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A quantitative analysis of public preferences for the wild boar management in urban and rural China

Xue-Hong Zhou^a, Wei Zhang^a, Dong-Yan Tang^a, Zhen Miao^a, Qiang Wang^{b,*}, Douglas C. MacMillan^c

^a College of Wildlife and Protected Area, Northeast Forestry University, Harbin, Heilongjiang Province 150040, China

^b Key Laboratory of Wetland Ecology and Environment, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, Changchun, Jilin Province 130102, China

^c Durrell Institute of Conservation and Ecology (DICE), University of Kent, Canterbury, Kent CT2 7NR, UK

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ABSTRACT

Human-wildlife conflict is rapidly evolving in response to significant ecological, social, and economic changes affecting society globally. Developing objective and acceptable resolution strategies is challenging because of divergence in perceptions and understandings of human-wildlife conflict between urban and rural populations, and this disparity is increasing with rapid urbanization. In this study, we explore preferences for wild boar conflict management in China using a mixed methods approach of a survey, choice experiments, and interviews. We found that significant differences in the preferences of wild boar management exist between rural and urban residents. The majority of rural residents preferred hunting whereas most urban residents in cities remote from the conflict preferred non-hunting measures. However, we found that economic cost played an important role in influencing public preferences for management measures. The urban population had positive preferences for hunting if they were required to pay an environmental tax to compensate farmers for crop damage when asked to consider their preferred management strategy package. We consider that the current management of hunting wild boar in China requires improvement, and we argue that China should adjust the current hunting management policy to take into account the benefits of wild boar population control and the economic development of the surrounding rural areas.

1. Introduction

Human-Wildlife Conflict (HWC) is a major conservation issue and is especially associated with large mammals (Jordan et al., 2020; König et al., 2020). Impacts such as crop damage, livestock predation, disease transmission, and attacks on humans (Inskip et al., 2013; Kansky and Knight, 2014) can place managerial and financial burdens on conservation organizations, and in recent years social media has introduced new perspectives and challenges from a burgeoning groups of youthful, urban-based bloggers and activists (Song et al., 2021) who are influencing the views and attitudes of the urban public about human-wildlife conflict in particular. Research regarding diverging views between rural and urban populations is therefore urgently required to understand long-term implications for

* Correspondence to: No. 138, Haping Road, Nangang District, Harbin, Heilongjiang 150081, China.

E-mail addresses: xuehong_zhou2012@nefu.edu.cn (X.-H. Zhou), zwfur@nefu.edu.cn (W. Zhang), dongyan_tang2017@163.com (D.-Y. Tang), miaozhen43566@163.com (Z. Miao), wangqiang_1978@126.com (Q. Wang), dun685@gmail.com (D.C. MacMillan).

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conservation management and to help formulate the effective implementation of inclusive conflict management strategies (König et al., 2020).

In this paper, we explore the attitudes and preferences for wild boar (*Sus scrofa*) management in China using a public survey incorporating a choice experiment. Wild boar is one of the most widely distributed large mammals in the world that comes into direct conflict with humans (Lombardini et al., 2017; Stillfried et al., 2017). In the past few decades, the distribution and number of wild boars have increased dramatically worldwide, due to their high reproduction capacity, rising food availability, reforestation, reduction in the number of natural enemies, and in some cases, their reintroduction for hunting purposes (Watkins et al., 2018). The cost of managing these booming wild boar populations is increasing rapidly as are their many negative effects on the ecosystem, farmers' livelihoods, and human health (Frank et al., 2015; Lombardini et al., 2017) including China (Li et al., 2010).

In China wild boar has been designated as a nationally protected species of "important ecological, scientific, and social value" since 2000. Since then, unsanctioned private hunting of wild boar has been prohibited in China and the population of wild boar is expanding rapidly (Li et al., 2010). Conflicts between wild boars and humans have various manifestations in China. The most common types of conflict include the destruction of crops (which occurs all year round and is the most serious in autumn) and the injury of livestock. Additionally, in some areas where wild boar populations are high, there is an increased frequency of wild boars entering villages or suburbs of cities, with a number of injuries to people and damage to property. For example, in May 2021, a village party secretary in Litang County, Ganzi Prefecture, Sichuan Province was attacked and killed by wild boar during a fire patrol (The Shanxi Evening News, 2021).

The economic costs of wild boar damage are significant and rising in many provinces in China. For example, in Hunchun City, Jilin Province, a total of 1076 wild boar hazard incidents occurred from 2012 to 2013, affecting an area of 518.83 ha, and the provincial government paid compensation of 3.6322 million yuan (roughly \$57,000 in 2021 exchange rates, the same below) to local farmers (Hello Science Popularization, 2021). In Sichuan Province, a total of 7000 to 8000 wild boar hazard incidents are reported every year, and the losses caused by the destruction of crops are about 215 million yuan (Yu, 2022). These damage estimates are likely to be underestimated as damage may not be reported through official channels.

Several schemes to mitigate the conflict between wild boars and humans have been implemented in China. In the past two decades, as wild boars are protected animals, the damage has been managed via non-lethal measures such as setting up of physical barriers (eg. fences and palisades), changes to the agronomic system, wild boar relocation, supplementary feeding, and sterilization (Zhang, 2015). These measures have been generally inadequate as the boar are quick to adapt and respond (Bobek et al., 2017) and the losses caused by wild boars in China are still increasing year on year. Therefore, in recent years, the Chinese government has begun to allow local governments to hunt wild boar populations to a limited extent by forming hunting organizations according to the damage inflicted in the wild boar range. Some provinces in China, such as Zhejiang, Jiangxi, Anhui, and Hubei, have launched wild boar hunting campaigns since 2006. However, hunting is strictly managed by local wildlife conservation authorities and subject to strict hunting quota limits. Also, due to long-standing politically contentious reasons (Zhou et al., 2021), hunting in these areas is more effective than previous non-lethal measures, but this has failed to effectively solve the problem.

To change this situation, in November 2021, based on the existing policies on wild boar management, the State Forestry and Grassland Administration (SFGA) of China permitted 14 provinces with serious human-wild boar conflicts, including "Shanxi, Sichuan, Fujian, Jiangxi, Hebei, Guangdong, Shaanxi, Hunan, Hubei, Liaoning, Heilongjiang, Zhejiang, Anhui and Ningxia", to establish comprehensive pilot projects for the prevention and control of wild boar hazards. These projects involve the establishment of professional teams to implement wild boar hunting and control, while commercial hunting is not allowed.

To date, nearly all research on public attitudes has focused solely on evaluating the preferences of farmers or the public for wild boar management and has been conducted mainly in western nations. For example, Caplenor et al. (2017) and Watkins et al. (2019) assessed the degree of support for wild boar management programs by landowners in Tennessee, USA, indicating that the provision of technical assistance for damage control and incentive-based capture programs were the most supported management strategies (Caplenor et al., 2017; Watkins et al., 2019). Conejero (2018) assessed the Spanish public's preference for boar management strategies and found that helping boars return to their habitat was the most popular management strategy, while culling was the least acceptable (Conejero et al., 2018). In addition, there are also a small number of studies that have used in-person interviews to compare the attitudes of different stakeholders. For example, Frank et al. (2015) conducted research on the opinions of the Italian public, hunters, and farmers on wild boar management programs and found that the public and hunters were most supportive of preventive measures and compensation plans, while farmers supported all management tools that could mitigate boar damage (Frank et al., 2015). Geeraerts et al. (2021) studied the attitudes of Belgian farmers, hunters, and wildlife managers towards boar management measures and found that wildlife managers were most supportive of prevention, hunters were most supportive of hunting, and farmers supported all damage reduction measures except prevention (Geeraerts et al., 2021).

The conflict with boar in developing countries is under-researched and less well-understood. In this study, we present a mixed-method approach to explore preferences in China, a nation with rapid urbanization, for alternative wild boar management strategies. Specifically, we compare and contrast the preferences of rural residents (in areas where human-wild boar conflicts are complex and acute) with urban residents. The latter group, though largely unaffected by wild boars, has become increasingly influential in policy-making in China due to urbanization, the widespread promotion of animal rights in social media, and a higher degree of interest in conservation management and policy (Zhou et al., 2021). By contrast, rural populations, as a result of outward migration and the growth of corporate agriculture, are increasingly vulnerable and are losing political influence (Niedziałkowski and Putkowska-Smoter, 2020). Therefore, our overall aim is to contribute to developing an inclusive and comprehensive strategy in the context of changes in China's wild boar management policies, which accurately can mitigate the various costs associated with wild boars and show sustainability in financial terms. One particular focus is on how to accommodate within a strategy the divergence between urban and rural

populations that take account of their individual and group socio-economic characteristics and belief systems (Hiller and MacMillan, 2021).

2. Material and methods

Our research uses a semi-structured questionnaire combined with a choice experiment survey, intending to provide information to policymakers about mitigating human-wildlife conflict in heterogeneous societies with different experiential understandings, economic, legal, cultural, and educational backgrounds.

2.1. Study population

Studies have shown that geographic and cultural distance from the location of human-wildlife shape people's attitudes and views towards the issue, as an important factor influencing public preference for wildlife management strategies (Liu et al., 2011; Conejero et al., 2019). We, therefore, based our sampling strategy on 'distance' from the human-wild boar conflict in spatial and wider economic, legal, cultural, and educational 'distance'.

We selected 4 locations as our research sites (Fig. 1). The first is rural Wuyuan, Shangrao City, Jiangxi Province, where the wild boar and human conflict occurred and is one of the areas most severely affected by wild boar populations in China. Wuyuan is located in the northeastern part of Jiangxi Province, and the terrain is mainly mountains and hills. Wuyuan is rich in natural resources, with a total of 457 species of vertebrates and 3500 species of higher plants, and the forest coverage rate of Wuyuan reached 82.64% in 2019. Wuyuan is also an excellent habitat for wild boars. According to reports, in rural areas of Wuyuan, more than 400 acres of farmland were destroyed by wild boars in 2017–2019, and the economic losses caused by wild boars to local farmers accounted for more than 40% of their average annual income (Tencent news, 2021).

At present, in addition to the urban area of Wuyuan County, Wuyuan has jurisdiction over 16 townships (towns) and 197 villages. By the end of 2019, the rural population of Wuyuan was about 172574, with an average per capita disposable income (PCDI) of 14304 yuan (\$2240.9) in 2019, which is somewhat lower than the overall average PCDI of 16021 yuan (\$2510.0) for rural residents and 42359 yuan (\$6636.2) for urban residents in China. The rural areas of Wuyuan have experienced complicated changes in wild boar management policies, and the conflict between wild boar and people in the area is complex and acute. Before 2006, the local government of Wuyuan allowed rural residents to use only non-lethal measures to prevent and control the damage caused by wild boars. Since 2006, the rural areas of Wuyuan have initiated limited hunting operations, and the local government has set up a hunting agency

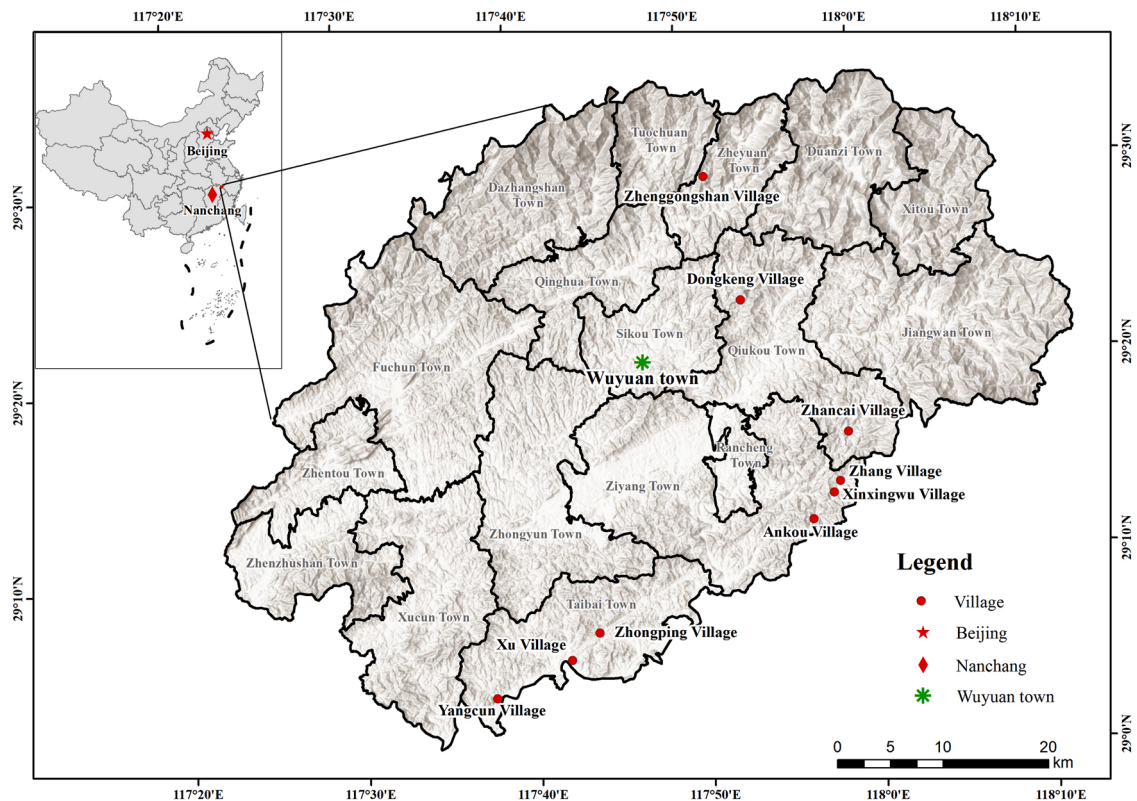


Fig. 1. Location map of the study areas.

to protect crops from wild boars. In late 2021, Jiangxi Province, where Wuyuan is located, was further designated by the Chinese government as a pilot province for wild boar hunting.

The second location is urban Wuyuan, which is in relatively close proximity to the boar-human conflict sites, with an average distance of 32 km from the rural areas of Wuyuan. Few urban residents in Wuyuan have directly experienced the conflict between wild boars and human, but Wuyuan residents have learned about the conflict through relatives, friends, TV, the Internet, and other ways. Urban Wuyuan is the political, economic, cultural, and financial center of the area, with a relatively concentrated population of about 173635, accounting for 50.2% of the total population in the Wuyuan area. In 2019, the regional GDP of Wuyuan County was 13.15 billion yuan, up 8.6% from the previous year, and the PCIDI of the urban population was 28330 yuan (\$4438.4).

The cities of Nanchang and Beijing were the remaining survey locations. Both are further away from areas of conflict, which are 260 km and 1391 km away from the rural area of Wuyuan, respectively. The residents in Nanchang and Beijing mainly obtain information about the conflict from the Internet. Nanchang is the capital and the most developed city in Jiangxi Province, with a current population of about 6.25 million. In 2019, the regional GDP of Nanchang was 5596.18 billion yuan, up 8% over the previous year, and its PCIDI was 44136 yuan (\$6914.6). The fourth location is Beijing. Beijing is the capital and the most developed city in China, with a current population of approximately 21.89 million. In 2019, the regional GDP of Beijing was 35371.3 billion yuan, up 6.1% from 2018, and its PCIDI was 67756 yuan (\$10615.1). This selection, therefore, allows us to compare preferences for wild boar management across a spectrum of economic, cultural, and educational backgrounds as well as experiential understandings.

2.2. Survey design

Two questionnaires were designed: one for rural residents and another for urban residents (Part III in the [supplementary materials](#)). The questionnaires consisted of five parts. The first part was the introduction, which briefly introduced some basic information about wild boars in China, such as distribution, protection status, the causes of population growth, the forms of harm caused by wild boar (such as possible damage to crops, livestock, and human casualties), as well as the main control measures for wild boar hazards, during which the purpose and salience of our research had been stressed. In the second part, we collected information about the basic personal characteristics of respondents, including gender, the number of family members, age, education level, occupation, receipt of subsistence allowances (rural residents only), and annual income (rural areas) / monthly income (urban areas), etc.

In the third part, based on the Likert five-point scoring scale, we set six questions to explore respondents' attitudes and views on wild boar conservation and management. Specifically, we divided the six questions into three aspects: "Degree of damage: respondents' perceptions towards consequences of wild boar-human conflict", "Degree of tolerance: respondents' tolerance to the wild boar and its abundance", and "Control measures: respondents' attitudes towards wild boar management and population control" (see Table A2 for specific questions). In this section, we also added questions about the wild boar control measures adopted by rural residents in the past three years. To gain further insight into the current situation regarding wild boar hunting, we also conducted interviews with the hunting agency staff and members in the Wuyuan area (Part I in [supplementary materials](#)).

The fourth and fifth sections of the questionnaire mainly explored respondents' preferences for wild boar control strategy. We asked about respondents' preferences for alternative wild boar control strategies in the fourth section, divided into hunting and the following non-hunting measures: physical obstacles; interference measures; changes in agronomy; biological control; immigration and relocation; compensation for loss, and others. In the fifth section, we focused on the choice experiment (Table 1). The design in the choice experiment is particularly significant because the attributes and levels of the researcher selection directly affect the parameter estimate of the model. In this study, we set the attributes and levels of choice experiment which are the key aspects of the conflict, namely: "Control time of wild boar population (Whether have swine fever)", "Control range of wild boar population (Scope of control measures)", "Control method of wild boar population (Hunting or not)" and "Control target of wild boar population (Population expectation)" guided by the relevant literature and experts. In addition, during the 2019 National People's Congress in China (an important meeting for China to decide key national issues, including formulating and amending laws and electing a president, etc), some

Table 1
Attributes and their levels in the choice experiment.

| Attribute (abbreviation) | Level (the value assignment of each level in processing data) |
|--|---|
| Control time of wild boar population (Whether have swine fever) | Outbreak period of African swine fever (value=0) Non outbreak period of African swine fever (value=1) |
| Control range of wild boar population (Scope of control measures) | Nationwide (value=0) Specific areas(value=1) |
| Control method of wild boar population (Hunting or not) | Non-hunting measures such as habitat protection + sterilization (high cost) (value=0) Managed hunting(value=1) |
| Control target of wild boar population (Population expectation) | Reduce from current population level(value=0) Remain unchanged from current population level(value=1) Increase from current population level(value=2) |
| Amount of tax per taxpayer required by the measures (Environmental protection tax) | 1 yuan/person annually(value=1) 2 yuan/person annually(value=2) 5 yuan/person annually(value=5) 10 yuan/person annually(value=10) 20 yuan/person annually(value=20) |

representatives proposed to collect environmental taxes on the public. In contrast to the traditional policy of the Chinese government, which fully bears the cost of wildlife conservation and management, this proposed policy may influence the public's attitude and perception of management measures. Therefore, based on this policy background, we added the attribute of environmental tax and set different amount levels to explore the potential trade-off between the tax cost to respondents and species management scenarios (as described by the attributes) under different amounts of environmental tax. However, we only applied Section 5 to urban residents, because urban residents in China are realistically the main potential taxpayers who can afford such a tax, and the environmental taxes paid by them are the source of compensation for the human-wild boar conflict. In contrast, the farmers are the direct victims of the human-boar conflict and should be compensated rather than taxed for it.

We used the orthogonal design to combine the attributes and levels in Table 1 and created 25 choice cards after deleting meaningless or obviously unreasonable combinations, and in this way, reduced the number of realistic combinations from an initial 120 (Yu et al., 2019; Han and Youn, 2020). To reduce the time and cognitive burden facing respondents, we asked them to make choices based on 8 choice sets chosen randomly from the 25 possible sets (Tan et al., 2018; Wang et al., 2021). Respondents chose one of their preferred measures (Plan A or Plan B) or neither for each choice set. In this way, each choice made provided information about their overall preferences for each attribute of the plan.

After the questionnaire was designed, we conducted pre-surveys with experts and various stakeholders, including wildlife managers, urban residents, and local farmers, and then made clear some expressions in the questionnaire to ensure that the questions in the questionnaires were realistic, fully understood, and accepted by the respondents, as well as reduce the ambiguity of the questions.

2.3. Survey implementation

From November 2019 to January 2020, the first round of data collection was conducted via face-to-face interviews in rural and urban areas of Wuyuan. Respondents from rural areas were randomly chosen from villages that had suffered wild boar damage based on discussions with the relevant staff from the Department of Wildlife Conservation (Fig. 1). In Wuyuan town, under the recommendation of the wildlife managers, we collected questionnaires in the urban zone where the population was more concentrated. During these investigations, we required each interviewer to clearly inform the interviewees of what each question related to, for example, that hunting refers to legally permitted hunting carried out by the hunting agency and not unsanctioned private illegal hunting.

In Nanchang and Beijing, we collected data online. We did this because the online community in the big cities of China can influence national wildlife management policies (Wu et al., 2018; Zhou et al., 2020). For example, in 2005 and 2011, the auction of hunting quotas for wild animals in China caused great social controversy and online debate, which ultimately led to the suspension of trophy hunting in China (Zhou et al., 2020). Therefore, from July to September 2020, we conducted a survey in Nanchang and Beijing on the App of "Questionnaire Star". We spread the questions of the "Questionnaire Star" to the public through the WeChat platform, and the groups interviewed in different cities depend on the degree of interest of people of different ages, genders and other characteristics about the conflict between human and wild boars.

2.4. Data analysis

All data were input into Excel, and statistical tests were carried out in SPSS 26.0 and NLOGIT 4.0. The Kruskal-Wallis H test was applied to analyze whether there were statistically significant differences in six attitudinal questions among respondents in different areas. In the Kruskal-Wallis H test, the Test Field selects six attitude questions from this study, and the Groups select areas. Since the Kruskal-Wallis H test can only represent significant differences in six attitudinal questions between at least two of the four areas, it does not reveal which two areas are significantly different. Therefore, we continue to use the Dunn nonparametric comparison method to compare the attitudes that show significance in the Kruskal-Wallis H test between different areas and use the Bonferroni method to adjust the P value to improve the accuracy of the model. The chi-square test was applied to analyze whether there were significant differences in the preferences of respondents in different areas in using hunting or no-hunting methods to control wild boar populations. Multinomial Logistic Regression (MNL) in NLOGIT 4.0 was applied to estimate respondents' overall preference for wild boar management policies from the Choice Experiment. In multiple logistic regression, the respondent's choice of the card is regarded as the dependent variable, and the five attribute values of the choice experiment are selected as independent variables to build the model. As differences between subgroups might be important when analyzing issues such as wildlife conservation and management policies, we also used the latent classification model (LCM) to learn the potential heterogeneity in subgroups in the choice of preferences (Zhou et al., 2021). The LCM is a logistic regression method based on the standard random utility model, which divided the sample population into two or more than two more homogeneous classes to explore the heterogeneity of preferences (Veríssimo, 2014). In the LCM, the optimal classification number was determined by balancing Akaike Information Criterion (AIC) and Bayes Information Criterion (BIC).

2.5. Ethical statement

All interviewees and potential candidates were anonymized and gave their informed consent for inclusion before they participated in the study. The investigators assured them that all the information provided would be kept strictly confidential to ensure their privacy. The study was approved by the Ethics Committee of Northeast Forestry University (Project identification code: 2021034).

3. Results

In sum, we distributed 438 questionnaires offline, and received 438 questionnaires, of which 434 were valid (effective rate 99.08%). Also, a total of 3413 questionnaires were distributed online, and 1567 questionnaires were collected, of which 1258 were valid (effective rate 80.28%). The distribution and recovery of questionnaires in the four areas are shown in Table 2, and the demographic data of the respondents in the four areas are shown in Table A3.

3.1. Comparison of cognition and attitude of urban and rural residents toward wild boar management

Respondents in the four areas agreed that in the absence of natural enemies such as tigers and wolves, reproducing wild boars above an environmentally sustainable level would destroy the ecological balance (Fig. 2). However, there was also a significant statistical difference between urban respondents in Wuyuan town and respondents in the other three areas, as urban respondents in Wuyuan were less supportive of this view (Table A5, $P_{(\text{Wuyuan rural areas vs Wuyuan towns})} < 0.01$, $P_{(\text{Wuyuan towns vs Nanchang})} < 0.001$, $P_{(\text{Wuyuan towns vs Beijing})} < 0.001$). Respondents in the four areas all believed that the destruction of crops and livestock by wild boars would harm the rural economy (Fig. 2). There was a significant statistical difference between respondents of rural and urban respondents of Wuyuan and city populations in Nanchang and Beijing, with the former more supportive (Table A5, $P_{(\text{Wuyuan rural areas vs Wuyuan towns})} < 0.001$, $P_{(\text{Wuyuan rural areas vs Nanchang})} < 0.001$, $P_{(\text{Wuyuan rural areas vs Beijing})} < 0.001$, $P_{(\text{Wuyuan towns vs Nanchang})} < 0.001$, $P_{(\text{Wuyuan towns vs Beijing})} < 0.001$).

In terms of “How much do you think the population of wild boar should change from its current level?”, respondents in the four areas all agreed that the wild boar population should decrease (Fig. 2). There was a significant statistical difference between respondents in rural Wuyuan and respondents in the other three areas (Table A5, $P_{(\text{Wuyuan rural areas vs Wuyuan towns})} < 0.001$, $P_{(\text{Wuyuan rural areas vs Nanchang})} < 0.001$, $P_{(\text{Wuyuan rural areas vs Beijing})} < 0.001$), with rural respondents in Wuyuan expecting a more significant reduction of wild boars. For example, 88% of them hoped that the current wild boar population would be reduced by as much as 50%; in comparison, urban respondents were less desirous for this change (33%, 13%, and 13% of respondents in Wuyuan towns, Nanchang and Beijing respectively)(Fig. 3).

On the issue of artificially controlling wild boar populations to reduce the spread of African swine fever in wild boars and domestic pigs, respondents in the four areas were all supportive of this view (Fig. 2). However, there were significant statistical differences in attitudes between rural and urban respondents in Wuyuan and respondents in Nanchang and Beijing, respectively, with respondents in Wuyuan less supportive of this view than those in Nanchang and Beijing (Table A5, $P_{(\text{Wuyuan rural areas vs Nanchang})} < 0.001$, $P_{(\text{Wuyuan rural areas vs Beijing})} < 0.001$, $P_{(\text{Wuyuan towns vs Nanchang})} < 0.001$, $P_{(\text{Wuyuan towns vs Beijing})} < 0.001$). All respondents agreed that scientific methods (including hunting and non-hunting measures) should be taken to manage and control wild boar numbers even despite it being a nationally protected species (Fig. 2). Also, there was a significant statistical difference among the respondents in Wuyuan and respondents in Nanchang and Beijing, among which the respondents in Wuyuan were more supportive of controlling the wild boar population than those in Nanchang and Beijing (Table A5, $P_{(\text{Wuyuan rural areas vs Nanchang})} < 0.001$, $P_{(\text{Wuyuan rural areas vs Beijing})} < 0.001$, $P_{(\text{Wuyuan towns vs Nanchang})} < 0.001$, $P_{(\text{Wuyuan towns vs Beijing})} < 0.05$, $P_{(\text{Nanchang vs Beijing})} < 0.01$).

Respondents in the four areas also differed significantly in their attitudes towards hunting as a way to control wildlife numbers (Table A5, $P_{(\text{Wuyuan rural areas vs Wuyuan towns})} < 0.01$, $P_{(\text{Wuyuan rural areas vs Nanchang})} < 0.001$, $P_{(\text{Wuyuan rural areas vs Beijing})} < 0.001$, $P_{(\text{Wuyuan towns vs Nanchang})} < 0.001$, $P_{(\text{Wuyuan towns vs Beijing})} < 0.001$, $P_{(\text{Nanchang vs Beijing})} < 0.01$), where respondents in Wuyuan were more optimistic about this view, while those in Nanchang and Beijing were neutral (Fig. 2). We further asked respondents specifically if they preferred hunting or no-hunting methods to control wild boars (Fig. 4). The results showed that there were significant differences among these areas ($X^2 = 5.734$, $P = 0.017 < 0.05$, Table A6), and the rural and urban respondents in Wuyuan County showed more support for hunting as a way to control wild boar populations, with 55% and 68.8% of rural and urban respondents of Wuyuan supporting hunting measures as a wild boar control strategy. In contrast, most respondents in Nanchang and Beijing preferred non-hunting measures (65.5% and 64.3%, respectively).

In the next part, we investigated urban respondents' attitudes toward hunting through a choice experiment that asked respondents to consider alternative management strategies based on carefully selected multiple attributes of human-wild boar conflict control. We used Latent Class analysis to explore the possible heterogeneity of wild boar strategy preferences across subgroups of urban respondents.

Table 2
The distribution and recovery of questionnaires.

| Study area | Number of distributed questionnaires | Number of returned questionnaires | Number of valid questionnaires | Effective rate |
|-----------------------------|--------------------------------------|-----------------------------------|--------------------------------|----------------|
| Wuyuan rural area (offline) | 222 | 222 | 218 | 98.2% |
| Wuyuan town (offline) | 216 | 216 | 216 | 100% |
| Nanchang (online) | 2481 | 896 | 626 | 69.9% |
| Beijing (online) | 932 | 671 | 632 | 94.2% |

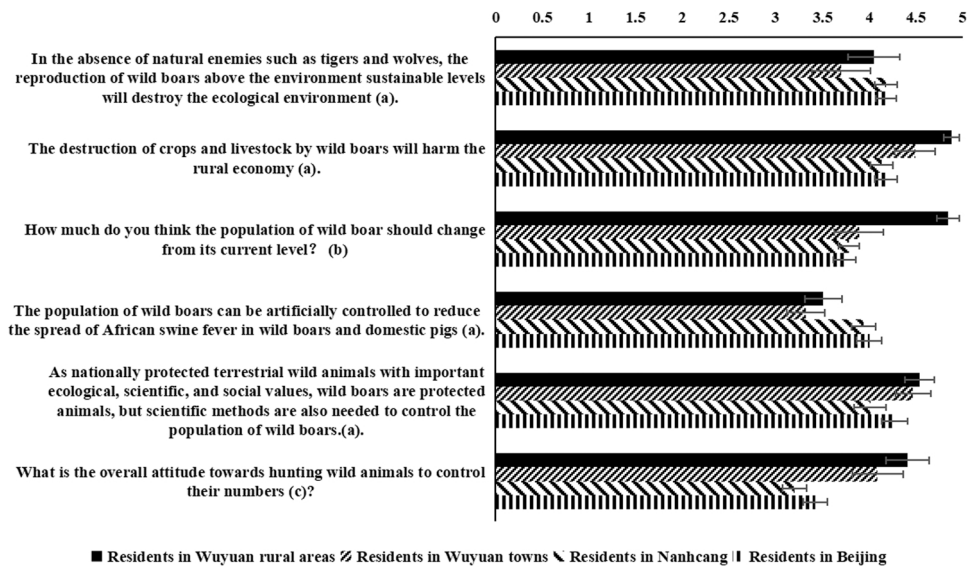


Fig. 2. Mean attitude scores of residents from Wuyuan rural areas, Wuyuan towns, Nanchang and Beijing, with a confidence interval of 95% (a: 1 = "strongly disagree"; 2 = "disagree"; 3 = "unknown"; 4 = "agree"; 5 = "strongly agree"; b: 1 = "Increase by 50%"; 2 = "Increase by 25%"; 3 = "Keep the same"; 4 = "Decrease by 25%"; 5 = "Decrease by 50%"; c: 1 = "strongly negative"; 2 = "relatively negative"; 3 = "neither negative/not positive"; 4 = "relatively positive"; 5 = "strongly positive").

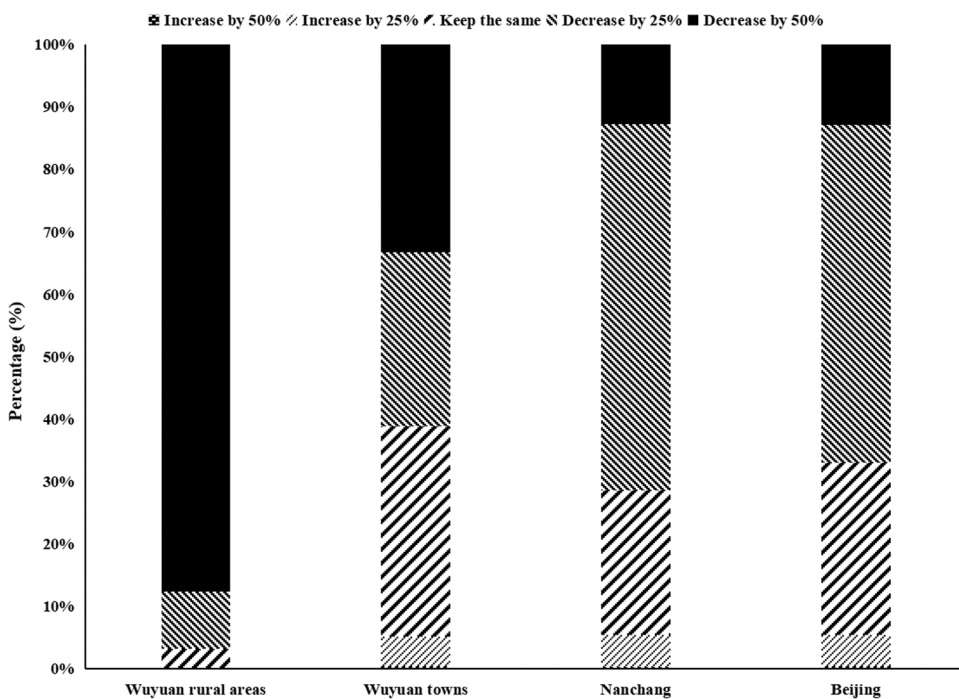


Fig. 3. Attitudes of respondents in Wuyuan rural areas, Wuyuan towns, Nanchang and Beijing on the current changes in wild boar populations.

3.2. Choice experiments

3.2.1. Wuyuan town

According to the MNL model, respondents in urban Wuyuan preferred hunting to manage the boar population (Hunting or not, $P < 0.001$), supported declining the boar population (Population expectation, $P < 0.001$), and showed an unwillingness to pay environmental protection tax (Environmental protection tax, $P < 0.001$) (Table 3). According to the selected LCM model, respondents in Wuyuan town were grouped under three categories based on the "Bayesian Information Criterion (BIC)" and "Akaike Information

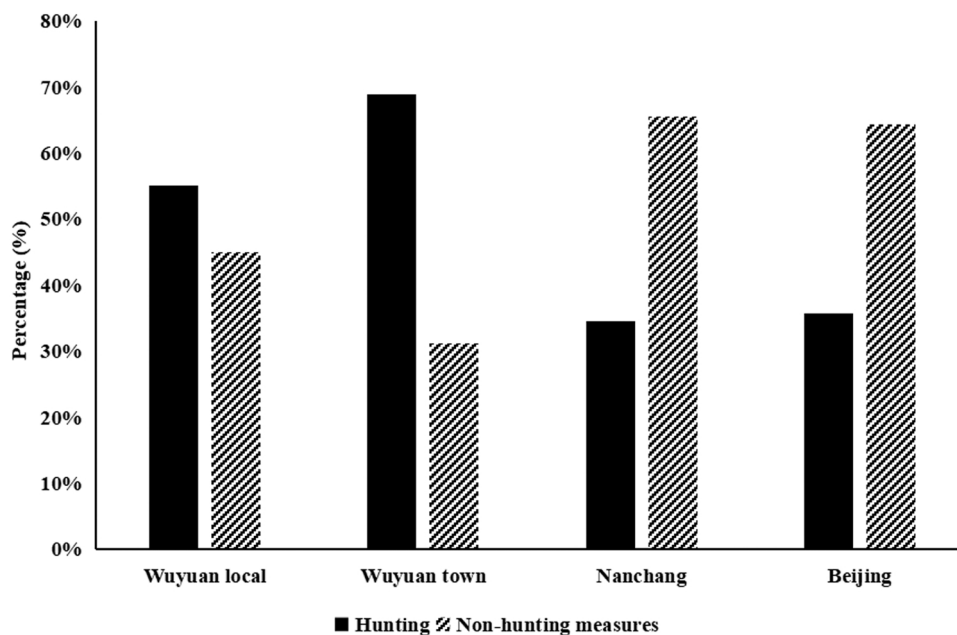


Fig. 4. Preference of respondents in Wuyuan rural areas, Wuyuan town, Nanchang and Beijing for control measures when boar and human conflict occurred (non-hunting measures mainly include "obstacles, interference measures, change the planting structure, biological control, immigration and relocation, compensation for loss, others").

Table 3

Estimation results of MNL model parameter in Wuyuan town, Nanchang and Beijing.

| Attribute levels | Wuyuan town | Nanchang | Beijing |
|------------------------------|---------------------------|---------------------------|---------------------------|
| ASC | -0.52532 *** (0.10212) | -1.68408 *** (0.06125) | -1.70803 *** (0.05991) |
| Whether have swine fever | -0.12715 (0.09168) | -0.06896 (0.04572) | 0.01892 (0.05087) |
| Scope of control measures | 0.06627 (0.08995) | 0.13570 *** (0.04337) | 0.05758 (0.04201) |
| Hunting or not | 0.82252 *** (0.08611) | 0.07831 ** (0.03865) | 0.11545 *** (0.04304) |
| Population expectation | -1.27450 *** (0.05677) | -0.30871 *** (0.02512) | -0.37281 *** (0.02526) |
| Environmental protection tax | -0.02681 *** (0.00613) | -0.02706 *** (0.00290) | -0.04031 *** (0.00292) |

Note: ASC refers to the Alternative Specific Constant. The values in the Table and parentheses are the Multinomial logit (MNL) estimates of the utility function for each attribute in the three study areas and the standard error. Significance levels: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. Attribute reference levels: 'Whether have swine fever: Period in the swine fever outbreak', 'Scope of control measures: Nationwide', 'Hunting or not: Other non-hunting measures such as habitat protection and sterilization', 'Population expectation: decline', 'Environmental protection tax: ¥1'.

Criterion (AIC)" (penalty factor of 3) when additional variables were included (Table A7). Respondents in the LCM1 model accounted for 28.5% of the total sample. This category of respondents supported regulating the wild boar population during the non-African swine fever (ASF) outbreak period (Whether have swine fever, $P < 0.001$) at a national level (Scope of control measures, $P < 0.001$). Also, they preferred the reduction of the wild boar population (Population expectation, $P < 0.001$), and as expected, preferred to pay the lowest amount of environmental protection tax (Environmental protection tax, $P < 0.001$). Respondents in this category were most likely to be women of older ages (28.5% of respondents). Respondents in the LCM2 model accounted for 33.5% of the total sample. They supported regulating wild boars during the ASF outbreak period (Whether have swine fever, $P < 0.001$). Also, they supported hunting as a measure to manage wild boars (Hunting or not, $P < 0.001$) and expected a reduction of the wild boar population (Population expectation, $P < 0.001$). The respondents in the LCM3 model accounted for 37.9% of the total sample. This category of respondents supported hunting as a measure to regulate and control wild boars (Hunting or not, $P < 0.001$), and also supported that the amount of environmental tax would be relatively low (Environmental protection tax, $P < 0.001$) (Table A8).

3.2.2. Nanchang

According to the MNL model, respondents in Nanchang preferred to manage the wild boar population in a specific area (Scope of

control measures, $P < 0.001$) and supported managing wild boars by hunting (Hunting or not, $P < 0.01$). They wanted the wild boar population to decline (Population expectation, $P < 0.001$) and showed an unwillingness to pay the environmental protection tax (Environmental protection tax, $P < 0.001$) (Table 3). In the LCM model, Nanchang respondents were grouped under two categories (Table A9). The respondents in the LCM1 model accounted for the most significant proportion in Nanchang, at 71.3%. They supported the regulation in specific areas (Scope of control measures, $P < 0.05$) and a reduction of wild boar population (Population expectation, $P < 0.001$), but showed little willingness to pay environmental protection tax (Environmental protection tax, $P < 0.001$). They were mainly people with higher incomes. The respondents in the LCM2 model accounted for a relatively small proportion of the total sample (28.7%). They supported hunting as a measure to control wild boars (Hunting or not, $P < 0.01$) in specific areas (Scope of control measures, $P < 0.01$). At the same time, they expected a reduction of the wild boar population (Population expectation, $P < 0.001$), and showed a relatively low willingness to pay the environmental protection tax (Environmental protection tax, $P < 0.001$) (Table A8).

3.2.3. Beijing

According to the MNL model, respondents in Beijing preferred hunting to manage the boar population (Hunting or not, $P < 0.001$), and expected a reduction of the boar population (Population expectation, $P < 0.001$), and showed an unwillingness to pay the environmental protection tax (Environmental protection tax, $P < 0.001$) (Table 3). In the LCM model, Beijing respondents were grouped under three categories (Table A10). The respondents in the LCM1 model accounted for the most minor proportion of the total (16.8%). This category of respondents supported the regulation of the wild boar population in specific areas (Scope of control measures, $P < 0.001$) and was willing to pay a relatively low amount of environmental tax (Environmental protection tax, $P < 0.001$). The respondents in the LCM2 model accounted for the most significant proportion (59%). This category of respondents supported the use of hunting as a measure (Hunting or not, $P < 0.01$) at a national level (Scope of control measures, $P < 0.05$) to regulate the wild boar population. Meanwhile, they also expected a reduction of wild boars (Population expectation, $P < 0.001$), but they were only willing to pay a lower amount of environmental protection tax (Environmental protection tax, $P < 0.01$). Respondents in the LCM3 model accounted for 24.2% of the total sample. This category of respondents supported the reduction of the wild boar population (Population expectation, $P < 0.001$) and showed a low willingness to pay the environmental protection tax (Environmental protection tax, $P < 0.001$) (Table A8).

Overall, the results showed considerable heterogeneity of wild boar control strategy preferences across the four samples. Specifically, the majority of rural respondents (55%) and urban respondents (68.8%) in Wuyuan preferred hunting measures as their wild boar control strategy, while the majority of Nanchang respondents (65.5%) and Beijing respondents (64.3%) who live in large cities remote from the problem, preferred non-hunting measures (Fig. 4). However, the MNL model of choice experiments indicated that urban respondents were either supportive or not opposed to hunting, when hunting was listed as part of a management strategy package with population changes and the deployment of an environmental tax. In the Discussion, we will further explore the ramifications of our results for wild boar management and also consider the potential of expanding the role of hunting in wild boar management in China based on part of interviews with local hunters in Wuyuan.

4. Discussion

This research shows the differences in attitudes and preferences toward wild boar management between urban and rural residents. It suggests that despite holding different wildlife values, there may be underlying similarities between the rural residents and urban public concerning wild boar management strategies in some wildlife management contexts. Our discussion aims to provide information and guidance for resolving human-wildlife conflict based on a scientific understanding of contextualized preferences of local stakeholder groups and the general public.

4.1. Attitudes and preferences of urban public and rural residents towards wild boar management

In attitudinal terms, we have found that most rural and urban residents agree that reproducing wild boars above the environment's sustainable levels will have destructive effects on the natural environment and wild boar population can be managed using scientific measures (measures here include non-hunting measures as well as hunting measures), which suggests that the conflict between wild boars and human has already been broadly acknowledged in the contemporary Chinese society. In the analysis of the attitudes towards wild boar management, it is found that although both rural residents and urban residents expect reducing the wild boar population, rural residents most directly affected by the problem desire more considerable reductions. It is likely to be explained by the fact that rural residents in Wuyuan county have suffered from the loss by wild boars for a long time, thus, showing very negative attitudes toward wild boars (Caplenor et al., 2017; Watkins et al., 2019).

Although most of the urban public wants the wild boar population to be scientifically managed and reduced, most prefer non-hunting measures such as interference measures, obstacles and biological control, etc. (Fig. 4). Other studies have also revealed strong public support for non-hunting control strategies (Frank et al., 2015; Liordos et al., 2017; Martínez-Jauregui et al., 2020). For example, Frank et al. (2015) showed that out of consideration for the existence value of wild boar, and animal welfare, the public agreed to regulate the wild boar population through non-hunting measures that were more "humanized" (Frank et al., 2015). However, most urban residents in Wuyuan towns prefer hunting probably because of their more profound and more intuitive understanding of the wild boar conflicts in Wuyuan rural areas resulting from their proximity to the conflict and a closer relationship with the villagers.

Interestingly, the urban public in all three areas has positive preference for hunting when considered part of a broader strategy (Table 3). Although there are differences in support for hunting among subgroups in different cities, it can be seen from the LCM model

that among the eight subgroups in the three urban areas, four groups are significantly supportive of hunting, while the other four groups only have no opposition to hunting (Table A8). Indeed, for city residents, the amount of environmental tax they would have to pay is the most critical aspect of the wild boar management strategy. It indicates preference for control measures is influenced by cost implications on the household of any management plan for human-wild boar conflict. The consideration of personal costs has been published elsewhere (Yang et al., 2014; Subroy et al., 2018), which supports the notion that participants are following "Rational choice theory" which refers to a rational analysis of expected benefits and costs of participating in collective action (Krajbich et al., 2009; Yaghi and Alibeli, 2017). In this study, it is found that although the urban public believe that non-hunting measures should be taken based on the belief and values of love animals, they will ultimately choose hunting measures if this results in lower household cost. Our results also suggest that opposition to hunting may reflect a moralistic feeling that hunting is wrong (mainly arising from social media campaigns) (Lindsey et al., 2016), but such feeling tends to be less strong when faced with practical considerations about implications for personal well-being or finances (Ekdahl, 2012; Dubois, 2014).

Most (55%) residents in Wuyuan rural areas prefer hunting measures as their first choice for wild boar management strategy (Fig. 4), which is consistent with the results of earlier studies; that is, farmers have experienced wildlife damage firsthand thus prefer hunting measures to directly reduce the population of wild boars (Liordos et al., 2017). However, surprisingly, in this study, nearly half (45%) of Wuyuan rural residents tend to prefer non-hunting measures (Fig. 4), such as interference measures and barriers to the prevention and control of wild boars. It may be explained by the low perceived effectiveness of hunting in Wuyuan and widespread dissatisfaction with hunting as currently managed. During interviews carried out with members of the local hunting organization (Part I in supplementary materials), we have learned that hunting wild boars is becoming more and more difficult, due to the complex terrain, the wild boar's quick response to hunting pressure and other interventions, technical difficulties in tracking, and the strict regulations governing hunting quota and permits. In many cases, the immediate effect of the hunt organized by the hunting agency is hampered by slow response times; also, many local farmers who have suffered persistent damage from wild boars have been "disappointed" with the local hunting agency. Such a problem may require a high degree of vigilance from China's wildlife conservation and management departments. Because poaching inspired by persistent and unsolvable conflicts is rapidly reducing local farmers' trust in wildlife conservation management agencies and their support for laws in other parts of the world, serious socio-political conflicts have been caused (Olson et al., 2014; Moreto, 2019; Gaodirelwe et al., 2020).

4.2. Challenges and opportunities of wild boar management in China

Human-wildlife conflict has become the focus of increasing attention of conservation authorities nowadays. Still, due to the complex nature of the conflict resulting from the range of ecological, social, economic, and cultural factors involved, conflict resolution is often more difficult than first assumed (Dickman, 2010; Jordan et al., 2020). This study shows that while urban and rural residents support the management of the wild boar population, there is a lack of consensus between groups regarding a preferred management strategy. The urban public has a greater preference for non-hunting measures, while farmers are more supportive of hunting measures for wild boar management (Fig. 4), which is similar to other studies on attitudes of urban and rural residents toward wildlife control measures (Frank et al., 2015).

However, this study also has found that personal costs in the shape of an environmental tax may weaken the concerns of the urban public about the use of lethal control measures (Fitzgerald, 2009), and preferences of the urban public become more homogeneous with rural residents if costs to their household as factored in (Table 3). Spreading the cost of the conflict may therefore help to align preferences between different groups and open up new ways to minimize barriers to effective management strategies. Future research can further investigate the influencing factors of urban public perception of the control strategies to find leverage points that unify the views of the urban public and rural residents and better facilitate the management of human-wildlife conflict.

Although equalizing the distribution of costs and benefits between rural and urban residents may be central to alleviating human-wildlife conflict (König et al., 2020), farmers in Wuyuan, the poorest members of Chinese society, currently bare all the costs and burdens of coexisting with wild boars. However, financial assistance to manage wild boars through non-hunting measures are often temporary solutions (Liordos et al., 2017). For example, the maintenance costs of fences are high and fall on the farmer; moreover, they can only control wild pigs for a period of time, and damage can resume once the pigs become accustomed to them (Snow et al., 2016). Direct financial compensation for losses incurred by the government can reduce farmers' economic losses to a certain extent and improve rural residents' tolerance of wild boars. However, the broad geographical scope of compensation and the rigorous accounting of losses make it costly to implement; also, the complex financial system involved in compensation can also be a breeding ground for corruption (Ravenelle and Nyhus, 2017) and frustration with the authorities among farmers most badly affected.

Expanding the source of funds for wildlife conservation and management and transferring part of the cost of coexistence with wildlife to urban residents through an environmental tax seems a feasible approach in this regard (Cohen et al., 2021). However, the results of the LCM model show that among the eight subgroups in the three urban areas, seven groups of urban respondents have a significantly negative attitude towards paying environmental tax, while the attitude of the remaining group of respondents is not clear (Table A8). Therefore, such a tax, if required by law, is unlikely to be implemented out of political concerns for resistance from the urban public. While a voluntary tax is possible, it is likely to suffer from free-riding and face significant transaction costs in terms of set-up, management, and control (McKinney et al., 2005).

Hunting has some advantages as a conflict mitigation mechanism, as it can directly solve the problem (population pressure and economic costs of damage), and, if appropriately managed, generate income for local farmers from both the sale of meat and hunting fees (Di Minin et al., 2016; Bobek et al., 2017). It is also a less contentious strategy than expected, given that opposition from the urban public significantly weakens when presented as an alternative to other equitable financing options such as an environmental tax. At

present, the hunting agency established in Wuyuan has played an essential role in reducing the density of the wild boar population locally; however, the current approach is ineffective in terms of rapidity and scale of responsiveness. Furthermore, it can be concluded from our interviews with local hunters and administrators that the hunting agency in Wuyuan has not brought substantial economic benefits to local farmers, meanwhile, lacking sufficient funds to expand culling operations and the purchase of advanced hunting equipment. Problems include the absence of top-up government financial support, legal restrictions on the selling of hunting quotas, and the loss of meat revenue following China's ban on wild pork and other meat from wild animals in 2020 in response to Covid-19 (See Part I in [supplementary materials](#)).

Reforming the hunting management model in Wuyuan can provide an opportunity to ease the conflict between wild boars and humans, if hunting rights could be sold to third parties such as hunting clubs (Rosa et al., 2018). It would generate much higher revenues while still promoting sustainable hunting to protect agricultural livelihoods, so the revenues could be used to compensate for losses caused by wildlife conflicts (Cooney et al., 2017). Additional income and benefits could also be derived from associated tourism development such as accommodation, food and hunting services like tracking (Wanger et al., 2017). This hunting model has been widely used in the world, such as Europe and North America, and has been successfully applied in managing excessive wild boar populations elsewhere (Hothorn and Müller, 2010; Quirós-Fernández et al., 2017).

However, there could also be challenges in bringing this hunting model to China. Currently, China's laws on wildlife hunting are not precisely defined or grounded in the application, and China has imposed general restrictions on wildlife hunting under various rules. Hence, many of the necessary regulations concerning the calculation of sustainable quotas, the methods of carcass handling, sources of funding, and distribution of profits, would need to be drafted and approved by relevant government departments. Previous studies have showed that weak legal regulation may encourage poachers to speculate and further increase the likelihood of wildlife being poached, ultimately jeopardizing sustainable and legal hunting activities, which can be inhumane and lead to little wider benefit to local communities (Treves et al., 2019). Therefore, new laws will require significant support of local wildlife managers.

Given the potential for hunting to be negatively portrayed in social media, it will be essential to develop an effective information and social marketing campaign to promote an objective understanding of hunting among the public (Zhou et al., 2020). For example, Dunn (2018) found that prior knowledge of human-wildlife conflict correlated with increased acceptance of lethal control measures for wildlife (Dunn et al., 2018). Therefore, raising public awareness and education about hunting are critical aspects that wildlife managers need to consider when developing sustainable wild boar management plans (Frank et al., 2015; Liordos et al., 2017; Dunn et al., 2018). In addition, governments should also pay attention to the role of the media in shaping public attitudes and values toward wildlife. It will be essential that wildlife managers learn to utilize social media to promote their activities, using various platforms to educate the public about the real-world situation concerning wild boar conflict and the necessity as well as the rationale for taking any management measures (Dubois et al., 2014; Song et al., 2021; Miao et al., 2021).

Our study also highlights the need to increase the political influence of rural residents in the core areas of the human-boar conflict if conservationists are to alleviate human-wild boar conflicts effectively. For example, studies have shown that the effectiveness of an individual's expression of interest is closely related to the organizational strength of the individual's 'group'. The more organized the group, the more effective the individual's expression of interests can be, and the more likely it is to affect the formulation of policies (Brou and Ruta, 2006). Therefore, policymakers could promote the establishment of various agricultural industry organizations to give farmers a voice in their interests. In addition, grassroots township governments can also open up a variety of channels, such as creating a public account and setting up a working group to hold regular forums, etc., to fully understand farmers' opinions, and effectively convey these opinions through various methods such as handing them to deputies to the People's Congress and strengthening external publicity.

In this study, both rural and urban residents generally prefer to manage wild boars through strategies with low personal costs and high efficiency. In recent decades, China has actively advocated wildlife conservation, including wild boars, but with such a high level of conservation effort, wild boars have also grown rapidly in some parts of China. Although the Chinese government has implemented a series of strategies to reduce the damage caused by wild boars, the prevention and control strategies implemented by the Chinese government for a long time seem to have deviated from public preferences. China is, therefore, at a critical "crossroads" in its approach to mitigating the conflict between wild animals and humans, and the Chinese government may need to act quickly to avoid a damaging schism developing between the rural and urban populations concerning sustainable management of wildlife (Moreto, 2019). Based on our results, we suggest improving the current management model in China by introducing a sustainable hunting model. On the one hand, hunting can help mitigate conflict with boar populations; on the other hand, hunting fees can provide the necessary funds for an equitable compensation package and a well-developed public education and outreach program. However, we must also point out that although hunting is an essential tool to mitigate the damage caused by wild boars, the ecological conditions of wild boars in different regions are different. Therefore, whether hunting strategies are suitable for all wild boar-human conflict areas need to be scientifically assessed in combination with the actual conflict situation in different regions and the ecological status of wild boar populations. In addition, given the potential negative impact that poorly managed hunting can have on wild boar populations (Connally et al., 2021a; Jaebker et al., 2021; Wevers et al., 2020; Keuling and Massei, 2021), we recommend that wildlife management authorities carefully design and implement a hunting policy, with full consideration of the number of hunters, hunter training, the hunting equipment, hunting ethics, and the potential impact of hunting on the behavior of wild boars, etc. (Von Essen et al., 2019; Von Essen, 2020; Keuling et al., 2021). In addition, hunting alone is unlikely to be effective in regulating the wild boar population due to difficulties in estimating population density and reproductive potential (Connally et al., 2021b). We therefore recommend that local wildlife management agencies should also introduce other strategies (Keuling et al., 2016), such as trapping and birth control to supplement the hunting plan.

5. Conclusion

In summary, in this study, we have found that rural residents in conflict core areas prefer hunting to control wild boar-human conflict, while urban residents far from conflict prefer non-hunting measures. However, economic cost plays vital role in influencing urban residents' preference for management measures, as they have showed positive preferences for hunting if they are required to pay an environmental tax to compensate farmers for crop damage. Based on the current state of wild boar management in China, we suggest that: 1) the Chinese government should improve the current hunting management policies and regulations to establish better mechanisms for the scientific management of the wild boar populations; 2) relevant departments need to continue to strengthen biodiversity conservation education for urban residents and promote their objective understanding of hunting; 3) relevant departments should increase the political influence of rural residents through multiple channels, such as establishing rural industry organizations, holding regular symposiums, reflecting the opinions of rural residents to deputies who can present them to the People's Congress, and strengthening external publicity; 4) local authorities should carefully design and implement hunting plans, as well as introduce other management strategies to minimize wild boar-human conflict. This study is of great significance for promoting human-wildlife conflict management and preventing social fragmentation due to wildlife conservation management by understanding the values and preferences of stakeholders comprehensively.

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CRedit authorship contribution statement

X.H.Z., Q.W. and W.Z. conceived and designed the study; Q.W. supervised the project; X.H.Z. received the funding; D.Y.T. and Z.M. collected the data; Q.W., D.Y.T. and Z.M. analyzed the data and prepared the figures; X.H.Z. wrote the first version of the manuscript, which was then revised by all authors. All authors read and approved the final manuscript.

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.

Data Availability

Data will be made available on request.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.gecco.2022.e02353](https://doi.org/10.1016/j.gecco.2022.e02353).

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