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Preferences of vulnerable social groups for ecosystem-based adaptation to flood risk in Central Vietnam

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ABSTRACT

Developing countries are increasingly impacted by floods, especially in Asia. Traditional flood risk management, using structural measures such as levees, can have negative impacts on the livelihoods of social groups that are more vulnerable. Ecosystem-based adaptation (EbA) provides a complementary approach that is potentially more inclusive of groups that are commonly described as more vulnerable, such as the poor and women. However, there is a lack of disaggregated and quantitative information on the potential of EbA to support vulnerable groups of society. This paper provides a quantitative analysis of the differences in vulnerability to flooding as well as preferences for EbA benefits across income groups and gender. We use data collected through a survey of households in urban and rural Central Vietnam which included a discrete choice experiment on preferences for ecosystem services. A total of 1,010 households was surveyed during 2017 through a random sampling approach. Preferences are measured in monetary and non-monetary terms to avoid issues that may arise from financial constraints faced by respondents and especially the more vulnerable groups. Our results reveal that lower income households and women are overall more vulnerable than their counterparts and have stronger preferences for the majority of the EbA benefits, including flood protection, seafood abundance, tourism, and recreation suitability. These findings strongly indicate that EbA is indeed a promising tool to support groups of society that are especially vulnerable to floods. These results provide crucial insights for future implementation of EbA projects and for the integration of EbA with goals targeted at complying with the Sendai Framework and Sustainable Development Goals.

1. Introduction

Floods are amongst the most devastating natural hazards (UNDRR, 2020). Climate change in combination with socioeconomic development is expected to result in increased flood risks (IPCC, 2012; IPCC, 2014). Historically, Asia has been heavily affected by flooding. More than 60 percent of the total global economic losses due to flooding between 1980 and 2015 occurred in Asia, according to the EM-DAT database (Bubeck et al., 2017). A single typhoon (Damrey) in November 2017 resulted in ~110 deaths and a loss of USD 650 million across the Philippines and Vietnam (Munich Re, 2018). Developing countries are generally more vulnerable to floods due to their limited capacity to prevent and absorb the effects of these disasters (Parker, 2006; Jongman et al., 2015). The large impacts of flooding create an urgent need for effective flood risk management, especially in developing countries, as disasters can prevent or undo economic development (Botzen et al., 2019).

In response to this need many regions in Asia consider structural measures, such as reservoirs and dikes, as the core focus of flood management (e.g. Nguyen et al., 2017). Structural measures can be effective at reducing flood impacts, but include high costs, on-going human management, and may reduce in effectiveness over the long-term (e.g. Sutton-Grier et al., 2015). Structural measures are furthermore often associated with negative effects on ecosystems and the services they provide (e.g. Sutton-Grier et al., 2015; van Wesenbeeck et al., 2014; Prosser et al., 2018; Gittman et al., 2016). It is generally the case that poor and vulnerable communities are more dependent on ecosystem services (ES) such as fish availability and flood protection (e.g. Stone, 2016). Ecosystem degradation more general is seen by the Association of Southeast Asian Nations (ASEAN) as a core driver of disaster and climate risk

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which threatens resource dependent livelihoods for whom risk is exacerbated by social inequality (ADB, 2020). Therefore, a strategy focused on structural measures only can result in negative impacts on the livelihoods of these groups of people.

Ecosystem-based adaptation (EbA) presents a complementary flood protection approach that can benefit livelihoods and may therefore be preferred by vulnerable groups in society (Munang et al., 2014; Ensor et al., 2018; Sutton-Grier et al., 2015). EbA uses biodiversity and ES as part of an adaptation strategy. ES are defined as the benefits that people obtain from ecosystems (Millennium Ecosystem Assessment, 2005) and the contributions of ecosystems to human well-being (TEEB, 2010; UN Environment, 2019). EbA includes the sustainable management and restoration of ecosystems to provide ES that help people adapt to the adverse effects of natural hazards and climate change in an overall adaptation strategy (Secretariat of the Convention on Biological Diversity, 2009; Baig et al., 2015; Lo, 2016; Bhattarai et al., 2021). Compared to a sole reliance on structural measures, combining structural measures with EbA may be preferred because the reinforcement of local ecosystems provides a range of benefits in terms of ES in addition to flood protection (e.g. Mumby et al., 2004; Sutton-Grier et al., 2015; Prosser et al., 2018). These additional ES benefits are especially important to the people whose livelihoods depend on the ecosystems. Moreover, EbA might be a suitable alternative in areas where structural measures are not feasible due to physical or economic factors.

Numerous EbA measures are known for providing flood risk reduction benefits. Mangrove forests, for example, have been proven to reduce wave and tidal energy and thereby reduce flood impacts in coastal communities (e.g. Beck et al., 2018a; Dasgupta et al., 2019; Bao, 2011). Coral reefs and salt marshes can provide flood risk reductions through similar processes (e.g. Temmerman et al., 2013; Beck et al., 2018b). Moreover, these ecosystems allow for natural accumulation of sediments at the shoreline which may play a vital role in protection against sea-level rise (e.g. Temmerman et al., 2013; Fagherazzi et al., 2012). In cities, urban green spaces can be effective in reducing flood risk up to 50% (e.g. Zhang et al., 2015; Kim et al., 2016). Furthermore, river flood risk reduction can be reduced by afforestation of the upper watershed and riparian buffers (e.g. Daigneault et al., 2016; Iacob et al., 2014). Next to risk reduction benefits, the benefits from EbA interventions can also provide support after disasters. For instance, Saroar et al., (2019) present that a mangrove focused EbA project in Bangladesh provides a range of ecosystem services, some of which serve the purpose of providing coastal protection against storm surges, erosion, and flooding, while other services support climate sensitive agriculture. Similarly, Fedele et al. (2016) describe how forest ecosystem services in Indonesia provide support both in terms of preventing a disaster (regulating ecosystem services) as well as in terms of recovering from a disaster (provisioning ecosystem services). EbA measures can therefore increase overall flood resilience by acting as a shelterbelt while also reinforcing the ES that local livelihoods depend upon.

1.1. Vulnerability of social groups

Two social groups whose livelihoods are often more dependent on ecosystems, and who are commonly described as being more vulnerable to flood impacts, are the poor and women. Vulnerability is a multifaceted concept without an agreed metric how to measure it (Klein, 2009). Accordingly, numerous definitions are used to assess vulnerability to natural hazards, climate change and extremes (Adger, 2006; Wolf et al., 2013; Zebisch et al., 2021). In this article, we refer to the commonly used definition of climate change vulnerability proposed by the IPCC in its fourth assessment report (Parry et al., 2007). According to this definition, vulnerability is [...] "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (Parry et al., 2007)". While the fifth assessment report introduced a new concept of "climate risk" with a partly deviating terminology, the general idea that a combination of climatic, natural, physical and socio-economic factors determines the root-causes and degree of negative impacts remains the same (Zebisch et al., 2021).

Poverty is multi-dimensional and is determined by factors including income and access to essential goods and services, such as water and education (World Bank, 2001; Fisher et al., 2014; Ahammad et al., 2019). Due to income constraints the poor often live in high risk areas or housing and are therefore more exposed to floods (De Silva & Kawasaki, 2018; Abeygunawardena et al., 2003; Brouwer et al., 2007; Tran et al., 2008). The sensitivity of the poor to floods has also been evidenced by previous studies conducted across Asia that indicated that the poor suffer relatively more from disaster events (De Silva & Kawasaki, 2018; Tran & Shaw, 2007; Tran et al., 2008; Razafindrabe et al., 2014; Pandey et al., 2018). Finally, studies conducted in Asia identify that the poor experience a lower level of adaptive capacity (Brouwer et al., 2007; Navrud et al., 2012; Tran et al., 2008). For example, Than Thi Pham et al. (2020) found that households living in one of the poorest regions in Vietnam really heavily on ecosystems that are highly vulnerable to flash floods and landslides, evidencing the high levels of exposure and sensitivity of this group that have resulted in lower levels of adaptive capacity.

Women are also commonly identified as more vulnerable to natural hazards in developing countries (e.g. Neumayer & Plümper, 2007; Cutter, 2017; Klein et al., 2019; DKKV, 2019; Mendoza et al., 2014; Owusu et al., 2019). The underlying causes of this vulnerability relate to differing disadvantages across social, cultural, economic, political and legal status and opportunities (Enarson, 1998; Morrow, 1999; Frankenberg et al., 2011; Chandra et al., 2017; Detraz & Peksen, 2017). For instance, due to higher unemployment rates and involvement in unpaid activities women may experience higher poverty rates compared to men (GIZ et al., 2015; Jabeen, 2014; Ajibade et al., 2013; Jungehülsing 2012; Nelson et al., 2002). Furthermore, because of the caretaker role that commonly ends up on women's plate because of gender and cultural patterns (Mendoza et al., 2014), women are less mobile during floods and have a higher change on mortality during severe events (Neumayer & Plümper, 2007), and may also experience a higher psychological burden during and after disasters (Ajibade et al., 2013; Jungehülsing, 2012; Mason & Agan, 2015; Bubeck & Thieken 2018). In combination with often low influence in the decision-making domain (Arora-Jonsson, 2011; Oloukoi et al., 2014) and limited access to information (Nalau et al., 2018; Oloukoi et al., 2014; Owusu et al., 2019), women experience lower adaptive capacity in combination with higher sensitivity to floods through socially constructed norms.

1.2. The potential of ecosystem-based adaptation

The ES benefits related to EbA have the potential to contribute to poverty alleviation and thereby support the poor. Poverty alleviation is commonly separated into poverty reduction and poverty prevention (Daw et al., 2011; Fisher et al., 2014). Poverty reduction includes lifting households out of poverty, whereas poverty prevention avoids households from falling (back) into poverty. ES such as fisheries and flood protection can contribute to poverty prevention by safeguarding income sources and avoiding large losses and related reparation costs, respectively. New cash earning opportuni-

ties such as eco-tourism offer opportunities for reducing poverty by increasing household incomes (Daw et al., 2011; World Resources Institute et al., 2008; Reid & Alam, 2017). Fisher et al. (2014) argue that changes in ES are more likely to be associated with poverty prevention than reduction, based on examples in the literature (Angelsen & Wunder, 2003; Béné et al., 2010; Fisher, 2004; Reid & Alam, 2017). There are nonetheless also studies that indicated that EbA benefits can increase income (Schuyt, 2005; Wang et al., 2009; Jha et al., 2017; Reid & Alam, 2017). For instance, an Indian national program focused on increasing water availability and expanding on agricultural practices has resulted in increased employment opportunities and daily wages (Jha et al., 2017). Furthermore, Reid and Alam (2017) found that an EbA project in Bangladesh has increased subsistence and livelihood options for especially poorer households.

Gender equality can be improved through strengthening of important EbA benefits for women. Fortnam et al. (2019) show that gender roles and perceptions of ES are closely connected and that woman perceive a relatively higher contribution of ES to their wellbeing through economic security. EbA projects that reduce the impact and frequency of natural hazard events can relieve the burden that is put on women during and after these events. This burden is the result of the women's caretaker role. Namely, women are often responsible for the safety of the children and elderly as well as for basic needs such as water and food. These responsibilities are harder to fulfill during and after disasters, leading to increased efforts and psychological stress on the women's side (Ajibade et al., 2013; Jungehülsing, 2012). This burden can result in a difference in recovery rates across men and women (Hudson et al., 2019; Hudson et al., 2021) . For instance, Hudson et al. (2019) measures subjective well-being, a known proxy of welfare, and find that male respondents recover their welfare losses by around 80% within 5 years compared to 70% for the female respondents based on data collected in Vietnam. Based on studies that examine gender differences in preferences for ES, women seem to mostly prefer improvements in regulating services, such as erosion control (Martín-López et al., 2012; Oteros-Rozas et al., 2014; Yang et al., 2018).

Overall EbA seems to present a promising means to reduce vulnerability of social groups that are commonly mentioned to be more vulnerable, while also limiting flood risk. EbA could thereby contribute to the achievement of the targets set by the Sendai Framework for Disaster Risk Reduction 2015–2030 (UNISDR, 2015) and multiple Sustainable Development Goals (SDGs) (UN, 2018), including SDGs 1 (no poverty), 5 (gender equality), 10 (reduced inequalities), 13 (climate action), 14 (life under water) and 15 (life on land) (IPBES, 2019). Both policies are at the heart of current disaster risk reduction and climate adaptation discussions. The Sendai Framework calls for an all-of-society engagement and partnership to reduce disaster risk, with an inclusive and accessible participation of people disproportionately affected by disasters (UNISDR, 2015). As described in the previous paragraphs, both the poor and women often experience relatively higher impacts from disasters. Both the Sendai Framework and the SDGs furthermore explicitly highlight the importance of strengthening the link between environmental and natural resource management and disaster risk reduction (UNISDR, 2015). Despite the importance of ecosystems for human well-being, unprecedented environmental degradation threatens both human health and life-support systems (UN Environment, 2019; Gupta et al., 2019; IPBES, 2019). At the implementation level, however, EbA is hardly considered by policy makers. Less than 1% of total investments in water resources management infrastructure is currently spent on EbA (UN-Water, 2018).

1.3. Research gap

For EbA to be more generally considered as a viable option for flood risk management portfolios, with a focus on how it can be used to support vulnerable groups, existing interventions need to be evaluated while our understanding on how the benefits of EbA are distributed among social groups needs to be improved. Currently, studies that evaluate EbA rarely focus on measuring social and economic benefits and the distribution of these benefits (Brink et al., 2016; Doswald et al., 2014; Baig et al., 2015). For instance, only 8% of the articles included in the review by Brink et al. (2016) addressed gender, of which half (i.e. 4%) mentioned it more than twice. This is problematic since knowing how the perceived benefits and costs of EbA are distributed can help create an environment that achieves socially beneficial outcomes (Rizvi et al., 2015). This is also reflected in evaluations of EbA projects, where it is identified that EbA projects may fail to account for differences in benefits (Baig et al., 2015; Rizvi et al., 2015; Lo, 2016), or to eliminate barriers for women to partake in decision-making processes (Oloukoi et al., 2014), together leading to obstacles to the inclusive use of EbA (Nalau et al., 2018).

How benefits are distributed in reality depends on how projects are implemented, but integrating the preferences of different groups in the design and implementation of EbA projects can contribute to achieving the goal of supporting the vulnerable groups (Yang et al., 2018; Fortnam et al., 2019; Ahammad et al., 2013; Soroar et al., 2019; ADB, 2020). Therefore, there is a need for more quantitative and disaggregated analyses to investigate the preferences for EbA in order to better understand the role that EbA can play in flood risk management (Daw et al., 2011; Suich et al., 2015; Doswald et al., 2014; Brink et al., 2016). This research gap is widely recognized and scholars further mention the need for better understanding on how different groups in society experience the impacts of flooding, manage environmental resources, and receive benefits from flood protection measures (e.g. Kreibich et al., 2014; Cutter, 2017; Hudson et al., 2019; Rizvi et al., 2015).

We contribute to this literature with an assessment of differences in vulnerability to flooding and differences in preferences for EbA benefits across income groups and gender. Based on the literature, our first hypothesis is that lower income households and women are more vulnerable to flooding than their counterparts. Our second hypothesis is that the lower income households and women express higher preferences for EbA benefits compared to their counterparts. To test our hypotheses, we conduct a quantitative analysis of these differences in both vulnerability and preferences using the results of a household survey in which a discrete choice experiment (DCE) is embedded. The DCE measures preferences for ES that are affected by EbA through monetary and non-monetary payment modes. We choose to include non-monetary payments to avoid possible problematic issues that may arise due to financial constraints faced by respondents, and those that are more vulnerable in particular. We conduct our study within Vietnam, a highly flood-prone developing country in Asia. Vietnam is furthermore considered as one of the most vulnerable countries in respect to climate-related hazards (e.g. Dasgupta et al., 2007). Moreover, we sample in coastal and urban areas since these present hotspots for future flood risk (Birkmann et al., 2016; IPCC, 2018).

By combining our empirical results on the vulnerability to floods and preferences for EbA with existing knowledge, we argue on the potential relevance of EbA in reducing the vulnerability of the more vulnerable through poverty alleviation and improvements in gender equality. Nonetheless, not everyone within the groups that we study will face the same degree of vulnerability as many of the described issues are intersectional in nature

(e.g. Djoudi et al., 2016; Sultana, 2014; Kaijser & Kronsell, 2014; Rao et al., 2019; Thomas et al., 2019). For example, women can display substantial differences in vulnerability across caste (Onta & Resurrección, 2011; Ravera et al., 2019), adaptation strategies adopted (Brockhaus, Djoudi, & Locatelli, 2014), participation in decision-making (Arora-Jonsson, 2011; Yilppa et al., 2019), household composition (Klasen, Lechtenfield, & Povel, 2015), but also education levels and age (Djoudi et al., 2016; Ravera et al., 2019; Huynh & Resurreccion, 2014). However, the results of our study can serve as a starting point to facilitate collective learning to better understand heterogeneous preferences for EbA (Murti & Mathez-Stiefel, 2019). We furthermore comment on methodological aspects regarding the measurement of preferences for EbA benefits in developing countries. The results of this study provide valuable information on differences in vulnerability and preferences for EbA in an Asian developing country context, with high relevance to policy makers and organizations working on disaster risk reduction and climate change adaptation.

2. Study sites

Vietnam has experienced high economic growth rates in recent decades and is increasingly dealing with problems associated with environmental degradation, climate change issues, a changing economy and ongoing population growth (Tuan et al., 2009; Tran & Shaw, 2007; Tran et al., 2008; van Tuyen et al., 2010). Furthermore, frequent flood events lead to high damage costs and loss of life. This study focusses on the Vietnamese province of Thừa Thiên-Hu , a coastal province in Central Vietnam. This province experienced a total of 40 floods between 1975 and 2005 (Bubeck et al., 2012), meaning that on average there was at least one flood a year, which is expected to increase in the future (MONRE, 2011; Tran et al., 2008). The flood with the highest impact occurred in 1999 and killed at least 547 people, resulted in damages of around USD 200 million, and affected 600,000 homes (Valeriano et al., 2009). The flood caused by the recent Typhoon Damrey in 2017 killed 9 people and resulted in damages of around USD 36 million in Thừa Thiên-Hu province (KTTV, 2017; Vietnam News, 2017). The threat posed by floods makes adapting to climate change and managing flood risks an urgent matter for Vietnam in general, and the coastal province of Thừa Thiên-Hu in particular.

The poor and women living in Thừa Thiên-Hu are particularly vulnerable to the impacts of flooding and climate change (Pham & Lam, 2016; Hudson et al., 2019; Navrud et al., 2012; Razafindrabe et al., 2014; Tran et al., 2008). For this reason, two community-led EbA measures were designed and implemented to reduce flood risks while simultaneously improving local livelihoods through the provision of various ES (DKKV, 2019). One of the EbA measures was situated in an urban setting, and the second in a rural setting. The projects were initiated in close consultation with the local communities, who actively participated in the planning, design, restoration activities and management of the projects after implementation. To enhance community participation several workshops and community information meetings and events were organized (DKKV, 2019). In practice the community members have contributed to the restoration activities by planting trees in the rural site and after the restoration activities they will keep the restored ecosystems clean, enforce the management plan as designed by the community, and maintain the areas in both sites.

In the city center of Hu City (see Fig. 1) urban water bodies were restored to increase their drainage capacity and to reduce flood damage during heavy rainfall events (i.e. pluvial flooding). These urban ponds belong to a traditional interconnected system of water bodies which play an important function for water retention, a common type of system in the province (Tran & Shaw, 2007). However, due to uncontrolled urban growth these water bodies are increasingly blocked by housing and solid waste (DKKV, 2019; Tran & Shaw, 2007). Other ES benefits resulting from the improved water flow are increases in the suitability for recreation activities, improved aesthetics, tourism possibilities, a cooling effect and increases in aquaculture and lotus production.

The rural EbA measure involved the restoration of mangroves in the Tam Giang lagoon (see Fig. 1). Mangroves were planted to reduce damages from storm surges, due to their ability to attenuate waves, and to keep in pace with rising sea levels by accretion of sediments (e.g. Temmerman et al., 2013). Moreover, the abundance of seafood in the lagoon has been decreasing since the 1980s due to unsustainable practices in combination with economic expansion and population growth, causing problematic issues for the surrounding communities (Boonstra & Hanh, 2015; van Tuyen et al., 2010). Tuan et al. (2009) measure the value of the Tam Giang lagoon's provisioning services and show that capture fisheries produce the highest net benefits and aquaculture the highest total benefits. Besides flood protection, the mangroves are expected to increase the abundance of seafood in the lagoon, improve the overall water quality, prevent erosion, attract tourists, and positively affect rice and aquaculture production.

3. Methods

To assess the levels of vulnerability and preferences for EbA benefits across income groups and gender we implemented a household survey in which a DCE was embedded. We measured vulnerability across income groups and gender to identify whether these social groups are indeed more vulnerable as commonly stated in the literature. Next, we investigated the preferences for EbA of lower income households and women for EbA benefits and compare their preferences to their counterparts, i.e. higher income households and men. We combined both results with previous studies' findings to identify opportunities for poverty alleviation and gender equality improvements through EbA projects, that could potentially result in reduced vulnerabilities. An overview of our methodological approach is included in Fig. 2.

3.1. Data collection

To develop the questionnaire and the DCE we started with a pre-test survey, followed by a pilot survey and finally the main study. Data collection took place between June and September 2017. First, 80 respondents were interviewed for both test surveys in both the urban and rural areas. Next, a total of 1,010 respondents were interviewed for the main survey and DCE, with 505 respondents from each of the two sample areas. A team of 14 local enumerators was trained over a period of four days after which they conducted the interviews. Kobo Toolbox software was used to record the interview responses.[1]

Sampling areas were selected based on whether the areas evidently benefited from the EbA measures, which meant that we interviewed households living near the ponds and mangroves. These areas included several villages and wards around the mangroves and ponds, respectively. Respondents were sampled randomly from each village or ward according to their size, i.e. if village one was twice the size of village two we sampled twice the number of respondents from village one compared to village two. The sampling frame consisted of a reliable estimate of the number of households provided by the community leaders. More details on the sampling approach can be found in Hudson et al. (2019), who note that the sample is representative of the province.

[1] https://www.kobotoolbox.org/

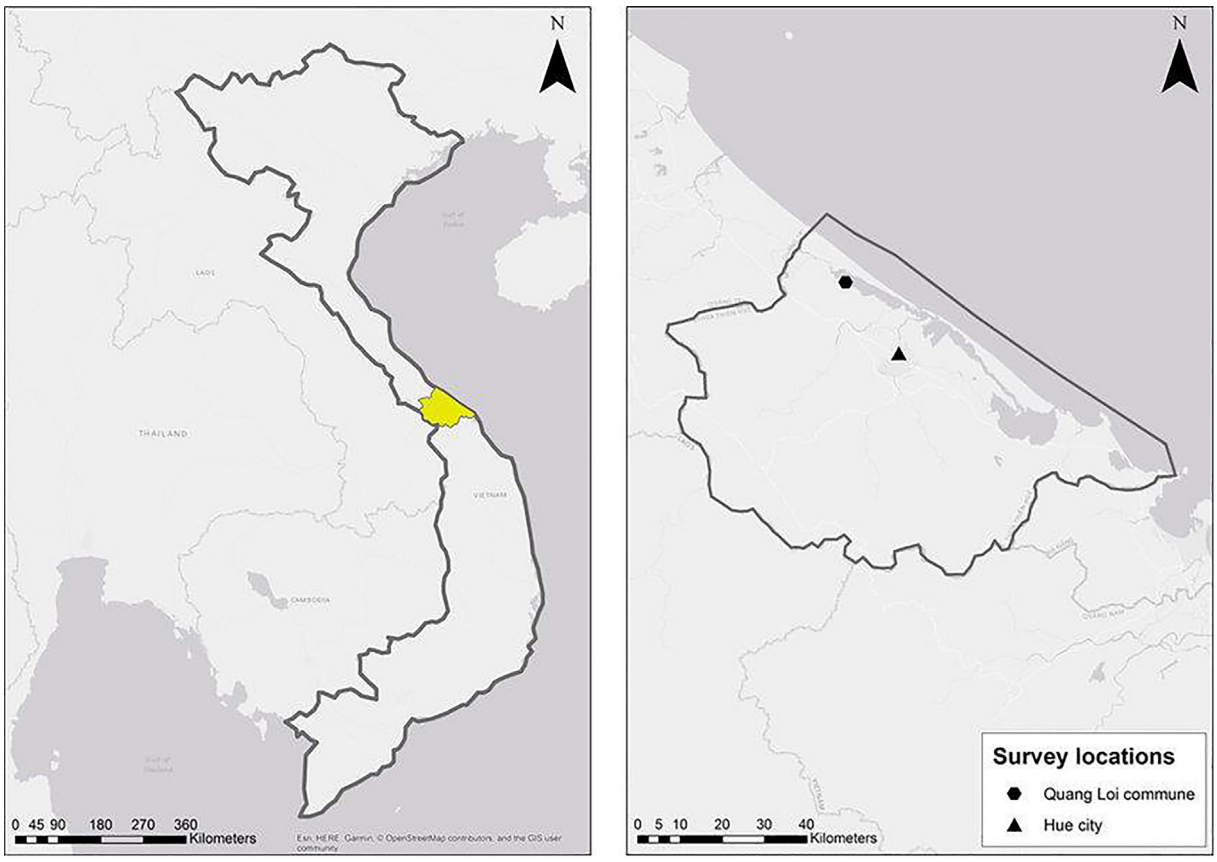

Fig. 1. Location of Thừa Thiên-Hu province and the study sites Hu City (16°28′41.8″N 107°34′49.2″E) and Quang Loi commune (16°37′24.8″N 107°27′24.1″E). . Source: Hudson et al. (2019)

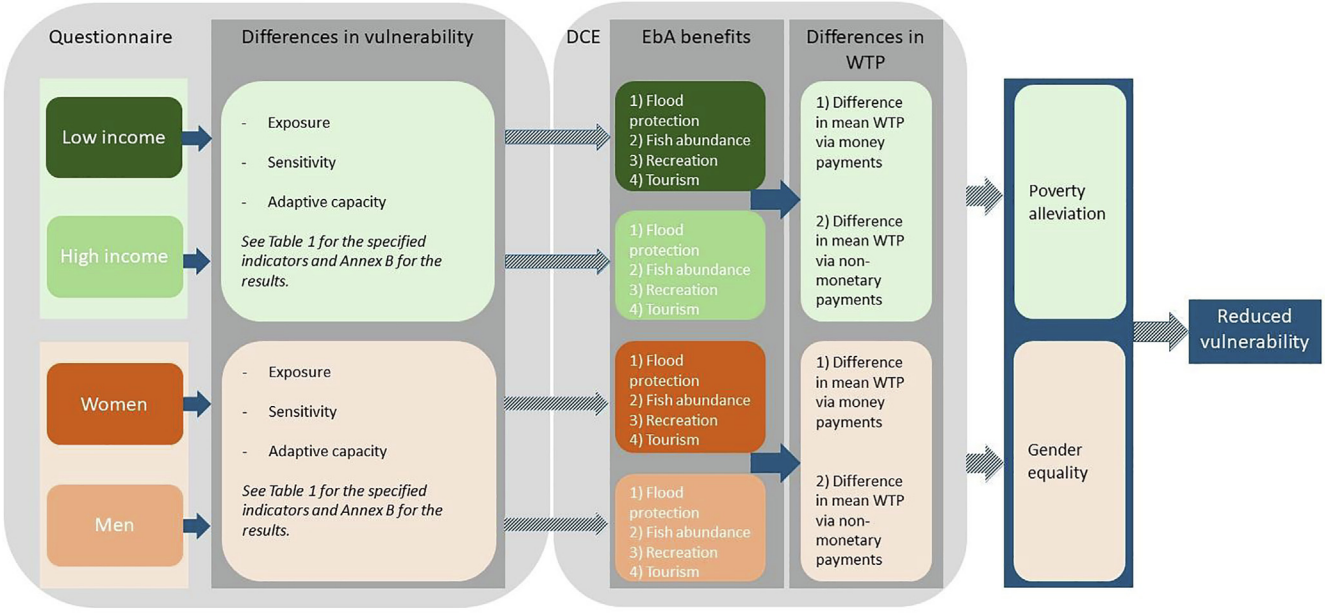

Fig. 2. Overview of methodological approach. The blue arrows are links that we base on our data whereas the dashed blue arrows present links that we base on assumptions made in accordance to the literature. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

The target was to interview the household head or partner, who were asked to answer to the questions on behalf of themselves and their household, depending on the specifics of the question. Interviews were conducted face-to-face in the respondent's house. In compliance with ethics requirements, we asked respondents for informed consent related to their voluntary participation in the study and provided information on how we treat their information, specified that they can drop out of the survey at any time without

disadvantages, described the topic and purpose of the research, and elaborated on what is expected from them. This aspect of the survey received specific focus during the training. We furthermore collected as little personal data as possible. Moreover, all respondents had to be over 18 and in good health and received a small compensation for their time. Our study has been approved by the provincial authority (Provincial People's Thừa Thiên-Hu) and through collaboration with CSRD, who knows the study population very well, we furthermore put specific focus on avoiding ethical dilemmas.

3.2. Questionnaire

The questionnaire consisted of eight sections covering questions on: dependence on ES; environmental perceptions; happiness; risk perceptions; DCE and DCE debriefing; community life; flood experiences and demographics. The questionnaire was identical across the study sites, except for questions specifically related to the ES due to the difference in ecosystems (i.e. mangroves and ponds). The questionnaire was developed in collaboration with the Centre for Social Research and Development (CSRD), University of Potsdam and Vrije Universiteit Amsterdam. The questions were trialed during the pre-test and pilot surveys to check the clarity of the questions and of the answers provided by respondents. Based on these trials we decided to adjust Likert scales and the wording of some questions, for instance. Most of the questions could be answered through a Likert scale or pre-defined categories that also included a "don't know" or "other" option. Before implementation the questionnaire was translated into Vietnamese.

To measure vulnerability across income groups and gender, we split both the urban and rural samples into sub-samples. We used income differences as an indicator of poverty, following for instance De Silva and Kawasaki (2018). We split the samples into two sub-samples based on the mean household income. The mean household income was derived from a survey question asking the respondent for the total monthly household income from all different income sources and was measured separately for both the urban and rural samples. For gender we created female and male sub-samples as derived from another survey question. Since a substantial sample size is necessary for the statistical analyses we conducted with the DCE (see next section), we were not able to apply more comprehensive measures of poverty or account for differences across women.

We summarize the variables used to assess differences in vulnerability among social groups in Table 1. As discussed above, there is no agreed metric for measuring vulnerability, resulting in numerous and varying variables and indices being used. The variables presented in Table 1 are based on regional literature on the vulnerability of the poor and women (e.g. De Silva & Kawasaki, 2018; Tran et al., 2008; Brouwer et al., 2007; Neumayer & Plümper, 2007; Navrud et al., 2012; Razafindrabe et al., 2014) as well as on vulnerability in general (e.g. Pandey et al., 2018; Omerkhil et al., 2020; Gupta et al., 2020; Sekhri et al., 2020; Thao et al., 2019; Hoang et al., 2020; Fritzsche et al., 2014). We use slightly different vulnerability measures for the analyses on income differences and the analyses on gender differences since some survey questions were asked on the household level and others on the individual level. For the analyses regarding income differences, we use household level variables as well as individual level variables that reflect on the household situation. For instance, we thereby assume that the severity of a flood as experienced by a member of the household also says something about the severity of a flood for the entire household. For the analyses regarding gender differences we only use individual level variables. We analyze the differences per variable by applying Mann-Whitney U tests or Chi-square tests, depending on the measurement of the variable.

Table.1
Vulnerability measures across the different components. Including description and noted in which analysis (i.e. income and/or gender differences) the variable is included.

Vulnerability component	Variable	Description	Included in the analysis on . . .
Exposure	Exposure flood	Perceived exposure to river/ lagoon floods on a 11 point likert scale.	Income and gender differences.
	Exposure storm	Perceived exposure to pluvial floods on a 11 point likert scale.	Income and gender differences.
	Number of floods	Total number of floods experienced over the past 10 years.	Income and gender differences.
Sensitivity	Natural resource dependency	Percentage of household income coming from natural resources.	Income differences.
	Flood impact: damages	Whether the household has or has not experienced damages due to floods.	Income differences.
	Flood impact: natural resource loss	Whether the household has or has not experienced natural resource losses due to floods.	Income differences.
	Flood impact: evacuation	Whether the household has or has not evacuated due to floods.	Income differences.
	Severity of flood	How severe flood impacts have been on a 11 point likert scale.	Income and gender differences.
	Psychological burden	How often a respondent still thinks about previous flood impacts.	Income and gender differences.
	Recovery rate	How much flood impacts still affect a respondent today on 11 point likert scale.	Income and gender differences.
	Mobility	Number of caretaker roles in the wake of a flood, including taking care of the children, sick and elderly and providing for the family.	Gender differences.
	Dwelling	Household lives in a permanent dwelling or not.	Income differences.
Adaptive capacity	Education	Education level of the respondent.	Gender differences.
	Social support	How many parties a respondent has received support from (community, government and charity).	Income and gender differences.
	Social cohesion	Expected support when needed from community members on a 11 point likert scale.	Income and gender differences.
	Social involvement	Number of memberships of social networks (e.g. fishers union and women's union).	Income and gender differences.
	Dependency ratio	Number of workers per household member.	Income differences.
	Income diversity /	Number of different income sources of the household.	Income differences.
	Occupation diversity	Number of different occupations of the respondent.	Gender differences.

We furthermore leave out gender and income variables since we already compare our results across these measures.

3.3. Discrete choice experiment (DCE)

The DCE was embedded in the questionnaire and is a stated preference valuation method that is used to elicit the preferences of respondents for specified changes in a good or service (Johnston et al., 2017) and is commonly applied in the environ-

mental valuation literature (e.g. Oleson et al., 2015; Gibson et al., 2016; Meginnis et al., 2020; Navrud & Vondolia, 2020). The DCE methodology asks survey respondents to make repeated choices between multi-attribute descriptions of a good or service that is presented to them in so-called choice cards (see Fig. 3 and Annex A for example choice cards). In our application, the restored ecosystem was the overall good, while its attributes consisted of the ES that are affected by the restoration activities and a contribution to ensure continued management of the restored ecosystem. This contribution attribute is the payment vehicle. The respondent was asked to answer to a series of choice cards such as the one presented in Fig. 3 by selecting his or her preferred management option, where trade-offs exist between the ecosystem's ability to supply ES and the monthly contribution amount (Johnston et al., 2017). By observing the trade-offs that the respondents made between the key attributes of an EbA measure, it was possible to estimate the relative preferences for, and willingness to pay (WTP) values of, changes in these attributes (Johnston et al., 2017). The main theoretical underpinnings of the DCE method are derived from the characteristic theory of value (Lancaster, 1966) and random utility theory (Hanley et al., 1998; McFadden, 1974). We refer to Johnston et al. (2017) for an introduction, history and guidance on stated preference valuation applications to environmental public goods.

3.3.1. Design of the DCE

To design a DCE it is common to implement a stepwise approach in order to select the attributes, payment vehicle and levels for all attributes as well as to trial the experiment (e.g. Johnston et al., 2017; Gibson et al., 2016; Meginnis et al., 2020; Navrud & Vondolia, 2020). Therefore, we first started with a pre-test survey. The pre-test survey included survey questions aimed at selecting the most important ES related to the EbA measure from the respondent's point of view. We selected the most important ES to be included as attributes in the DCE since including all affected ES is undesirable due to the significant increase in complexity on

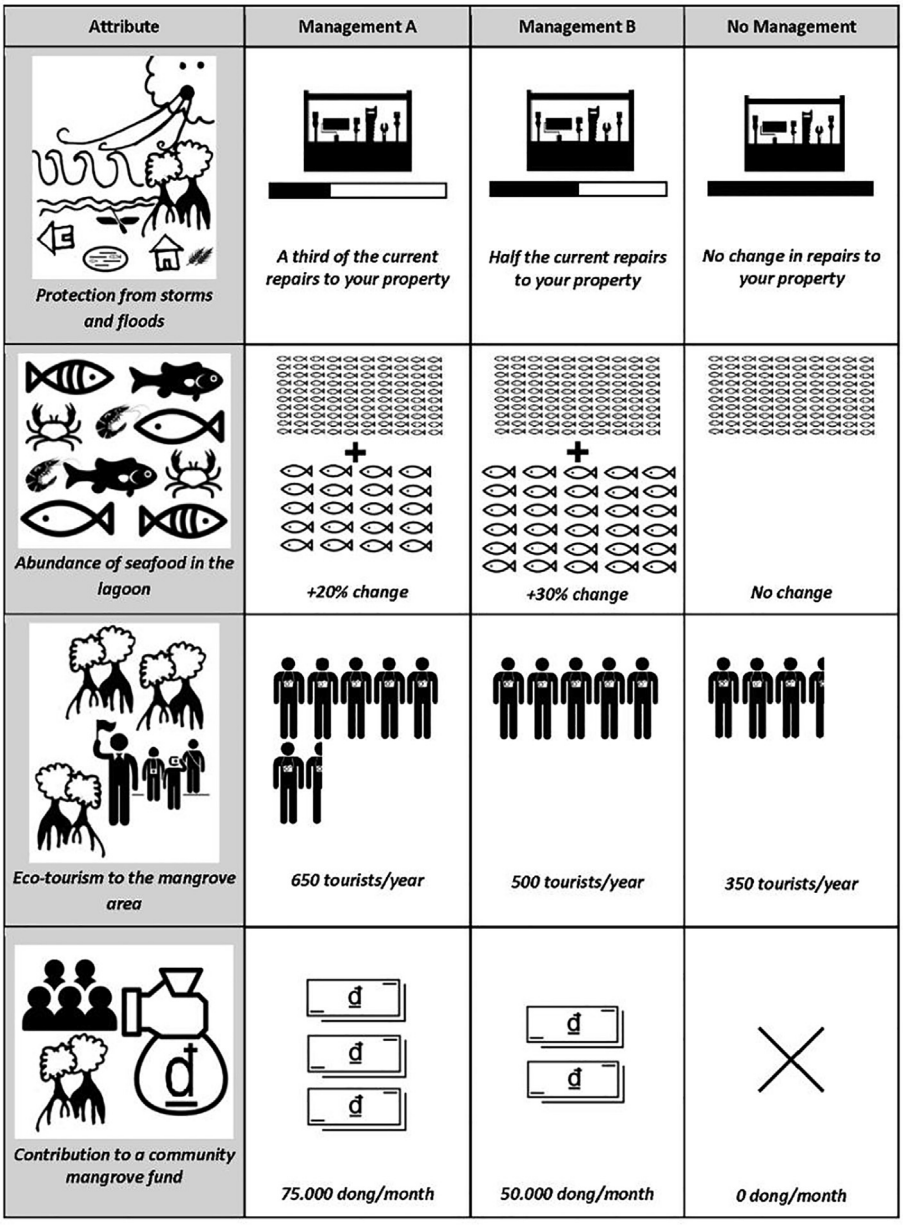

Fig. 3. Example choice card of the rural experiment with money payments (see Annex A for an example of the other three experiments).

the respondent's side as well as in the necessary sample size. In the urban area, protection from storms and floods, recreation suitability and tourism in Hu City were identified as the most important ES. For the rural area, these ES are protection from storms and floods, abundance of seafood in the lagoon and tourism to the mangroves. The pre-test survey also included questions that aimed to measure the suitability of different payment vehicles (Morrison et al., 2000). The most suitable payment vehicles proved to be a 'standard' monetary payment made by the household to a community fund and a non-monetary contribution of time by the household that would be spent on tending and cleaning the restored ecosystems. Due to limited financial means in developing countries, a non-monetary payment vehicle is arguably more suitable. Recent studies in developing countries have therefore adopted non-monetary payment vehicles next to monetary ones (e.g. Hagedoorn, Koetse, & van Beukering, 2021; Gibson, Rigby, Polya, & Russell, 2016; Navrud & Vondolia, 2020; Pondorfer & Rehdanz, 2018; Vondolia & Navrud, 2019). Since the more vulnerable groups often face increased financial constraints, a non-monetary payment vehicle seems especially relevant for our study purpose, since these respondents might be able to express their preferences more freely through non-monetary contributions (e.g. Alam, 2006; Brouwer et al., 2009). The answers to the questions in the pre-test survey furthermore provided input for the selection of levels for both the ES and the payments in the DCE.

The pilot test survey followed the pre-test survey and included a first version of the DCE that was designed based on the information obtained in the pre-test survey. The goals of the pilot test were to test the credibility of the presented management scenarios and clarity of the choice questions, descriptions of the attributes, and the pictures that are used to describe the attribute levels (Johnston et al., 2017). The feedback on this pilot test allowed us to design the final DCE in such a manner that the DCE would be able to successfully capture the preferences of the surveyed respondents. Changes made after the pilot test included adjustments in the payment levels in the monetary experiment and pictures used for the seafood abundance attribute.

Table 2 presents the final DCE design, including the attributes and levels for both the urban and rural experiments using both payment vehicles. The ES attributes were defined using four levels and the payment vehicles were defined using five levels. For the statistical design of the DCE, we applied a fractional factorial orthogonal design, in which 60 choice cards were generated and divided into six choice sets. The same statistical design was used for both urban and rural experiments. Three management options were presented on each choice card: Management A, Management B and an opt-out option that was defined as a scenario in which there is no management. For the No Management option all the attributes were at their least favorable level (low) and the payment vehicle at its most favorable level (i.e. 0 Vietnamese dong (VND) or 0 days). See Fig. 3 for an example choice card of the rural experiment with money payments, Annex A for example choice cards of the other three experiments, and Hagedoorn, Koetse, van Beukering, & Brander (2020) for more detailed information on the DCE design.

3.3.2. Analysis of the DCE

The data collected through the DCE was analyzed using random parameter logit (RPL) regressions to examine the relative influence of each attribute and level on the choices that respondents make (e.g. Brouwer et al., 2010; Koetse & Brouwer, 2016). The dependent variable in the RPL regressions is binary, representing that a management option on a choice card is chosen or not. The attribute levels are the explanatory variables that define the specific management option. In the experiment, selecting one management option over the other two management options in a choice card suggests that the utility of that management option is higher for the respondent compared to the other (no) management options on that choice card (as also described in Meginnis et al., 2020, for instance). The estimated coefficients from the RPL model can then be interpreted as the marginal utility of each attribute level and reflect respondents' preferences for the attributes and levels. For instance, in the example shown in Fig. 3, a respondent that selects option A over option B and C prefers increased flood protection and higher tourist numbers over further increases in fish abundance or current levels ES delivery and lower payments.

Comparison of marginal utilities for each attribute level reflect relative preferences and can be used to compute rates of exchange between attributes, which is also done for the calculation of WTP values as explained in Equation (1) (see also Gibson et al., 2016, for instance), where β represents the coefficient (i.e. marginal utility) for the attribute or payment vehicle in question.

$$Marginal\ WTP_{Ecosystem\ service} = -1 * \frac{\beta_{Ecosystem\ service}}{\beta_{Payment\ vehicle}} \quad (1)$$

Before estimation of the RPL models we excluded so-called protest respondents, people that chose the No Management option in each of their choices for protesting reasons (as described in for instance Do & Bennett, 2008; Alemu et al., 2013; Meyerhoff et al., 2014; Diafas et al., 2017). We excluded ten respondents from the urban sample and nine from the rural sample. This is common

Table 2
Attributes and attribute levels for the both the urban and rural discrete choice experiments.

Attribute	Urban area			Rural area		
	# of levels	Levels	Opt-out level	# of levels	Levels	Opt-out level
Protection from storms and floods (in % reduction in damages)	4	50; 67; 83	0	4	50; 67; 83	0
Seafood abundance in the lagoon (in % increases in abundance)				4	10; 20; 30	0
Suitability for recreation and other activities (in changes of suitability level)	4	Low; medium; high	Very low			
Tourism (in number of tourists to the mangrove area per year)				4	500; 650; 800	350
(in percentage change)	4	5; 10; 15	0		–	–
Monthly contribution made by the household to a community fund (in VND per month)	5	20,000; 40,000; 80,000; 120,0000	0	5	25,000; 50,000; 75,000; 100,0000	0
Time spent on tending and cleaning the natural areas by the household (in days per month)	5	0.5; 1; 2; 3	0	5	1; 2; 3; 4	0

practice in the stated preference literature. The relatively low number of protesters indicates that the respondents generally hold a positive attitude towards the options in which management takes place. Those that were identified as protesters were so based on their answers to a follow-up question. These answers included that they felt no responsibility to take on the described tasks, did not feel that the measures would be effective or did not trust that others will also contribute.

The attributes were included in the RPL models as continuous variables. In the RPL models we allowed for heterogeneity in preferences across respondents. We assumed that the coefficients (i.e. utilities) for the attributes are triangularly distributed and we took 3,200 Halton draws from the distributions to estimate the mean and standard deviation of these coefficients. The values were restricted in the model to be positive for the seafood, recreation, and protection attributes since it was expected that people hold positive preferences towards increases in these ES. The values for tourism are not restricted since positive and negative preferences could be expected regarding increasing tourist numbers (e.g. positive due to greater economic opportunities, negative due to overcrowding). For the payment vehicles we estimated a fixed coefficient (i.e. utility level) by taking draws from the lognormal distribution and restricting the standard deviation to 0, in accordance to the latest standard to estimate WTP (Carson & Czajkowski, 2019). To obtain a 95% confidence interval of the WTP values, we applied Krinsky and Robb (1986) simulations. Overall this analysis approach is according to current modeling standards (Czajkowski & Budziński, 2019; Carson & Czajkowski, 2019) and similar to the approach in Hagedoorn et al. (2020). We thereafter continued to statistically compare the WTP results across both income groups and genders in each study site by applying Mann-Whitney U tests.

4. Results and discussion

4.1. Community characteristics

In the urban area, most respondents participated in jobs or small businesses (i.e. temporary shops or selling goods on the street). Men were relatively more active as laborers, civil servants or employees whereas women were more active in small businesses (Chi-square tests, p = 0.000, p = 0.000, p = 0.033, p = 0.000, respectively). Wages served as the most important income source, accounting on average for 55% of the household income. Turning to flood impacts, most of the households have experienced at least one flood (85%) and the average flood experience was eight events during the past ten years. Flood damage occurred at 47% of the households and affected the house and appliances. Regarding the respondents' relation to the ponds: the average distance between respondents' homes and the restored ponds was 18 meters, and 50% of the respondents visited the ponds at least once a week to cool down and enjoy the view.

In the rural area, the majority were fishers (70%). They mostly caught fish, shrimps and crabs and sold about 90% of their catch at the market. This is reflected in the income sources, as on average 54% of the household income came from fisheries in the lagoon. Women were commonly more active in small businesses whereas men were more active as fishers (Chi-square tests, p = 0.000, p = 0.000, respectively), although percentages for the latter were high among both genders (74% of men and 67% of women). Regarding flood impacts, 95% percent of the respondents have experienced at least one flood before, and the average flood experience equals one flood per year. About two thirds of the households have suffered from flood damage, which mostly affected boats, houses and appliances, and to a lesser extent the fish ponds.

4.2. Differences in vulnerability among social groups

In regard to the comparison of vulnerability across income groups, we found that lower income households are overall more vulnerable to floods in both the urban and rural areas (see Table B.1 and Table B.3 in Annex B for the detailed analyses). In terms of exposure, we find higher levels for the lower income households, although the identified differences were mostly insignificant. That these results are not significant can be explained by the relatively small geographical area that we surveyed that therefore included little variation in terms of exposure. The results for sensitivity were mostly significant and indicated that lower income households are more sensitive due to higher levels of natural resource dependency, more experienced flood impacts, higher experienced severity of floods, increased psychological burden, longer recovery rates, and due to the inhabitation of non-permanent dwellings. In terms of adaptive capacity we found differing results, being that lower income households' adaptive capacity is comparable to higher income households in terms of social factors but lower in terms of income diversity (see Annex B). Taking everything together the results confirmed that the lower income households in our sample are more vulnerable to floods compared to the higher income households, in compliance with identified vulnerabilities of the poor in the regional literature (e.g. De Silva & Kawasaki, 2018; Brouwer et al., 2007; Tran et al., 2008; Tran & Shaw, 2007; Razafindrabe et al., 2014; Pandey et al., 2018; Navrud et al., 2012; Mendoza et al., 2014).

The comparison of vulnerability measures across gender provided a slightly more nuanced picture. We again found little differences in terms of exposure, which is explained by the relatively small geographically surveyed area. More specifically, in the rural area we find no differences in exposure and in the urban area we find no differences in terms of perceived exposure but a slightly higher number of experienced flood events by men. For the measures covering sensitivity we found higher levels, although not significant, for women in both areas in terms of experienced severity of floods, psychological burden and recovery rates. The difference in mobility was significant in both areas and reflects that women take on more caretaker tasks in the wake of a flood, which was also identified in Mendoza et al. (2014)'s study in the same province. The studies of Hudson et al. (2019) and Hudson et al. (2021), which are based on the same data as used in this study showed that women experience longer flood recovery rates compared to men, supporting the notion that women in our sample have a higher sensitivity. In terms of adaptive capacity we found significantly lower levels of education and occupation diversity for women, and mixed results in terms of social factors. The fact that women partly show higher levels in terms of some of the social factors hints towards their importance and capacity to support community resilience. Most of these results comply with many previous studies who identified that women are more vulnerable than men (Neumayer & Plümper, 2007; Cutter, 2017; Klein et al., 2019; DKKV, 2019; GIZ et al., 2015; Jabeen, 2014; Ajibade et al., 2013; Jungehülsing 2012; Nelson et al., 2002; Neumayer & Plümper, 2007; Mason & Agan, 2015; Bubeck & Thieken 2018; Mendoza et al., 2014; Owusu et al., 2019). However, the identified differences were not unidirectional and were also not always significant. This means that more nuance is needed to understand women's vulnerability. For instance, Nong, Gan, & Hu (2020) identified negligible differences in vulnerability across male and female-headed households in northern Vietnam, but did for instance find differences in terms of access to agricultural services. Moreover, women are a heterogeneous group and differences in vulnerability may arise because of ethnic background, as was the case in Tinh and The (2013)'s study in the same province, or more general due to differences in age, participation in decision-making,

and household composition among others (e.g. Arora-Jonsson, 2011; Klasen et al., 2015; Djoudi et al., 2016).

4.3. Preferences for EbA benefits

We estimated 16 RPL models: two for the different income groups (below and above mean household income) and two for gender (female and male), for both the urban and rural samples as well as for both the monetary and non-monetary payments. The results of these analyses are included in Annex C. The DCE results were according to expectations and implied that the respondents preferred positive changes in ES and lower contributions.

The WTP values per payment vehicle, study area, ES and social group are presented in Figs. 4 to 7. The overview of the confidence intervals of the WTP values is included in Annex D. Mann-Whitney U tests show that the identified differences in WTP (i.e. preferences) across the social groups were significant except for two results (see Annex E). The first insignificant result was the difference in monetary WTP across the income groups for the urban tourism attribute (see Fig. 4). The second insignificant result was the difference in non-monetary WTP across the genders for the rural tourism attribute (see Fig. 7).

Figs. 4 and 5 present the results covering the differences in preferences across income groups. Focusing on the results for the non-monetary payment mode we find higher WTP for all ES for the lower income households. For the monetary payments we find similar results, except for the urban recreation and rural protection attributes, where WTP is higher for the higher income households. This difference in result across payment type suggests that lower income households can express their preferences more freely when asked for time contributions compared to money contributions. Overall, the poorer half of the community expresses higher WTP in 10 out of 12 cases, of which 9 present a significantly higher WTP value.

In our sample we identified higher levels of vulnerability for the lower income households compared to the higher income households, which supports these findings in the differences in preferences. For instance, lower income households are more dependent on natural resources for their income, explaining the higher preferences for the seafood attribute in the rural area. The identified higher levels of sensitivity to floods among lower income households may in turn explain the higher preferences for the protection attribute. Given the importance of fishing and resource extraction from the lagoon in the rural area, avoiding flood damage to fishing gear is especially important for the lower income households (Boonstra & Hanh, 2015). Both increases in seafood as well as increases in protection can result in poverty prevention by stabilizing or increasing income sources while preventing necessary repairs after floods. The link between poverty prevention and ES has also been discussed by Fisher et al. (2014) and shown by others (Angelsen & Wunder, 2003; Béné et al., 2010; Fisher, 2004; Reid & Alam, 2017). The results for the tourism attribute can be explained by the lower income diversity of lower income households in combination with the potential of poverty reduction via the creation of new cash earning opportunities as a result of increases in tourism numbers (Jha et al., 2017; Schuyt, 2005; Wang et al., 2009; Reid & Alam, 2017).

Figs. 6 and 7 present the results covering the differences in preferences across gender. For the urban area we identified higher WTP for women for the protection attribute under both payment modes, and for the recreation attribute under the non-monetary payment mode (see Fig. 6). Fig. 7 shows higher WTP for women for the ES in the rural area under both payment modes, except for the tourism attribute under the non-monetary payment mode. The difference in results for the urban recreation attribute depending on the selected payment mode seems to suggest that women are better able to state their full value when asked for time contributions. At the same time, recreation suitability could also be seen as a luxury good and therefore women might hold lower preferences to this attribute. Overall, women reveal higher WTP values in 8 out of 12 cases, all presenting significant differences.

As was the case with the results on the comparison of vulnerability across gender, the results for the differences in preferences across gender are more nuanced. There are however several links between the results on vulnerability and the identified differences in preferences for the EbA benefits, especially for the protection attribute, for which women systematically express higher preferences. Namely, from both our vulnerability analysis as well as from the analyses presented in Hudson et al. (2019) and Mendoza et al. (2014) and Hudson et al. (2021), we learn that women in the investigated areas are more sensitive to floods. The caretaker role of women is regularly mentioned in relation to this (e.g. Mendoza et al., 2014; Neumayer & Plümper, 2007; Ajibade et al., 2013; Jungehülsing, 2012), and in our sample women also take on more caretaker roles. The identified higher preferences of women for the protection attribute furthermore also add to previous studies that found that women prefer regulating services (Martín-López et al., 2012; Oteros-Rozas et al., 2014; Yang et al., 2018). The higher preferences of women for the seafood attribute in the rural area can be explained by the prominent role that women play in the on-shore fisheries sector. The higher preferences for the recreation attribute in the urban area can be linked to that women are commonly active in running small businesses such as cafes in the vicinity of the ponds that could benefit from increased recreationists around the ponds (DKKV, 2019). These results indicate the close relation between women's current livelihoods and their preferences for EbA, a relation that was also identified by Lien and Brown (2020) in a different province in Vietnam, and reflect the potential of EbA benefits to stimulate economic opportunities for women in Thừa Thiên-Hu province, a link that women strongly recognized in the study of Fortnam et al. (2019). On a different note, even though women were found to have less diversity in terms of occupations compared to men, women state lower preferences for the tourism attribute in 3 out of 4 cases, while increases in tourism could present new cash earning opportunities. Potentially this relates to our finding that women are currently less active in formal jobs such as those in tourism, which means that unless special focus is put on women's involvement, developing tourism is likely to benefit men more than women. Taken together, these findings show that the differences in preferences across genders for these attributes can be related to differences in gender-specific limitations and livelihoods (Yang et al., 2018; Fortnam et al., 2019).

Our results furthermore provide a subtle suggestion that the more vulnerable groups in society can express their preferences more freely when asked for non-monetary contributions. This is in line with argumentation provided in the stated preference literature that focuses on the comparison of time and money payment vehicles in developing countries (i.e. Navrud et al., 2012; Alam, 2006; Gibson et al., 2016). The fact that women fulfill multiple time-consuming caretaker tasks and that lower income households need to spend much of their time on resource extraction activities can explain the minimalized differences across the payment types. In support of this, we find that women and representatives of lower income households spend more time on unpaid work (i.e. housework and subsistence farming or fishing) as well as more time on work in total (Mann-Whitney U tests, p = 0.000, p = 0.000, p = 0.003, p = 0.001, respectively). This possibly also explains why Navrud et al. (2012), who conducted their study in a neighboring province, did not find evidence that WTP under the non-monetary payment mode is higher for households with a lower income or for women. They focused on valuing flood protec-

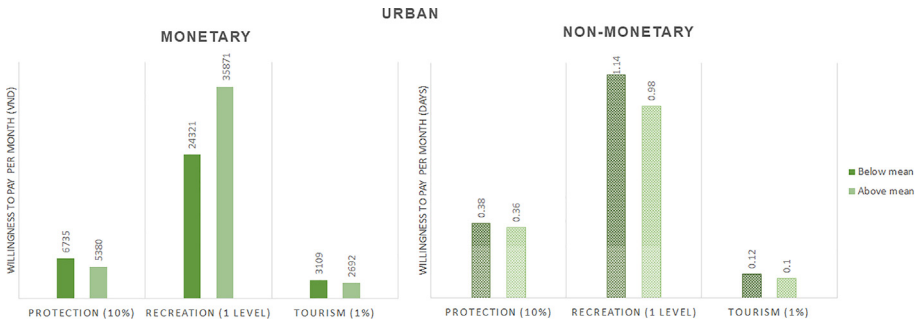

Fig. 4. Willingness to pay (WTP) values per ecosystem service across different income groups (below and above mean sample household income) for both payments in the urban area. Note: the WTP values for each ecosystem service differ significantly from each other across the income groups, except for the tourism attribute under the monetary payment mode (see Annex D).

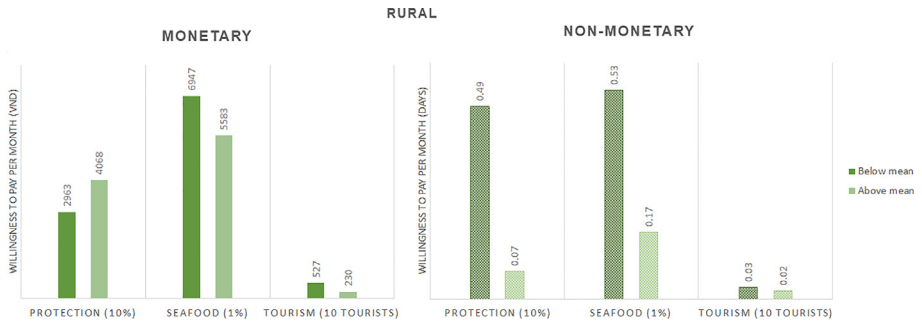

Fig. 5. Willingness to pay (WTP) values per ecosystem service across different income groups (below and above mean sample household income) for both payments in the rural area. Note: the WTP values for each ecosystem service differ significantly from each other across the income groups (see Annex D).

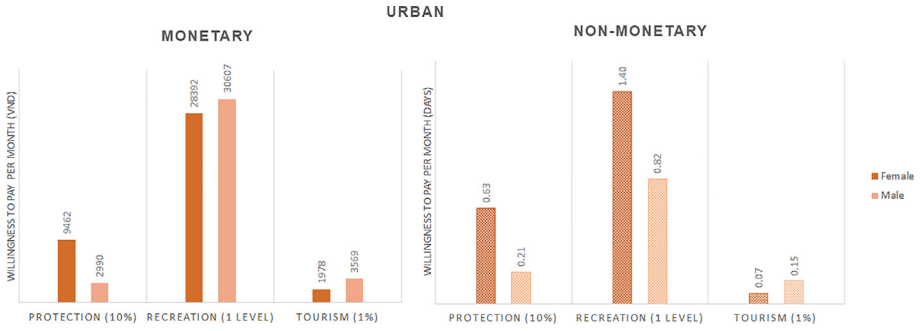

Fig. 6. Willingness to pay (WTP) values per ecosystem service across gender for both payments in the urban area. Note: the WTP values for each ecosystem service differ significantly from each other across the genders (see Annex D).

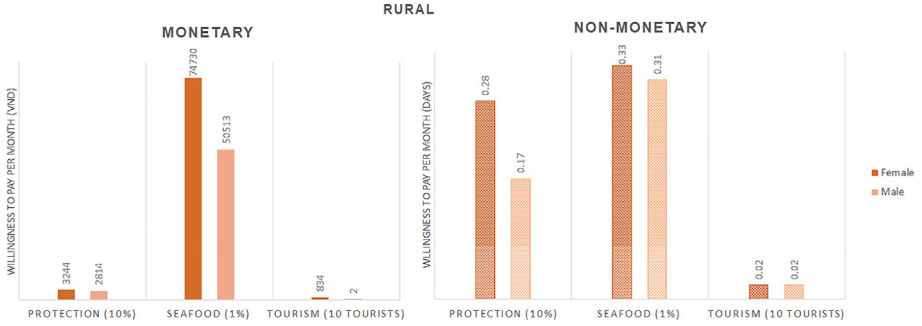

Fig. 7. Willingness to pay (WTP) values per ecosystem service across gender for both payments in the rural area. Note: the WTP values for each ecosystem service differ significantly from each other across the genders, except for the tourism attribute under the non-monetary payment mode (see Annex D).

tion only and did not specify the flood prevention program. These differences in valuation approach between our study and Navrud et al. (2012) could serve as another explanation on why they did not detect differences in WTP across social groups.

5. Conclusions and policy implications

5.1. Conclusions

In this study we identify that the poor and women are overall more vulnerable to floods and express higher preferences for flood protection and co-benefits of EbA as compared to their counterparts. The results for the different income groups are more pronounced than those for the gender differences. For the lower income groups we find consistently higher vulnerability levels as well as higher preferences for the EbA benefits. We used the mean household income as point of comparison since we were not able to use national or global poverty lines due to methodological constraints. The preferences of those under the poverty lines may however differ, especially since they are likely to face even tighter financial as well as time constraints. Future studies may focus on identifying differences across different measures and levels of poverty. For women the differences in vulnerability are less substantial and consistent, but can nonetheless be linked to differences in preferences for EbA benefits via relatively higher sensitivity and lower adaptive capacity to floods and current livelihood activities of women (i.e. fishing and small businesses). Future studies may want to investigate how the results on gender differ across women based on age, wealth and household composition, for instance, to account for the intersectional nature of vulnerability.

Additionally, our results suggest that to some extent the type of payment used in the DCE affects the results on preferences for EbA benefits. Using a non-monetary contribution seems to circumvent financial constraints and enable lower income households and women to express their preferences for EbA benefits more freely. The extent of this effect may be minimized by higher time spendings on subsistence and unpaid activities by the poor and women. Future studies that focus on eliciting preferences and values for ES and EbA projects in developing countries may however want to consider non-monetary payment vehicles next to monetary ones to avoid underestimation of values for financially constrained groups.

Overall, our results indicate that EbA has the potential to reduce vulnerability of the more vulnerable groups through poverty alleviation and gender empowerment. However, whether this will occur in reality will to a large extent depend on project design and management. To ensure that the benefits of EbA end up with those that need them the most it is likely that the project will need to put policies in place that focus on this specifically. Long-term monitoring and evaluation of EbA projects in terms of the distribution and effects of EbA benefits is of utmost importance to better understand how and to what extent poverty alleviation and gender empowerment can be achieved through EbA projects in the long-run. To further investigate this potential of EbA there is a need for longitudinal studies focusing on the socioeconomic effects of EbA.

5.2. Policy implications

Based on the evidence presented in this paper, we recommend the province of Thừa Thiên-Hu to increase its investments in EbA measures. Its (vulnerable) population evidently values the outcomes of these measures, and there will be opportunities for the province to reduce inequalities by supporting the livelihoods of lower income households and women. Large-scale restoration could furthermore counteract ongoing environmental degradation in the Tam Giang lagoon and could eventually benefit up to 100,000 people directly and contribute to the livelihoods of 300,000 people (Tuan et al., 2009; van Tuyen et al., 2010). We recommend integrating the EbA approach into traditional risk management practices, since it is likely that many EbA investments are most effective when combined with traditional measures (Jongman, 2018). For instance, the restoration activities for the urban ponds would be especially effective when combined with the installation of sluice gates (DKKV, 2019). Moreover, this study focused on the most important outcomes of the EbA measures in terms of ES and highlighted the importance of co-benefits, but more can be expected, such as improvements in health and sanitation (Nagano et al., 2014; Tran et al., 2008) and wellbeing effects (Hudson et al., 2019). The results of integrating EbA into existing risk management policies can lead to more holistic flood management strategies that benefit those who might otherwise be negatively affected.

More generally for developing countries situated within and outside of Asia, the results in this paper show that EbA can potentially support socioeconomic goals next to flood protection. However, our results are based on two study sites in Vietnam, and although they are situated within the wider Asian context, further studies are needed to confirm the identified patterns in different socioeconomic and cultural contexts. In case results prove to be comparable, developing countries may want to investigate the possibilities of integrating EbA measures in their plans to meet the SDGs and to comply with the Sendai Framework. A direct link to the Sendai Framework is to empower women as well as to build their capacity to secure alternate means of livelihood in post-disaster situations (UNISDR, 2015). Empowering women and securing the resources that they depend upon furthermore link to SDG 5 (gender equality). The described ability of the (co–) benefits of EbA to contribute to poverty alleviation means that EbA can potentially play a role in the achievement of SDG 1 (no poverty). Since EbA measures can support the social groups that are generally more vulnerable, and that are commonly affected by larger (but often necessary) structural measures, it also supports SDG 10 (reduced inequalities). Beyond the socio-economic effects of EbA, the measures can contribute to SDG 13 (climate action), 14 (life under water) and 15 (life on land) (IPBES, 2019).

It must be noted, however, that EbA measures often have the characteristics of public goods, which means that they are subject to issues related to the tragedy of the commons (Dietz et al., 2003). To avoid this, the management of the EbA measures should be carefully designed to address critical aspects commonly mentioned in the literature. These include, for instance, the creation of ownership by the community through an inclusive and participatory design process, ensuring that the project reflects the community's needs, utilizing a mix of institutional types, and the provision of direct benefits to the people (Dietz et al., 2003; van Tuyen et al., 2010; Hagedoorn et al., 2019; Klein et al., 2019; Ahammad et al., 2019). Accounting for the differences in preferences for EbA benefits as discussed in this study can be added to this. Many EbA projects have failed to do this (e.g. Saroar et al., 2019; Baig et al., 2015; Rizvi et al., 2015; Kaufmann et al., 2021), which can result in social conflicts (Saroar et al., 2019; Kaufmann et al., 2021). For instance, the study of Saroar et al. (2019) showed that an EbA project has increased ecosystem management but thereby created social conflict due to the lack of alternative livelihood options provided to those that suffered from the adjusted management practices. The Asian Development Bank (ADB) therefore advocates for active involvement of vulnerable groups to reorganize power dynamics and help address social inequalities (ADB, 2020). Identifying the preferences of different groups in society and taking these preferences into account in the design of EbA projects can serve as a first

step towards this goal. In addition, sites for EbA measures must be carefully assessed beforehand in terms of physical characteristics and suitability, to ensure the success of natural systems in providing flood protection and associated co-benefits.

Data availability statement: The survey dataset analyzed during the current study is available from the corresponding author on reasonable request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

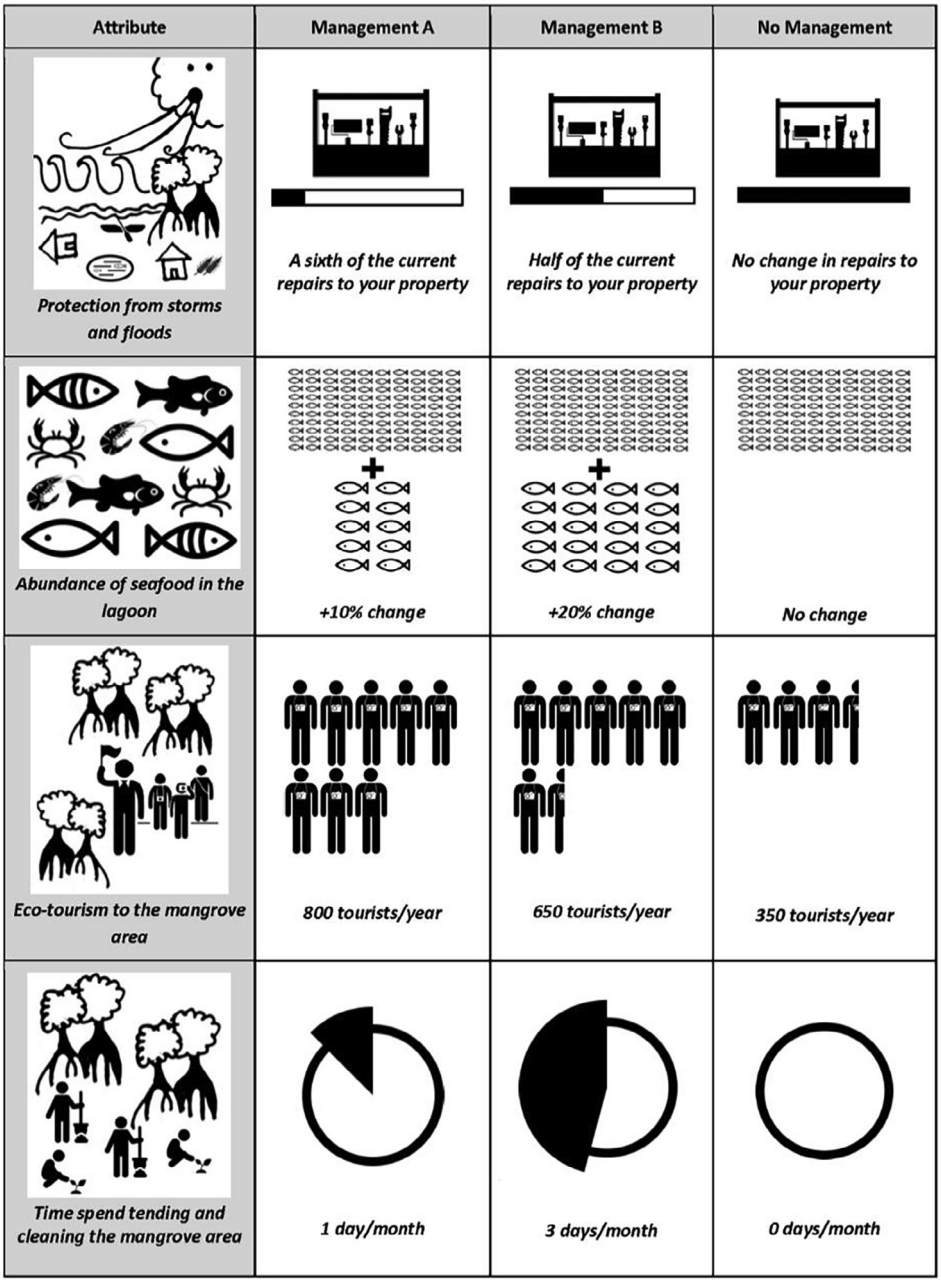


Fig. A1. Example choice card of the rural experiment with time payments.

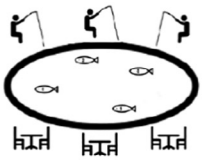
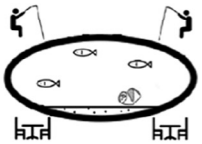
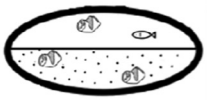
Attribute	Management A	Management B	No Management
Protection from storms and floods	 *A third of the current repairs to your property*	 *A sixth of the current repairs to your property*	 *No change in repairs to your property*
Suitability for recreation and other activities	 *High*	 *Medium*	 *Very low*
Tourism	 *+5%*	 *+15%*	 *No change*
Contribution to a community fund for pond maintenance	 *120.000 dong/month*	 *40.000 dong/month*	 *0 dong/month*

Fig. A2. Example choice card of the urban experiment with money payments.

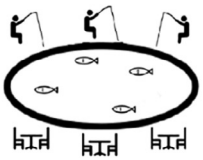
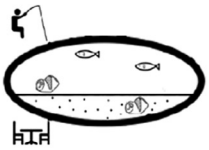
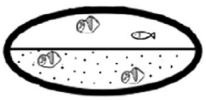
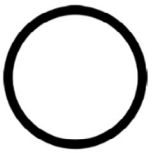
Attribute	Management A	Management B	No Management
Protection from storms and floods	 *A sixth of the current repairs to your property*	 *A third of the current repairs to your property*	 *No change in repairs to your property*
Suitability for recreation and other activities	 *High*	 *Low*	 *Very low*
Tourism	 *+10%*	 *+5%*	 *No change*
Time spend on tending and cleaning the ponds	 *3 days/month*	 *2 days/month*	 *0 days/month*

Fig. A3. Example choice card of the urban experiment with time payments.

Appendix B

Table B.1
Differences in vulnerability measures across income groups in the urban area. P-values are based on Mann-Whitney U tests or Chi-square tests, based on the type of variables as described in Table 1.

Variable	Below mean income	Above mean income	*p*-value
	Exposure		
Exposure flood	6.57	6.38	0.120
Exposure storm	7.13	6.95	0.213
Number of floods	7.77	7.79	0.067
	Sensitivity		
Natural resource dependency	0.03	0.02	0.488
Flood impact: damages	0.50	0.43	0.070
Flood impact: natural resource loss	0.34	0.19	0.000
Flood impact: evacuation	0.23	0.08	0.000
Severity of flood	6.65	6.47	0.240
Psychological burden	11.70	2.50	0.000
Recovery rate	7.04	6.92	0.332
Dwelling	0.89	0.93	0.073
	Adaptive capacity		
Social support	0.70	0.84	0.580
Social cohesion	6.43	6.34	0.313
Social involvement	0.44	0.33	0.014
Dependency ratio	0.56	0.58	0.003
Income diversity	0.75	1.03	0.000

Table B.2
Differences in vulnerability measures across gender in the urban area. P-values are based on Mann-Whitney U tests or Chi-square tests, based on the type of variables as described in Table 1.

Variable	Women	Men	*p*-value
	Exposure		
Exposure flood	6.63	6.32	0.218
Exposure storm	7.00	7.06	0.375
Number of floods	7.20	8.27	0.032
	Sensitivity		
Severity of flood	6.67	6.44	0.107
Psychological burden	8.15	5.53	0.372
Recovery rate	7.07	6.89	0.176
Mobility	3.49	3.23	0.096
	Adaptive capacity		
Education	3.48	4.37	0.000
Social support	0.63	0.89	0.054
Social cohesion	6.57	6.23	0.006
Social involvement	0.68	0.13	0.000
Occupation diversity	0.81	0.96	0.000

Table B.3
Differences in vulnerability measures across income groups in the rural area. P-values are based on Mann-Whitney U tests or Chi-square tests, based on the type of variables as described in Table 1.

Variable	Below mean income	Above mean income	*p*-value
	Exposure		
Exposure flood	6.54	6.50	0.733
Exposure storm	7.16	6.92	0.056
Number of floods	9.93	9.64	0.482
	Sensitivity		
Natural resource dependency	0.71	0.66	0.000
Flood impact: damages	0.74	0.65	0.018
Flood impact: natural resource loss	0.72	0.66	0.084
Flood impact: evacuation	0.55	0.45	0.016
Severity of flood	6.93	6.64	0.157
Psychological burden	4.10	3.19	0.000
Recovery rate	7.15	6.73	0.014
Dwelling	0.88	0.90	0.278
	Adaptive capacity		
Social support	1.50	1.48	0.879
Social cohesion	6.96	6.58	0.021
Social involvement	0.86	0.86	0.848
Dependency ratio	0.62	0.61	0.931
Income diversity	1.17	1.65	0.000

Table B.4
Differences in vulnerability measures across gender in the rural area. P-values are based on Mann-Whitney U tests or Chi-square tests, based on the type of variables as described in Table 1.

Variable	Women	Men	*p*-value
	Exposure		
Exposure flood	6.59	6.46	0.375
Exposure storm	7.03	7.06	0.967
Number of floods	9.73	9.82	0.812
	Sensitivity		
Severity of flood	6.84	6.74	0.339
Psychological burden	3.72	3.62	0.622
Recovery rate	6.99	6.92	0.571
Mobility	3.31	2.76	0.001
	Adaptive capacity		
Education	2.19	2.47	0.001
Social support	1.41	1.54	0.233
Social cohesion	6.82	6.74	0.646
Social involvement	0.95	0.79	0.001
Occupation diversity	1.18	1.39	0.002

Appendix C

Table C.1
Results of the RPL models for the monetary experiments on income differences.

	Urban area				Rural area			
	Below mean		*Above mean*		*Below mean*		*Above mean*	
Attribute	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
				Means of random parameters				
Protection from storms and floods	0.008***	0.062	0.005**	0.002	0.005	0.003	0.005	0.004
Recreation suitability	0.305***	0.035	0.304***	0.035	–	–	–	–
Seafood abundance	–	–	–	–	0.118***	0.006	0.066***	0.004
Tourism	0.039***	0.015	0.023**	0.011	0.001*	4.6E-04	2.7E-04	3.5E-04
Contribution to a community fund	−4.380***	0.062	−4.771***	0.097	−4.074***	0.080	−4.443***	0.113
ASC opt-out	−25.755**	10.425	−8.829***	3.195	−42.091***	14.372	−41.045*	21.634
				Standard deviations of random parameters				
Protection from storms and floods	0.008***	0.003	0.005**	0.002	0.005	0.003	0.005	0.004
Recreation suitability	0.305***	0.035	0.304***	0.035	–	–	–	–
Seafood abundance	–	–	–	–	0.118***	0.006	0.066***	0.004
Tourism	0.189***	0.039	0.134***	0.035	0.005***	0.001	0.002	0.003
Contribution to a community fund	0.0	–	0.0	–	0.0	–	0.0	–
ASC opt-out	29.575***	10.763	10.971***	3.809	50.623***	15.662	47.662**	22.477
				Model performance				
Observations	1170	1300		1350	1130			
N	117	130		135	113			
AIC	1630	2048		1651	1571			
Pseudo *R*-squared (adjusted)	0.37	0.29		0.45	0.37			
Log likelihood	−808	−1017		−819	−778			

Table C.2
Results of the RPL models for the non-monetary experiments on income differences.

	Urban area				Rural area			
	Below mean		*Above mean*		*Below mean*		*Above mean*	
Attribute	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
				Means of random parameters				
Protection from storms and floods	0.012***	0.002	0.014***	0.002	0.015***	0.002	0.002	0.003
Recreation suitability	0.360***	0.040	0.376***	0.037	–	–	–	–
Seafood abundance	–	–	–	–	0.160***	0.009	0.048***	0.003
Tourism	0.038***	0.011	0.039***	0.013	0.001**	4.2E-04	4.6E-04	3.1E-04
Time spent on tending and cleaning the natural areas	−1.154***	0.110	−0.956***	0094	−1.197***	0.113	−1251***	0.100
ASC opt-out	−43.373**	20.472	−11.062***	3.698	−121.525*	68.504	−21.068***	7.430
				Standard deviations of random parameters				
Protection from storms and floods	0.012***	0.002	0.014***	0.002	0.015***	0.002	0.002	0.003
Recreation suitability	0.360***	0.040	0.376***	0.037	–	–	–	–
Seafood abundance	–	–	–	–	0.160***	0.009	0.048***	0.003
Tourism	0.067	0.064	0.039***	0.013	0.003	0.002	2.3E-04	0.014
Time spent on tending and cleaning the natural areas	0.0	–	0.0	–	0.0	–	0.0	–
ASC opt-out	55.645**	24.106	14.941***	3.971	139.564*	77.653	23.560***	7.584
				Model performance				
Observations	1060	1420		1220	1260			
N	106	142		122	126			
AIC	1455	2102		1285	1812			
Pseudo *R*-squared (adjusted)	0.38	0.33		0.53	0.35			
Log likelihood	−721	−1044		−635	−899			

Table C.3
Results of the RPL models for the monetary experiments on gender differences.

	Urban area *Female*		*Male*		Rural area *Female*		*Male*	
Attribute	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
			Means of random parameters					
Protection from storms and floods	0.011***	0.002	0.003	0.002	0.006	0.004	0.004	0.003
Recreation suitability	0.325***	0.035	0.297***	0.036	–	–	–	–
Seafood abundance	–	–	–	–	0.130***	0.007	0.066***	0.004
Tourism	0.023*	0.013	0.035***	0.012	0.001***	4.5E-04	3.0E-07	3.7E-04
Contribution to a community fund	−4.469***	0.071	−4.637***	0.078	−4.053***	0.081	−4.337***	0.100
ASC opt-out	−17.906	7.056	−10.164***	3.245	−27.586***	9.389	−35.324**	13.961
			Standard deviations of random parameters					
Protection from storms and floods	0.011***	0.002	0.003	0.002	0.006	0.004	0.004	0.003
Recreation suitability	0.325***	0.035	0.297***	0.036	–	–	–	–
Seafood abundance	–	–	–	–	0.130***	0.007	0.066***	0.004
Tourism	0.166***	0.038	0.159***	0.035	0.002	0.003	0.004***	0.001
Contribution to a community fund	0.0	–	0.0	–	0.0	–	0.0	–
ASC opt-out	21.102***	7.462	12.592***	3.540	36.231***	10.653	41.386***	14.843
			Model performance					
Observations	1150	1320		1170	1310			
N	115	132		117	131			
AIC	1657	2028		1438	1772			
Pseudo *R*-squared (adjusted)	0.35	0.31		0.45	0.39			
Log likelihood	−821	−1007		−712	−879			

Table C.4
Results of the RPL models for the non-monetary experiments on gender differences.

	Urban area *Female*		*Male*		Rural area *Female*		*Male*	
Attribute	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
			Means of random parameters					
Protection from storms and floods	0.021***	0.002	0.008***	0.003	0.009***	0.003	0.005***	0.002
Recreation suitability	0.480***	0.045	0.296***	0.036	–	–	–	–
Seafood abundance	–	–	–	–	0.104***	0.006	0.092***	0.005
Tourism	0.023*	0.013	0.054***	0.013	0.001*	4.1E-04	0.001**	3.3E-04
Time spent on tending and cleaning the natural areas	−1.072***	0.117	−1.017***	0.090	−1.165***	0.107	−1.226***	0.102
ASC opt-out	−39.035**	17.638	−13.236***	4.289	−41.860**	16.694	−32.516**	13.858
			Standard deviations of random parameters					
Protection from storms and floods	0.021***	0.002	0.008***	0.003	0.009***	0.003	0.005**	0.002
Recreation suitability	0.480***	0.045	0.296***	0.036	–	–	–	–
Seafood abundance	–	–	–	–	0.104***	0.006	0.092***	0.005
Tourism	0.152***	0.043	0.211***	0030	0.004***	0.001	3.1E-04	0.013
Time spent on tending and cleaning the natural areas	0.0	–	0.0	–	0.0	–	0.0	–
ASC opt-out	50.750**	20.446	17.173***	4.563	51.178***	18.464	36.120**	14.114
			Model performance					
Observations	1100	1380		1050	1430			
N	110	138		105	143			
AIC	1493	2055		1317	1868			
Pseudo *R*-squared (adjusted)	0.39	0.33		0.44	0.41			
Log likelihood	−740	−1020		−652	−927			

Appendix D

Table D.1
Results of the Krinsky and Robb simulations for the monetary experiments on income differences in Vietnamese dong per household per month (1 USD ≈ 23,000 VN dong).

	Urban area *Income below mean*			Urban area *Income above mean*				Rural area *Income below mean*			Rural area *Income above mean*		
Attribute	WTP	95% confidence interval		WTP	95% confidence interval		Attribute	WTP	95% confidence interval		WTP	95% confidence interval	
Protection from storms and floods *Per 10% reduction in damages*	6,735***	2,806	10,664	5,380**	857	9,904	Protection from storms and floods *Per 10% reduction in damages*	2,963	−900	6,826	4,068	−1,833	9,969
Recreation suitability *Per increase in recreation level*	24,321***	19,145	29,498	35,871***	27,572	44,171	Seafood abundance in the lagoon *Per 1% increase in abundance*	6,947***	6,052	7,843	5,583***	4,529	6,636
Tourism to Hue city *Per 1% increase in tourism*	3,109***	808	5,411	2,692**	91	5,293	Tourism to the mangrove area *Per 10 extra tourists visiting each year*	527**	4	1,051	230	−389	849

Statistical significance: * 10%; ** 5%; *** 1%.

Table D.2
Results of the Krinsky and Robb simulations for the non-monetary experiments on income differences in days per month.

Attribute	Urban area *Income below mean*			Urban area *Income above mean*			Attribute	Rural area *Income below mean*			Rural area *Income above mean*		
	WTP	95% confidence interval		WTP	95% confidence interval			WTP	95% confidence interval		WTP	95% confidence interval	
Protection from storms and floods *Per 10% reduction in damages*	0.38***	0.24	0.53	0.36***	0.26	0.47	Protection from storms and floods *Per 10% reduction in damages*	0.49***	0.33	0.65	0.07	−0.12	0.26
Recreation suitability *Per increase in recreation level*	1.14***	0.89	1.39	0.98***	0.78	1.17	Seafood abundance in the lagoon *Per 1% increase in abundance*	0.53***	0.42	0.64	0.17***	0.14	0.20
Tourism to Hue city *Per 1% increase in tourism*	0.12***	0.05	0.19	0.10***	0.03	0.17	Tourism to the mangrove area *Per 10 extra tourists visiting each year*	0.03**	4.3E-03	0.06	0.02	−5.2E-03	0.04

Statistical significance: * 10%; ** 5%; *** 1%.

Table D.3
Results of the Krinsky and Robb simulations for the monetary experiments on gender differences in Vietnamese dong per household per month (1 USD ≈ 23,000 VN dong).

Attribute	Urban area *Female*			Urban area *Male*			Attribute	Rural area *Female*			Rural area *Male*		
	WTP	95% confidence interval		WTP	95% confidence interval			WTP	95% confidence interval		WTP	95% confidence interval	
Protection from storms and floods *Per 10% reduction in damages*	9,462***	5,745	13,179	2,990	−1,532	7,513	Protection from storms and floods *Per 10% reduction in damages*	3,244	−1,315	7,802	2,814	−1,786	7,415
Recreation suitability *Per increase in recreation level*	28,392***	22,779	34,006	30,607***	23,509	37,706	Seafood abundance in the lagoon *Per 1% increase in abundance*	7,473***	6,451	8,495	5,015***	4,226	5,877
Tourism to Hue city *Per 1% increase in tourism*	1,979*	−360	4,318	3,570***	1,098	6,042	Tourism to the mangrove area *Per 10 extra tourists visiting each year*	834***	343	1,325	2E-05	−6E-01	6E01

Statistical significance: * 10%; ** 5%; *** 1%.

Table D.4
Results of the Krinsky and Robb simulations for the non-monetary experiments on gender differences in days per month.

Attribute	Urban area *Female*			Urban area *Male*			Attribute	Rural area *Female*			Rural area *Male*		
	WTP	95% confidence interval		WTP	95% confidence interval			WTP	95% confidence interval		WTP	95% confidence interval	
Protection from storms and floods *Per 10% reduction in damages*	0.63***	0.48	0.77	0.21***	0.08	0.35	Protection from storms and floods *Per 10% reduction in damages*	0.28***	0.11	0.45	0.17**	0.01	0.32
Recreation suitability *Per increase in recreation level*	1.40***	1.13	1.67	0.82***	0.63	1.01	Seafood abundance in the lagoon *Per 1% increase in abundance*	0.33***	0.27	0.40	0.31***	0.26	0.37
Tourism to Hue city *Per 1% increase in tourism*	0.07*	−0.01	0.14	0.15***	0.08	0.22	Tourism to the mangrove area *Per 10 extra tourists visiting each year*	2.16E-03	−0.01	0.05	2.44E-03**	2.7E-03	0.05

Statistical significance: * 10%; ** 5%; *** 1%.

Appendix E

Table E.1
Results of the Mann-Whitney U tests on the significance of the differences in preferences in the urban area.

	Monetary experiments		Non-monetary experiments	
	Below mean – above mean	*Female - male*	*Below mean – above mean*	*Female - male*
Attribute	*p*-value	*p*-value	*p*-value	*p*-value
Protection from storms and floods	0.000	0.000	0.000	0.000
Recreation suitability	0.000	0.000	0.000	0.000
ourism to Hue city	0.824	0.001	0.012	0.000

Table E.2
Results of the Mann-Whitney U tests on the significance of the differences in preferences in the rural area.

	Monetary experiments		Non-monetary experiments	
	Below mean – above mean	*Female - male*	*Below mean – above mean*	*Female - male*
Attribute	*p*-value	*p*-value	*p*-value	*p*-value
rotection from storms and floods	0.000	0.000	0.000	0.000
Seafood abundance in the lagoon	0.008	0.000	0.000	0.045
Tourism to the mangrove area	0.000	0.000	0.000	0.161

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