**Choice B** Increased use of NBS compared to current situation	**Choice C** Status quo/no change to the current situation
Prevailing type of measures	 Majority of building based measures	 Majority of trees and grass-based measures	No change to current situation
Species composition of measures	 Few species measures (few number of species)	 Multispecies measures (high diversity of species)	No change to current situation
Costs for your household	500 CZK annually	1000 CZK annually	No change to current situation
Your choice			

Fig. A2. Example of a Choice card (English mock version).

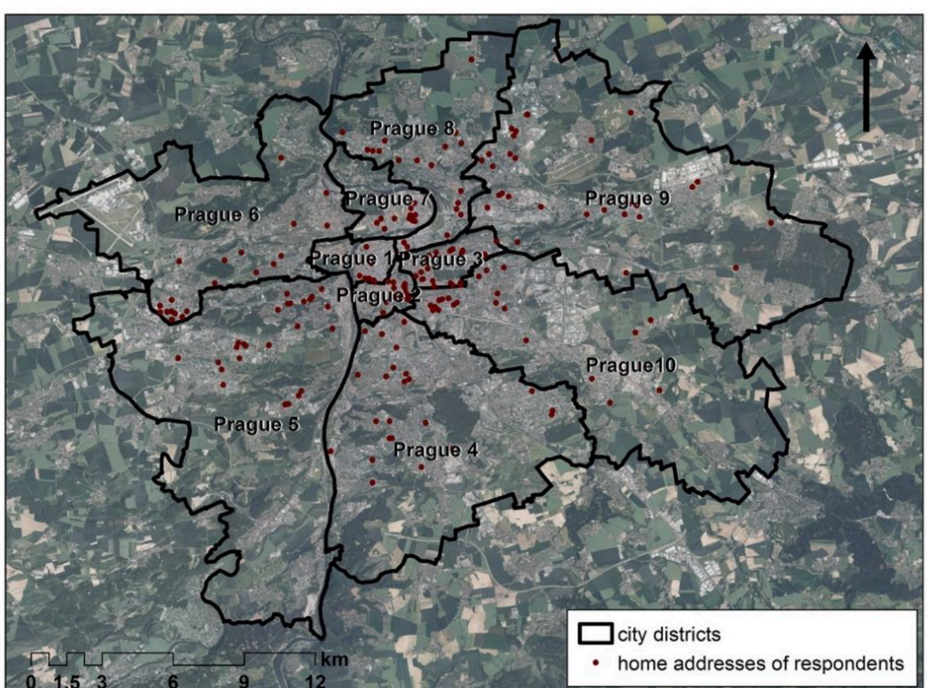

Fig. A3. Spatial distribution of sample respondents - geographical (own creation).

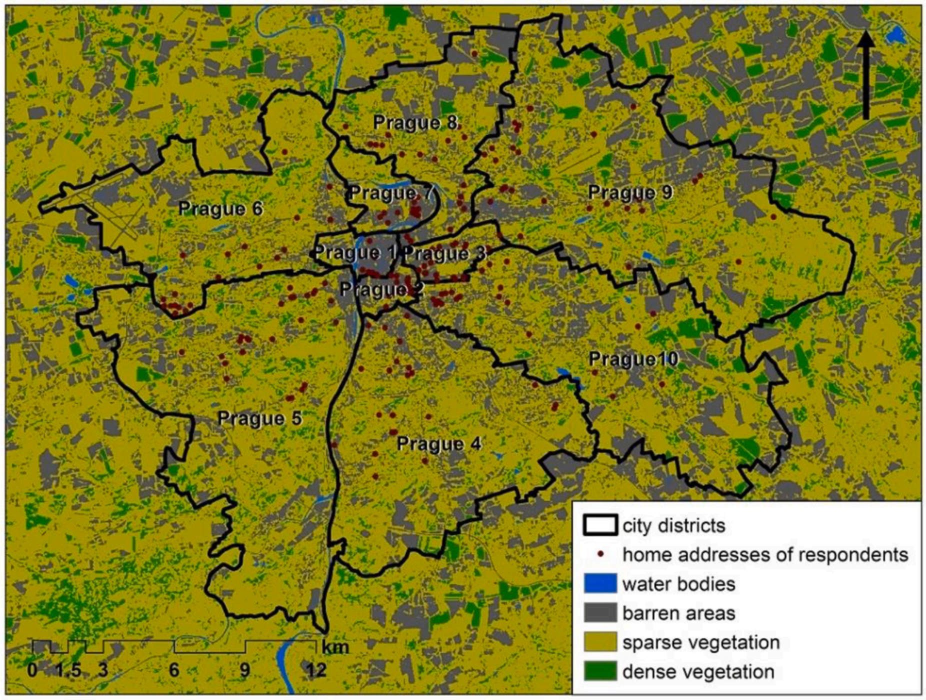

Fig. A4. Spatial distribution of sample respondents – Landsat Normalized Difference Vegetation Index (own creation). The map below provides categorisation of Normalized Difference Vegetation Index (link) into four classes {−1–0 = water bodies, 0–0.2 = barren area, 0.2–0.5 = sparse vegetation, 0.5–1 = dense vegetation}. The map was created using images from Landsat 8 (OLI) from 30.06.2018.

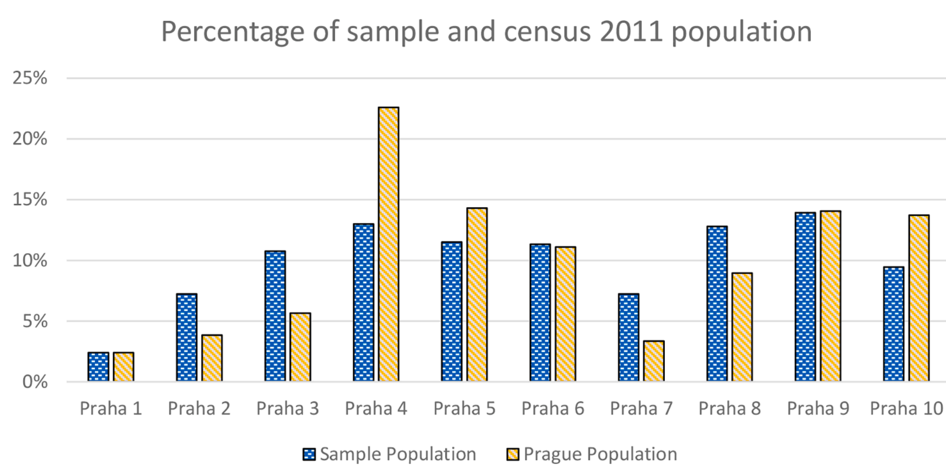

Fig. A5. Distribution of respondents and census population across municipal districts (Prague 1–Prague 10).

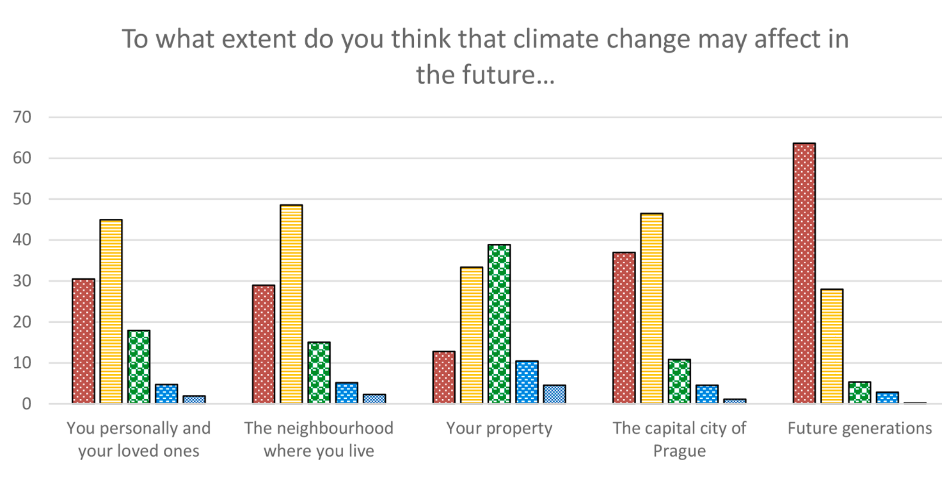

Fig. A6. Perceptions of climate change impacts.

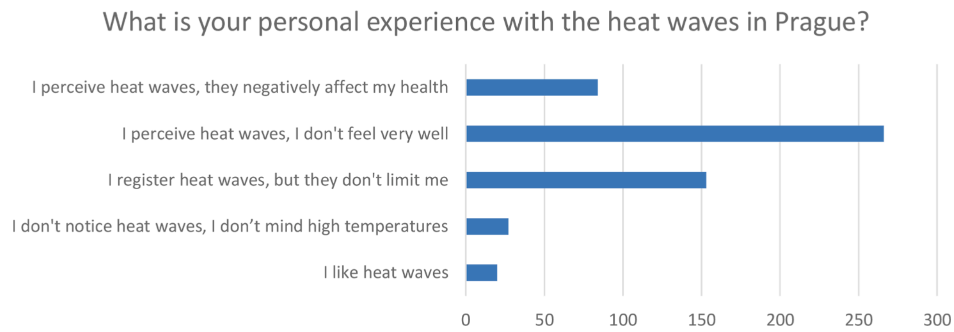

Fig. A7. Personal experience with the heat waves (number of respondents).

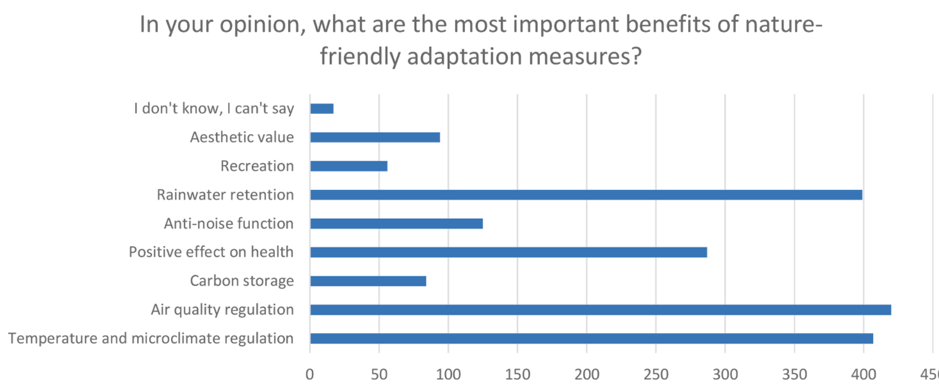

Fig. A8. Perception of benefits of NBS (number of people choosing the benefit; each respondent had option to select maximum three).

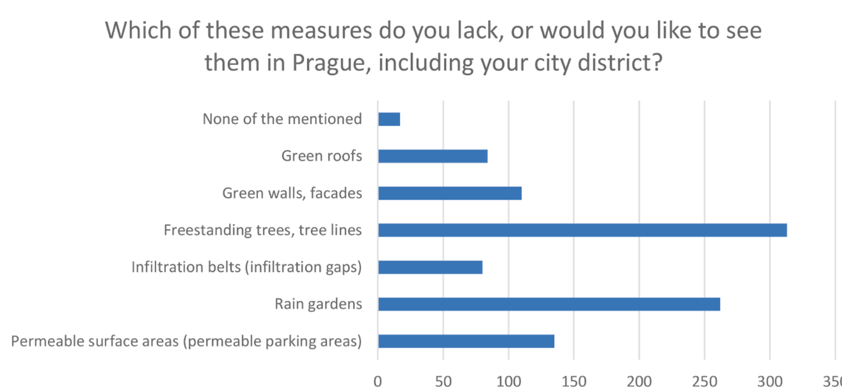

Fig. A9. Preference for individual NBS (number of people choosing the NBS; each respondent had option to select two at the most).

Table A1
Conditional Logit model. The Conditional logit model (McFadden, 1973) assumes that the probability of choice is i.i.d. with Gumbel distribution and therefore does not account for the interdependence of multiple choices within each respondent or the preference heterogeneity across the sample population as the MXL model does. It is nevertheless a standard basic model to estimate the CE data with and as such is reported here.

	Mean (st.err.)	WTP CZK [95% conf. int.]
Type1	−0.009	−19
	(0.064)	[−263, 226]
Type2	−0.328****	−644
	(0.080)	[−954, −335]
Species1	0.527***	1037
	(0.063)	[790, 1284]
Species2	0.640***	1259
	(0.076)	[963, 1555]
SQ	−5.563***	−3404
	(0.554)	[−3782, −3027]
Cost	−0.001***	
	(0.000)	
Number of observations		9450
Number of respondents		525
Log-likelihood		−2662
McFadden pseudo-R2		0.231
AIC		5336
BIC		5379

Table A2
MXL models - all coefficients random & random coefficients selected by Lagrange Multiplier test, *Cost* lognormally distributed; correlated coefficients, 1000 Halton draws. In Table A2 we present models reported in the main text (Table 4), and split sample models in below also with WTP values (Table 5), and three further models (full sample and two split sample models) with random parameters selected by the Lagrange multiplier test by the McFadden and Train (2000), whereby the *SQ* (an alternative specific constant for the status quo), *Cost* and *Type2* attributes were identified by the test to be treated as random parameters in the model, with *Cost* being lognormally distributed.

	All random, Log(cost)			Lagrange Multiplier test, Log(cost)		
Mean values	**Full**	**Heat**	**NoHeat**	**Full**	**Heat**	**NoHeat**
Type1	0.154	0.195	0.118	0.104	0.125	0.092
	(0.090)	(0.113)	(0.168)	(0.078)	(0.095)	(0.133)
Type2	−0.547***	−0.503**	−0.645**	−0.742***	−0.524***	−0.967***
	(0.123)	(0.154)	(0.232)	(0.145)	(0.157)	(0.261)
Species1	0.965***	0.951***	1.078***	0.797***	0.792***	0.828***
	(0.105)	(0.138)	(0.191)	(0.079)	(0.098)	(0.136)
Species2	1.151***	1.054***	1.330***	0.954***	0.984***	0.950***
	(0.132)	(0.170)	(0.240)	(0.098)	(0.124)	(0.165)
SQ	−5.846***	−5.563***	−7.000***	−5.824***	−5.208***	−6.585***
	(0.465)	(0.554)	(1.044)	(0.478)	(0.489)	(0.875)
Log(Cost)	−7.216***	−7.154***	−7.275***	−7.240***	−7.222***	−7.202***
	(0.111)	(0.123)	(0.210)	(0.114)	(0.123)	(0.220)
Standard Deviation						
Type1	0.486**	0.637***	0.646			
	(0.154)	(0.18)	(0.367)			
Type2	0.698**	0.689**	1.181***	0.676***	0.611*	1.188***
	(0.215)	(0.253)	(0.338)	(0.189)	(0.26)	(0.298)
Species1	0.71***	0.737***	0.87**			
	(0.162)	(0.2)	(0.279)			
Species2	0.834***	0.879**	1.118**			
	(0.201)	(0.26)	(0.334)			
SQ	3.822***	3.604***	4.737***	3.886***	3.153***	4.901***
	(0.375)	(0.468)	(0.725)	(0.39)	(0.411)	(0.733)
Log(Cost)	1.855***	1.599***	2.219***	1.962***	1.653***	2.609***
	(0.09)	(0.088)	(0.143)	(0.141)	(0.099)	(0.172)
Number of observations	9450	6048	3402	9450	6048	3402
Number of respondents	525	336	189	525	336	189
Log-likelihood	−2184	−1379	−791	−2200	−1392	−798
McFadden pseudo-R2	0.295	0.288	0.312	0.289	0.282	0.307
AIC	4421	2813	1637	4425	2808	1620
BIC	4614	2994	1802	4511	2888	1693

Table A3
Heat and NoHeat MXL models, correlated coefficients, 1000 Halton draws, WTP values (CZK & EUR/Household/year).

Model Heat: subsample with negative experience with heat wave					**Model NoHeat:** subsample with no negative experience with heatwaves				
	Mean (st.err.)	**S.D.** (st. err.)	**WTP CZK** [95% conf. int.]	**WTP EUR** [95% conf. int.]		**Mean** (st.err.)	**S.D.** (st. err.)	**WTP CZK** [95% conf. int.]	**WTP EUR** [95% conf. int.]
Type1	0.195	0.637***	69	2.72	*Type1*	0.118	0.646	14	0.57
	(0.113)	(0.18)	[−11, 149]	[−0.41, 5.86]		(0.168)	(0.367)	[−26, 55]	[−1.02, 2.16]
Type2	−0.503**	0.689**	−179**	−7.03**	*Type2*	−0.645**	1.181***	−79*	−3.11*
	(0.154)	(0.253)	[−293, −65]	[−11.49, −2.56]		(0.232)	(0.338)	[−145, −14]	[−5.67, −0.56]
Species1	0.951***	0.737***	339***	13.28***	*Species1*	1.078***	0.87**	133***	5.21***
	(0.138)	(0.2)	[219, 458]	[8.61, 17.94]		(0.191)	(0.279)	[66, 200]	[2.57, 7.84]
Species2	1.054***	0.879**	375***	14.72***	*Species2*	1.330***	1.118**	164***	6.42***
	(0.170)	(0.26)	[230, 521]	[9.01, 20.43]		(0.240)	(0.334)	[80, 247]	[3.14, 9.7]
SQ	−5.563****	3.604***	−1981***	−77.69***	*SQ*	−7.000****	4.737***	−862***	−33.81***
	(0.554)	(0.468)	[−2450, −1512]	[−96.09, −59.29]		(1.044)	(0.725)	[−1148, −577]	[−45.01, −22.62]
Log(Cost)[A]	−7.154****	1.599***			*Log(Cost)*	−7.275***	2.219***		
	(0.123)	(0.088)				(0.210)	(0.143)		
Cost[B]	−0.0028***				*Cost*	−0.0081***			
	(0.0004)					(0.0019)			
Number of observations			6048		Number of observations			3402	
Number of respondents			336		Number of respondents			189	
Log-likelihood			−1379		Log-likelihood			−791	
McFadden pseudo-R2			0.288		McFadden pseudo-R2			0.312	
AIC			2813		AIC			1637	
BIC			2994		BIC			1802	

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